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To What Extent Is the Protective Effect of Breastfeeding on Future Overweight Explained by Decreased Maternal Feeding Restriction?

Elsie M. Taveras, MD, MPH^{a,b}, Sheryl L. Rifas-Shiman, MPH^b, Kelley S. Scanlon, PhD, RD^c, Laurence M. Grummer-Strawn, PhD^c, Bettylou Sherry, PhD, RD^c, and Matthew W. Gillman, MD, SM^{a,b,d}

^aObesity Prevention Program and Center for Child Health Care Studies, Boston, Massachusetts

^bDepartment of Ambulatory Care and Prevention, Harvard Pilgrim Health Care and Harvard Medical School, Boston, Massachusetts

^cNational Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia

^dDepartment of Nutrition, Harvard School of Public Health, Boston, Massachusetts

Abstract

OBJECTIVE—Previous studies have found that breastfeeding may protect infants against future overweight. One proposed mechanism is that breastfeeding, as opposed to bottle feeding, promotes maternal feeding styles that are less controlling and more responsive to infant cues of hunger and satiety, thereby allowing infants greater self-regulation of energy intake. The objective of this study was to determine the extent to which the protective effect of breastfeeding on future overweight is explained by decreased maternal feeding restriction.

PATIENTS AND METHODS—We studied 1012 mother-infant pairs in Project Viva, an ongoing prospective cohort study of pregnant mothers and their children. The main exposure was breastfeeding duration, assessed at 1 year postpartum. At 3 years of age, the main outcomes were age- and gender-specific BMI *z* score and the sum of subscapular and triceps skinfold thicknesses, with overweight defined as a BMI 95th percentile. We defined maternal restriction of infant's access to food as strongly agreeing or agreeing, with the following question from the Child Feeding Questionnaire: "I have to be careful not to feed my child too much." To examine the association between breastfeeding duration and our outcomes, we used multivariate linear and

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Address correspondence to Elsie M. Taveras, MD, MPH, Department of Ambulatory Care and Prevention, Harvard Pilgrim Health Care and Harvard Medical School, 133 Brookline Ave, 6th Floor, Boston, MA 02215. elsie_taveras@harvardpilgrim.org.

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logistic models, adjusting for several potential confounders. In subsequent models, we also adjusted for maternal restriction of infant's access to food.

RESULTS—The mean duration of breastfeeding was 6.5 months, and 12% of women strongly agreed or agreed with the restriction question. At age 3, mean for BMI z score was 0.47. Each 3-month increment in breastfeeding duration was associated with a reduction of 0.045 BMI z score. After adjusting for maternal restriction, the estimate was -0.039 , a 13% attenuation.

CONCLUSION—The protective effect of breastfeeding on future overweight seems to be explained only partially by decreased maternal feeding restriction.

Keywords

breastfeeding; body mass index; BMI; infant feeding; maternal feeding restriction

Several recent studies and a meta-analysis indicate that increased duration of breastfeeding predicts lower rates of child and adolescent overweight.^{1–4} Many studies and 2 meta-analyses also show that ever having been breastfed is associated with lower prevalence of overweight,^{1–3,5–10} although a recent meta-analysis suggested that having been breastfed was not associated with lower mean BMI.¹¹

One proposed mechanism by which breastfeeding may protect against overweight is behavioral. Infants naturally regulate their energy intake, but their parents' behavior can override cues for hunger and satiety. During infancy, it is possible that mothers who breastfeed may be more responsive than parents who bottle feed to their infants' signals in terms of frequency and volume of feedings.¹² In this way, the mothers of breastfeeding infants may develop feeding styles that are less controlling, thereby allowing their infants to maintain their natural ability to regulate their energy intake and respond to internal appetite cues.

Several studies have examined the role of parental control over children's eating habits in the development of childhood overweight. By using findings from cross-sectional studies, Birch et al^{13,14} showed that highly controlling feeding practices by parents were directly associated with poorer self-regulation of energy intake among children aged 3 to 5 years. Increased adiposity was also noted among the girls but not the boys. Increased parental feeding restriction has also been found to be associated with increased child eating and weight status.^{15–18} In a systematic review of parental feeding styles and later child eating and weight status, Faith et al¹⁹ found that increased parental feeding restriction, but not other feeding domains, was associated with later increased eating and weight status among children.

