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PEDIATRIC HIGHLIGHT

A longitudinal study of infant feeding and obesity throughout life course

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Background: The Centers for Disease Control and Prevention and the US Department of Health and Human Services promote breastfeeding as a strategy for reducing childhood overweight. We evaluated the relation between infant feeding and the development of overweight and obesity throughout life course.
Methods: We investigated the association between infant feeding and obesity among 35 526 participants in the Nurses' Health Study II who were followed prospectively from 1989 to 2001. Mothers of participants provided information by mailed questionnaires on the duration of breast- and bottle-feeding, as well as the type of milk or milk substitute in the bottle. Information on body shape at ages 5 and 10, weight at age 18, current weight between 1989 and 2001, and height was reported by the participants.
Results: The duration of breastfeeding, including exclusive breastfeeding, was not related to being overweight ($25 \leqslant$ body mass index (BMI) $< 30\,kg/m^2$) or obese (BMI $\geqslant 30\,kg/m^2$) during adult life. Women who were exclusively breastfed for more than 6 months had a risk of 0.94 (95% confidence interval (CI) 0.83–1.07) of becoming obese as adults compared with women who were not breastfed. Exclusive breastfeeding for more than 6 months was associated with leaner body shape at age 5 (odds ratio (OR) = 0.81; 95% CI 0.65–1.01 for the highest vs the lowest category of body shape) compared to women who were not breastfed or breastfed for less than 1 week, but this association did not persist during adolescence or adulthood.
Conclusions: We did not find that having been breastfed was associated with women's likelihood of becoming overweight or obese throughout life course. Although breastfeeding promotes the health of mother and child, it is unlikely to play an important role in controlling the obesity epidemic.
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Keywords: overweight; infant feeding; breastfeeding; infant formula

Introduction

The Centers for Disease Control and Prevention promote breastfeeding as a strategy for reducing childhood overweight. [1] The US Department of Health and Human Services sponsors an advertisement campaign encouraging women to breastfeed their baby for 6 months to 'reduce the child's risk for childhood obesity'.[2] An association between having been breastfed as an infant and a lower risk of childhood obesity has been suggested in numerous epidemiologic studies and several meta-analyses summarizing the evidence have recently been reported.[3,4]

Breastfed infants gain weight more slowly during the first year of life than formula-fed infants, probably due to the natural limitations of available energy supply.[5] Reports have been ambiguous whether this early growth difference translates into differences in growth and body mass in subsequent years of life.[6] Breast milk is lower in protein than infant formula, which may affect growth.[7] Formula-fed infants have higher plasma-insulin concentrations, possibly resulting in increased insulin resistance[8] and affecting

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programming of insulin metabolism.[9] Formula-fed infants also have higher levels of insulin-like growth factor I.[10] Breastfeeding is more common among families of higher socioeconomic status (SES) and has been for the past several decades.[11–13] Other factors associated with higher SES also decrease childhood obesity, and whether breastfeeding affects the incidence of obesity in childhood independently of other lifestyle factors is not entirely clear. In a recent sibling study, which inherently controlled for SES, no association was found between having been breastfed and being overweight as an adolescent. In an analysis ignoring sibship, however, the previously reported inverse association with duration of breastfeeding was confirmed.[14]

Whether any effect of breastfeeding on body mass in childhood translates to life remains to be examined. Although overweight children tend to become obese adults,[15,16] few studies have directly addressed the relation between infant feeding and body weight. We therefore studied the association between infant feeding and obesity throughout life course among 35 526 participants of the Nurses' Health Study II (NHS II) whose mothers provided information on infant feeding.

Methods

Study population

The NHS II is a prospective cohort of 116 678 female registered nurses aged 25–42 years in 1989 and living in one of 14 US states. Participants are predominantly Caucasian white. In 1989, we mailed a four-page questionnaire about various demographic and lifestyle factors, anthropometric variables including weight at age 18, and prevalent disease. Follow-up questionnaires were sent to study participants every 2 years updating information on lifestyle and anthropometric factors. In March 2001, participants in the NHS and in NHS II who were alive and free of cancer were sent letters asking about the health status of their mothers, whether the nurse would be willing to have her mother participate in the Nurses' Mothers' Cohort Study, and if so to provide the mother's address. If the nurse agreed and her mother was able to participate, the mother was sent a questionnaire and a prepaid return envelope. A total of 52 155 Mothers' Questionnaires were mailed in 2001 and 2002. Overall, 39 904 (76.5%) completed questionnaires were returned to us. Approximately 90% of the mothers have nurse daughters in NHSII, whereas the remaining 10% are mothers of NHS members. For the present analysis, we restricted the Maternal Cohort population to participants in NHS II ($n = 35\,830$) for ease of computation. NHS II and the Mothers' Cohort were linked, providing data on the entire lifespan of the nurse from conception to adult life, with repeatedly assessed information on adult life variables. NHS II participants who were adopted were excluded from this analysis. The population for this analysis was 96% Caucasian white.