Two recent longitudinal studies show that breastfeeding may promote parent feeding styles that are more responsive to infant cues of hunger and satiety.^{20,21} In a study of 55 infants and their mothers, Fisher et al²⁰ found that mothers who breastfed their infants for at least 12 months used lower levels of control when feeding their infants at 18 months of age. In a previous analysis of 1160 mother-infant pairs in Project Viva,²¹ our study team showed that breastfeeding duration was associated with less maternal restriction at 1 year of age. After adjusting for mothers' preexisting concerns about their children's future eating and weight

status, as well as sociodemographic, economic, and anthropometric predictors of breastfeeding duration, the longer the mothers breastfed, the less likely they were to restrict their children's food intake at age 1 year. The adjusted odds ratio (OR) was 0.89 (95% confidence interval [CI]: 0.84 to 0.95) for each 1-month increment in breastfeeding duration. Thus, one underlying pathway by which breastfeeding may be related to child and adolescent overweight is through its influence on maternal feeding restriction.

The purpose of our study was to examine the extent to which maternal feeding restriction mediates the overall relationship between breastfeeding and overweight. We hypothesized that the protective effect of breastfeeding on future overweight is partially explained by a decreased tendency of breastfeeding mothers to report restricting their children's food intake.

METHODS

Subjects and Study Design

The subjects for this study were participants in Project Viva, a prospective observational cohort study of gestational diet, pregnancy outcomes, and offspring health.²² We recruited women who were attending their initial prenatal visit at 8 urban and suburban obstetrical offices of a multi-specialty group practice located in eastern Massachusetts. Eligibility criteria included fluency in English, gestational age <22 weeks at the initial prenatal clinical appointment, and singleton pregnancy. Details of recruitment and retention procedures are available elsewhere.²²

Of the 2128 women who delivered a live infant, 1768 agreed to enroll their infants in the study. At the time of analysis, 1579 participants were eligible for 3-year follow-up. We excluded 92 participants who refused to participate in the 3-year follow-up, 40 participants who did not complete the 3-year assessment, and 23 infants whose gestational age at birth was <34 weeks. In addition, we excluded 88 participants who were missing data on our main exposures (ie, breastfeeding duration and 6-month infant feeding status), 228 participants who were missing data on 1-year maternal restriction, and 96 participants who were missing 3-year outcome data (BMI z score and subscapular plus triceps skinfold measurements at 3 years old). Thus, our sample size for analysis was 1012 mother-infant pairs. Comparison of the 1012 participants in this analysis with the full 2083 Project Viva nonpremature participants who delivered showed only small differences. For example, the group of eligible subjects had slightly more white (77% vs 67%) and more educated (26% vs 35% less than college education) individuals and had slightly higher household incomes (10% vs 13% under \$40 000 per year) than the total sample, but the 2 groups did not differ on mean maternal prepregnancy BMI or infant birth weight.

After obtaining informed consent, we performed in-person study visits with the mothers at the end of their first and second trimesters of pregnancy and with both the mother and their infants immediately after delivery and at 6 months' and 3 years' postpartum. At each in-person visit, we measured the infant's height and weight; at 3 years of age, we also measured the child's skinfold thicknesses. The participating mothers completed mailed questionnaires 1 year postpartum, on which they updated the information on their infant-

feeding practices. Institutional review boards of participating institutions approved the study, and all procedures were in accordance with the ethical standards for human experimentation established by the Declaration of Helsinki.

Measurements

Main Exposures—Our 2 exposures of interest were (a) duration of breastfeeding reported 1 year postpartum and (b) nonuse of infant formula feeding during the infant's first 6 months of life. During the 1-year assessment, we asked mothers, "Are you still breastfeeding?" Mothers could have completed the 1-year assessment any time after their child turned 12 months old. Of the mothers who reported that they had breastfed their infants for any length of time, we asked the following question at the 1-year assessment, "How old was your child when you stopped breastfeeding?" Response options included months, weeks, and days. If mothers were still breastfeeding or reported stopping after 12 months, we coded their response as "12 months." We converted all responses to months for statistical analyses.

At 6 months' postpartum, we grouped women into 4 categories on the basis of their extent of breastfeeding or formula feeding: (a) "no infant formula feeding," which included mothers who fed their infants breast milk only, no formula, since birth; (b) mixed breast milk and formula feeding, which included mothers who were feeding their infants formula in addition to breast milk at 6 months of age; (c) weaned, in which mothers had initiated breast milk feeding but discontinued it completely before 6 months of age; and (d) formula feeders, in which mothers fed their infants only formula since birth. In multivariate analyses, we examined 3 groups: "no infant formula feeding during the first 6 months of life," "mixed breast milk and formula feeders at 6 months of life," and "weaned/formula feeding only at 6 months of life."

Outcome Measures—We measured the children's height and weight by using a calibrated stadiometer (Shorr Productions, Olney, MD) and scale (Seca Model 881; Seca Corporation, Hanover, MD). We calculated age- and gender-specific BMI *z* scores and percentiles by using US national reference data.²³ We then measured the children's subscapular and triceps skinfold thicknesses by using Holtain calipers (Holtain LTD, Crosswell, United Kingdom) and calculated the sum (subscapular plus triceps). We defined overweight as BMI for age and gender ≥95th percentile and at risk of overweight as a BMI for age and gender between the 85th and 95th percentiles.²³ Research assistants performed all measurements following standardized techniques,²⁴ and participated in biannual in-service training to ensure measurement validity (IJ Shorr; Shorr Productions, Olney, MD). Interrater and intrarater measurement errors were well within published reference ranges for all measurements.²⁵

Maternal Feeding Restriction—The main intermediate of interest was the mothers' reports of restricting their children's food intake. At 1 year postpartum we measured maternal restriction by using the following modified item from the Child Feeding Questionnaire (CFQ)²⁶: "I have to be careful not to feed my child too much." We dichotomized the response categories to strongly agree/agree versus strongly disagree/disagree for statistical analyses. 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 ages 2 to 11 years.²⁶ To measure maternal feeding restriction, the CFQ uses a series of questions including, “I have to be sure that my child does not eat too many sweets (candy, ice cream, cake, or pastries),” “I have to be sure my child does not eat too many high fat foods,” and “I have to be sure that my child does not eat too much of her favorite foods.” We made the modifications noted above to the CFQ for parents of children 1 year of age.

Other Measures

Through a combination of questionnaires and interviews, we collected information about maternal race/ethnicity, age, education, parity, prenatal smoking (never, former, or early pregnancy) and household income. Mothers reported their prepregnancy weight and height and paternal weight and height. We obtained the infants’ birth weights from medical charts.

Statistical Analysis

We first examined descriptive statistics for our sample characteristics and main outcomes (BMI z score, sum of subscapular and triceps skinfold thickness, and prevalence of overweight). Next, we examined the bivariate relationships of breastfeeding with our main outcomes and the effect of adjustment for restriction on the relationship between breastfeeding and BMI z score.

We used multivariable linear regression models to assess the independent effects of maternal feeding restriction on our main outcomes, adjusted for child’s age, birth weight, and gender; maternal age, race/ethnicity, education, income, parity, prepregnancy BMI, and smoking history; and paternal BMI.

We then used multiple linear and logistic regression models to assess the independent effects of breastfeeding duration and type of breastfeeding at 6 months’ postpartum on our main outcomes. Model 1 was unadjusted. Multivariable Model 2 adjusted for child’s age, gender, and birth weight; maternal age, race/ethnicity, education, income, parity, prenatal smoking, and prepregnancy BMI; and paternal BMI. In Multivariable Model 3, we also adjusted for maternal feeding restriction to examine its role as an intermediate in the association between breastfeeding and overweight. We hypothesized that adjustment for maternal feeding restriction would attenuate observed associations between breastfeeding and overweight.

We report regression estimates or ORs and 95% CIs for the main predictors. In our logistic regression models, the reference group was BMI between the 5th to 84th percentiles. We excluded 22 children whose BMI was <5th percentile, which is considered underweight when compared with national reference data.²³ We conducted all analyses by using SAS 9.1 (SAS Institute, Inc, Cary, NC).

RESULTS

Characteristics of the study participants are summarized in Table 1. When the children were 3 years of age, the mean (SD) for the BMI z score was 0.47 (1.0) and the mean (SD) for subscapular plus triceps skinfold measurement was 16.8 (4.2); 9% of the children were

overweight. The mean (SD) duration of breastfeeding assessed 1 year postpartum was 6.5 (4.5) months. At 6 months' postpartum, 9.9% of the women fed their infants formula only since birth, 40.6% weaned their infants from breast milk to formula feeding, 24.9% were providing mixed feeding, and 24.6% fed their infants no formula since birth (Table 2).