Assessment of infant feeding

Participants in the Nurses' Mothers' Cohort Study were asked whether they ever breastfed their nurse daughter and if so the age of the nurse daughter when breastfeeding ended. Mothers were also asked whether they ever fed the nurse daughter infant formula or evaporated milk and if so, the ages of introduction and duration, as well as the ages of introduction of solid food and cow's milk. Exclusive breastfeeding was defined as not supplementing with formula, evaporated milk or solid food. Duration of exclusive and partial breastfeeding was calculated using the information on breastfeeding and supplemental feeding. A total of 66 participants were missing information on infant feeding.

Assessment of body mass index

Participants in the NHS II were asked in 1989 to report their height, their current weight and their weight at age 18. Information on current weight was updated on biennial questionnaires. Body mass index (BMI) was calculated as weight divided by the square of height (kg/m^2). The validity of recalled weight at age 18 and self-reported current height was examined among 118 participants of NHS II using records from physical examinations conducted at college or nursing school entrance.[17] The correlation between recalled and measured past weight was 0.87 and between reported current height and measured past height was 0.94. Mean BMI values were 21.6 kg/m^2 for BMI calculated using recalled weight and were 22.1 kg/m^2 using weight from medical records; the correlation was 0.84. Overall, the validity of recalled weight at 18 years of age and self-reported height appears to be high among women in this cohort. Participants of the Nurses' Health Study were also asked about their current weight. The self-reports were validated in a subsample of participants.[18] Self-reported weight data were compared with standardized measurements taken approximately 6 months apart by technicians who visited participants at their homes. The correlation between self-reported and measured weights was 0.97.

NHS II participants were also asked to recall their body shape at ages 5 and 10 using a nine-level figure drawing (Figure 1) originally developed by Stunkard.[19] Must *et al*.[20] evaluated the validity of remote recall of body fatness among 181 participants in the Third Harvard Growth Study, a Boston-area longitudinal study of physical and mental growth in children that was conducted between 1922 and 1935.Height and weight were measured as part of annual examinations during childhood and adolescence and were used to calculate BMI in kilograms per meters squared (kg/m^2). In 1988 and 1989, when participants were between ages 71 and 76, they were interviewed again and asked to recall their body fatness at ages 5, 10, 15 and 20, using the same 9-level

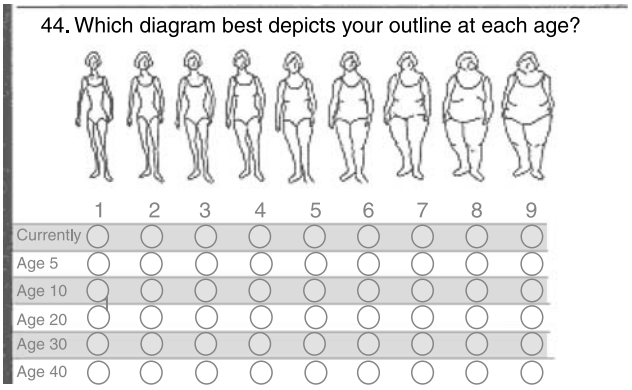

Figure 1 Nine-level figure drawing used to assess body fatness at different ages among NHS II participants.

figure drawing as on the 1989 NHS II questionnaire. Pearson correlations between recalled body fatness and BMI at approximately the same ages were 0.60 for age 5, and 0.70 for age 10. Other studies had similar findings,[21–23] indicating that, although imperfect, these figure drawings can provide useful information on body fatness at young ages.