In bivariate analyses, the mean BMI z score and subscapular plus triceps skinfold thickness at 3 years of age decreased with increasing duration of any breastfeeding (Table 2). The overall pattern of decreased adiposity with increasing duration of breastfeeding was also seen in prevalence of overweight (Table 2). In addition, children who were fed formula only since birth had higher mean BMI z scores, subscapular plus triceps skinfold thickness, and prevalence of overweight than children who had been weaned from breast milk to formula by 6 months of age, were receiving mixed breast milk and formula at 6 months of age, or had been fed no infant formula since birth (Table 2).

Figure 1 shows the bivariate association between breastfeeding duration and BMI z score before and after adjusting for maternal feeding restriction. Maternal feeding restriction minimally attenuated the association between breastfeeding duration and BMI z score, but the effect seemed slightly stronger with greater duration of breastfeeding.

In multivariate analyses adjusting for potential confounders, maternal agreement with the feeding restriction statement, "I have to be careful not to feed my child too much," at 1 year of age was associated with a higher child BMI z score (regression estimate: 0.21, 95% CI: 0.02 to 0.41). There was also a trend toward higher subscapular plus triceps skinfold thickness (regression estimate: 0.75; 95% CI: -0.09 to 1.58) and greater odds of a child being overweight (OR: 1.64; 95% CI: 0.83 to 3.26) at 3 years of age. Maternal feeding restriction was also associated with greater odds of a child being at risk of overweight (OR: 1.69; 95% CI: 1.02 to 2.82) at 3 years of age.

In multivariate analyses adjusted for potential confounders, each 3-month increment in breastfeeding duration was associated with a reduction of 0.045 BMI z -score units (95% CI: -0.088 to -0.002). After adjusting for mothers' feeding restriction, the estimate (CI) was -0.039 (-0.082 to 0.005), a 13% attenuation. Evaluation of the sum of subscapular and triceps skinfold thicknesses and odds of overweight as outcomes gave similar results (Table 3). Receiving no infant formula feeding during the first 6 months of life and receiving mixed breast milk and formula at 6 months' postpartum were associated with a reduction in the BMI z score and the sum of subscapular and triceps skinfold thicknesses (Table 4). After adjusting for covariates, no infant formula feeding during the first 6 months of life was also associated with much lower odds of being overweight at 3 years of age (OR: 0.33; 95% CI: 0.13 to 0.84) than for infants who had been formula fed since birth or who had been weaned from breast milk to formula by 6 months' postpartum. Attenuation with restriction had little effect once we adjusted for covariates. We observed a greater attenuating effect of restriction on no infant formula feeders during the first 6 months of life than on mixed breast milk and formula feeders. For example, adjustment for maternal feeding restriction attenuated the estimates for no infant formula feeders and BMI z score by 11% (estimate: -0.18 before adjustment for restriction; estimate: -0.16 after adjustment for restriction) but did not attenuate the estimates for mixed breast milk and formula feeders (Table 4).

DISCUSSION

In this study, we found that breastfeeding duration was associated with a reduction in BMI z score and the sum of subscapular and triceps skinfold thicknesses at 3 years of age. We also found that receiving no infant formula feeding since birth was associated with decreased odds of overweight at 3 years of age. Maternal feeding restriction, measured at age 1, was independently associated with a higher BMI z score at 3 years of age. However, maternal feeding restriction only minimally attenuated the association between breastfeeding and our anthropometric outcomes at 3 years of age.

Several factors may explain the small magnitude of the mediating effect of restriction that we observed. First, we measured maternal feeding restriction by using only 1 question from the CFQ. Although we confirmed the value of this question through factor analysis, the gold standard included 8 questions,²⁶ and measuring this domain imprecisely could have underestimated the attenuation. Second, breastfeeding may work through other behavioral mechanisms to prevent overweight; mothers who breastfeed may exert less pressure on their children to eat in the absence of hunger. In a previous analysis of this cohort, however, breastfeeding was not associated with mothers' pressuring their infant's to eat,²¹ and a recent review suggests that maternal feeding restriction is the only feeding domain related to future weight status.¹⁹ Our findings that maternal feeding restriction during the first year of life was associated with higher BMI z scores, overweight prevalence, and subscapular plus triceps skinfold thicknesses among children at 3 years of age are consistent with the conclusions of that review.¹⁹ Third, it is possible that metabolic influences of breast milk, such as higher levels of insulin and leptin, may be more important in protecting against future overweight than behavioral influences.^{27,28} Fourth, formula feeding may teach an infant to ignore normal cues of satiety.