Assessment of covariates

Information on covariates was obtained from the mother as well as the nurse daughter. The Mothers' questionnaire included items on the birthweight and gestational age of the daughter, the mother's prepregnancy weight and weight gain during pregnancy, maternal smoking during pregnancy, mother's and father's education and occupation, and parents' homeownership at the time of the nurse daughter's birth. From the NHS II questionnaires, we used information on age of the nurse, age at menarche, parity of the nurse, age at first birth, nurse's smoking status, physical activity, alcohol consumption, energy intake, menopausal status, husband's education and household income; information was updated during follow-up with data from each biennial questionnaire.

Statistical analysis

Follow-up for our analysis started in 1989, when participants first reported their adult height and weight, and ended in 2001. Women for whom no breastfeeding information was reported by their mother were excluded from the analyses ($n=66$). Women who did not report height or weight in 1989 were excluded from the analyses on adult BMI ($n=190$). Time periods during which participants were pregnant were skipped during follow-up. BMI was categorized as normal weight ($<25\,kg/m^2$), overweight (25–29.9 kg/m^2) and obese ($30+\,kg/m^2$). We used polytomous logistic regression to obtain odds ratios (ORs) for being overweight or obese relative to being normal weight in 2001, depending on having been breastfed as an infant. Information on infant feeding was coded as (1) having been breastfed for at least 1 week vs having never been breastfed or breastfed for less than 1 week, (2) duration of any breastfeeding (1 week–3 months, 3–6 months, 6–9 months, 9–12 months, one year or more) and (3) duration of exclusive breastfeeding (1 week–3 months, 3–6 months, 6 months or more). A test for trend using midpoints of intervals was calculated for the categories of duration of breastfeeding and duration of exclusive breastfeeding. Statistical models were age-adjusted (in 1-year intervals) and included potential predictors of obesity during early and adult life: year of birth of the nurse (<1952, 1952–1957, 1958–1964), birthweight (<2500, 2500–2999, 3000–3499, 3500–3999, >4000 g), gestational age (<38, 38–42, 43+ weeks), mother's prepregnancy weight (quintiles) and weight gain during pregnancy (<14, 15–19, 20–29, 30–39, 40+ lb), maternal smoking during pregnancy (binary), mother's and father's education (<4 years high school, 4 years high school, 1–3 years college, 4+ years college) and occupation during the nurse's infancy and childhood, parents' homeownership at the time of the nurse daughter's birth (binary); the nurse's age at menarche (<11, 12, 13, 14, 15+ years), parity of the nurse (0, 1, 2, 3, 4+), age at first birth (<25, 25–30, 30+ years), nurse's smoking (0, 1–5, 6–10, 11–15, 16–20, 20+ pack-years), physical activity (quintiles of metabolic equivalents (METS) per week), alcohol consumption (none, 0.1–5, 5.1–10, >10 g/day), energy intake (quintiles), menopausal status (premenopausal, postmenopausal), husband's education (<high school, high school, 2 years college, 4 years college, postgraduate) and household income (<15 000; 15 000–19 000; 20 000–29 000; 30 000–39 000; 40 000–49 000; 50 000–74 000; 75 000–99 000; 100 000–149 000; 150 000+ dollars). For the analysis using BMI in 2001, the value of the covariates reported on the questionnaire most recently preceding 2001 was used.

We also addressed the question whether infant feeding affected body size assessed repeatedly throughout follow-up. We used a polytomous general estimation equations (GEE) model to regress repeatedly assessed BMI between 1989 and 2001 categorized as normal weight, overweight and obese on infant feeding history. Covariate information assessed during follow-up was updated in the analyses.

BMI at age 18 was also classified as normal ($<25\,kg/m^2$), overweight (25–29.9 kg/m^2) and obese ($30+\,kg/m^2$) and regressed on infant feeding using a polytomous logistic regression model. Covariate information was used from the baseline questionnaire in 1989.

The relation between infant feeding and body shape at ages 5 and 10 was analyzed using a polytomous logistic regression model. Participants who did not report their body fatness at one of these ages were excluded for the relevant analyses. Because few participants recalled their body fatness as greater than level 5 at ages 5 and 10, figures 5–9 were combined into a single category.

All *P*-values are two-sided.