Our findings that prolonged breastfeeding during the first year of life was associated with lower BMI and overweight prevalence among preschool age children are supported in the literature.^{2,3,6,29} However, only 1 previous study among children 0 to 6 years of age has examined anthropometric data other than height and weight, namely subscapular and triceps skinfolds. In a study of 6-year-old German children ($n = 480$), Bergmann et al⁶ showed that children who were breastfed ≥ 3 months had lower odds than children who were breastfed for <3 months of having subscapular and triceps skinfold thicknesses ≥ 97 th percentile. In our study, we found that associations with skinfold thicknesses mirrored the associations with BMI z scores, providing assurance that observed effects of breastfeeding were on adiposity per se, not just body size. We also observed markedly lower odds of overweight prevalence among infants who had not been fed any formula in the first 6 months of life. Our estimates are much lower than those previously shown for exclusive or predominant breastfeeding in the literature^{1,2,5,30} and may reflect differences in our study cohort compared with those of other populations studied, ie, sociodemographic characteristics.

When interpreting our study, several limitations should be considered. First, although mothers in the study had diverse racial/ethnic backgrounds, their educational and income levels were relatively high. Previous studies have found that women of higher socioeconomic status are more likely to breastfeed for longer periods of time³¹ and less

likely to restrict their children's food intake.²¹ Moreover, racial/ethnic minorities and children of lower socioeconomic position have particularly high rates of obesity in childhood and beyond.³² Thus, it is possible that there may be residual confounding by shared cultural determinants of breastfeeding, maternal feeding restriction, and obesity that we were unable to measure. Our results may not be generalizable to more socioeconomically disadvantaged populations. However, the narrow socioeconomic range may also act to remove confounding by socioeconomic status. Additional studies of breastfeeding, maternal restriction, and overweight are needed among a low-income, minority population. Strengths of this study include a well-characterized cohort with control for a large set of potential confounding variables of the relationship between breastfeeding and overweight, most importantly parental obesity, socioeconomic status, and maternal smoking, thereby reducing the chance of residual confounding.

CONCLUSIONS

Our findings suggest that decreased maternal feeding restriction may be in the intermediate pathway between breastfeeding and overweight but is not the primary mechanism by which breastfeeding protects against future overweight. Additional studies are needed to evaluate plausible mechanisms, including behavioral and metabolic effects. In the meantime, our findings suggest that continued promotion and support of breastfeeding could help to attenuate the rising prevalence of overweight in the United States and elsewhere. Implications of our results would also be that strategies to promote infant self-regulation of energy intake and encourage parental feeding styles that are less restrictive might decrease children's risk of later overweight.

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Abbreviations

OR	odds ratio
CI	confidence interval
CFQ	Child Feeding Questionnaire

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FIGURE 1.

Relationship between breastfeeding duration and BMI z score with and without adjusting for restriction. The circles and lines represent the BMI z -score unit and 95% confidence limits for each category of breastfeeding duration, unadjusted, and the squares represent the BMI z -score unit after adjustment for maternal restriction.

TABLE 1

Maternal and Infant Characteristics of 1012 Mother-Infant Pairs Participating in Project Viva

Characteristic	
Maternal age, mean (SD), y	32.7 (4.8)
Maternal prepregnancy BMI, mean (SD), kg/m ²	24.3 (4.8)
Paternal BMI, mean (SD), kg/m ²	26.4 (3.8)
Infant's birth weight, mean (SD), kg	3.53 (0.51)
BMI z score at 3 y (unit), mean (SD)	0.47 (1.0)
Subscapular + triceps skinfolds, mean (SD), mm	16.8 (4.2)
Maternal restriction ("I have to be careful not to feed my child too much"), %	
Agree	12
Disagree	88
Child's BMI at 3 y %	
<5th percentile	2
5th–84th percentile	71
85th–94th percentile	18
95th percentile	9
Child's gender, %	
Male	50
Female	50
Household income, %	
Do not know or missing data	5
At least \$40 000	10
More than \$40 000	85
Education, %	
Some college or less	26
College graduate or more	74
Parity, %	
0 previous births	49
1 previous births	51
Race/ethnicity %	
White	77
Black	10
Hispanic	5
Other	8
Maternal smoking status, %	
Never smoked	68
Former smoker, quit before pregnancy	22
Smoked during early pregnancy	9

TABLE 2

Mean BMI z Score and Subscapular + Triceps Skinfold Thicknesses and Prevalence of Overweight at 3 Years of Age According to Breastfeeding Duration and Type

	<i>n</i>	BMI z Score, Mean (SD)	Subscapular + Triceps, mm	Overweight, %
Breastfeeding, mo				
Never or <1	174	0.65 (1.08)	17.8 (4.89)	14
1–3	156	0.63 (1.00)	16.9 (4.25)	10
4–6	199	0.45 (1.05)	16.6 (4.05)	9
7–9	127	0.37 (1.00)	17.1 (4.57)	11
10–11	72	0.37 (1.01)	16.2 (3.79)	6
12	284	0.35 (0.94)	16.1 (3.77)	5
Type of infant feeding at 6 mo				
Formula feeding only since birth	98	0.64 (1.16)	18.0 (5.22)	13
Weaned from breast milk to formula	401	0.60 (0.97)	17.1 (4.16)	11
Mixed breast milk and formula feeding	246	0.31 (1.10)	16.2 (4.07)	10
No infant formula feeding since birth	243	0.32 (0.88)	16.2 (3.56)	3

Data from 1012 mother-infant pairs participating in Project Viva.

TABLE 3

Multivariable Adjusted Anthropometric Estimates at 3 Years of Age According to Breastfeeding Duration, With and Without Adjustment for Maternal Restriction

Breastfeeding Duration (Effect per 3-mo Increment)	Regression Estimate (95% CI)		BMI 95th Percentile, OR (95% CI) ^b
	BMI z Score	Subscapular + Triceps Skinfolts (mm) ^a	
Model 1: Crude	−0.082 (−0.12 to −0.040)	−0.35 (−0.53 to −0.18)	0.80 (0.69 to 0.93)
Model 2: Model 1 + covariates ^c	−0.045 (−0.088 to −0.002)	−0.24 (−0.42 to −0.056)	0.91 (0.76 to 1.08)
Model 3: Model 2 + restriction	−0.039 (−0.082 to 0.005)	−0.22 (−0.41 to −0.033)	0.93 (0.78 to 1.11)

Data are from linear and logistic regression analyses of 1012 mother-infant pairs participating in Project Viva.

^a All models predicting subscapular + triceps skinfold thicknesses were adjusted for child's age and gender.

^b Referent group includes children with a BMI between the 5th and 84th percentiles.

^c Model 2 adjusted for child age, birth weight, and gender, paternal BMI, and maternal age, race/ethnicity, education, income, parity, prepregnancy BMI, and smoking history.

TABLE 4

Multivariable Adjusted Anthropometric Estimates at 3 Years of Age According to Type of Infant Feeding at 6 Months, With and Without Adjustment For Maternal Restriction

Type of Infant Feeding at 6 Mo	Regression Estimate (95% CI)		BMI 95th Percentile, OR (95% CI) ^b
	BMI z Score	Subscapular + Triceps Skinfolts, mm ^a	
Model 1: crude			
Weaned/formula feeding only	0 (ref)	0 (ref)	1.00 (Ref)
Mixed breast milk and formula feeding	-0.30 (-0.46 to -0.15)	-1.02 (-1.65 to -0.39)	0.80 (0.47 to 1.34)
No infant formula feeding since birth	-0.29 (-0.44 to -0.13)	-1.00 (-1.64 to -0.37)	0.23 (0.10 to 0.51)
Model 2: model 1 + covariates ^c			
Weaned/formula feeding only	0 (ref)	0 (ref)	1.00 (Ref)
Mixed breast milk and formula feeding	-0.22 (-0.37 to -0.07)	-0.90 (-1.53 to -0.26)	1.15 (0.64 to 2.09)
No infant formula feeding since birth	-0.18 (-0.33 to -0.02)	-0.67 (-1.34 to 0.004)	0.33 (0.13 to 0.84)
Model 3: model 2 + restriction			
Weaned/formula feeding only	0 (ref)	0 (ref)	1.00 (Ref)
Mixed breast milk and formula feeding	-0.22 (-0.37 to -0.06)	-0.87 (-1.51 to -0.23)	1.17 (0.65 to 2.13)
No infant formula feeding since birth	-0.16 (-0.32 to -0.002)	-0.62 (-1.30 to 0.05)	0.34 (0.14 to 0.87)

Data are from linear and logistic regression analyses of 1012 mother-infant pairs in Project Viva

^a All models predicting subscapular + triceps skinfold thicknesses are adjusted for child's age and gender.

^b Referent group includes children with a BMI between the 5th and 84th percentiles.

^c Model 2 adjusted for child age, birth weight and gender, paternal BMI, and maternal age, race/ethnicity, education, income, parity, prepregnancy BMI, and smoking history.