Results

In our study population, 41% of women were breastfed whereas 59% were not breastfed or were breastfed for less than 1 week. Overall, 43.5% of nurse participants were fed evaporated milk, 34.6% within the first 3 months, 41.1% received commercial infant formula, 33.1% within the first 3 months, 5.5% were given cow's milk within the first 3 months and 3.2% were fed soy milk. The mean BMI in 2001 was 26.4, the median BMI in 2001 was 24.9, and the 5th and 95th percentile of the BMI distribution in 2001 were at 19.6 and 38.8, respectively. The mean BMI at age 18 was 21.1, the median 20.5 and the 5th and 95th percentile of the BMI distribution at age 18 were 17.5 and 27.1, respectively.

Nurse participants who were breastfed had a mean age of 40.5 during the follow-up period 1989–2001, whereas the mean age of women who had been bottle-fed in infancy was 39.3 years. Women who were breastfed had a slightly higher birthweight, their mother was less likely to have smoked during her pregnancy with the nurse, and both parents were more educated but somewhat less likely to own a home at the time the nurse was born than women who were bottle-fed exclusively (Table 1). Nurses who were breastfed were somewhat less likely to be nulliparous than their colleagues who were bottle-fed.

Table 1 Age-standardized characteristics of daughters of the Nurses' Mothers' Cohort according to breastfeeding history in infancy (1989–2001)

	Breastfed	*Not breastfed*[b]
Total N	14 449	21 077
Age (years)	40.5	39.3
Information from Mothers' Questionnaire		
Birthweight (g)	3324	3263
Gestational age (weeks)	39.9	39.7
Prepregnancy weight of mother (lbs)	125.7	124.9
Mother's prepregnancy BMI	21.3	21.3
Maternal weight gain during pregnancy (%)[a]		
<14 lb		
15–19 lb	13	13.9
20–29 lb	19.1	19.2
30–39 lb	38.5	38.5
40 lb	16.2	15.7
	4.7	5.2
Maternal smoking during pregnancy (%)	22	29
Mother's education (%)[a]		
<4 years high school	13.2	13.7
4 years high school	43.5	54
1–3 years college	29.2	23.4
4 years college +	13.8	8.5
Father's education (%)[a]		
< 4 years high school	17.3	18.1
4 years high school	32.8	39.4
1–3 years college	19.8	19
4 years college +	26.3	18.8
Mother's occupation (%)[a]		
Executive, teacher	3.9	2.5
Nurse	8.6	5.2
Sales, crafts worker	1.6	1.8
Machinist, farming	4.3	4
Service, laborer	1.4	1.7
Homemaker	54.2	56.2
Did not work	10.9	11.9
Father's occupation (%)[a]		
Executive, lawyer	31.8	26.4
Sales, mechanic	30.2	33.6
Machinist, farming	18.8	18.7
Laborer, military	12.7	14
Did not work	0.4	0.4
Parents owned home at time of birth (%)	45.1	48

Table 1 (*Continued*)

	Breastfed	*Not breastfed*[b]
Information from Nurses' Questionnaire		
Age at menarche (%)[a]		
<11 years	7	7.1
11 years	15.9	16.5
12 years	30.3	30.5
13 years	28.2	27.5
14 years	10.7	10.7
15+ years	7.5	7.3
Nulliparous (%)[c]	22.5	24.2
Number of children (among parous women)[c]	1.8	1.7
Age at first birth (among parous women) (years)	26.2	26.4
Physical activity (METS/week)[c]	19.7	21
Alcohol consumption (g/day)[c]	3.5	3.6
Alcohol consumption (%)[c]	57.5	60.4
Alcohol consumption among drinkers only (g/day)[c]	6.1	5.9
Pack-years of smoking[c]	3.4	3.9
Smoker (%)[c]	30.1	33.2
Pack-years smoked by smokers[c]	11.15	11.46
Daily energy intake[c]	1831	1799
Menopausal status (%)[a,c]		
Premenopausal	91	91
Postmenopausal	6	6
Husbands education (%)[a]		
<high school	0.6	0.5
High school	14.4	15.9
2 years college	16.9	16.6
4 years college	27.7	27.5
>college	28.4	27.1
Income in 2001 (%)[a]		
<30 000	2.3	2.3
30 000–49 000	11.4	10.5
50 000–74 000	23.5	22.1
75 000–99 000	17.8	17.9
100 000–149 000	18.3	18.8
150 000+	10.1	10.1

Abbreviation: BMI, body mass index. Means unless indicated otherwise. [a]Percent do not add up to 100 due to missing values [b]Not breastfed or breastfed for less than 1 week [c]Average values during follow-up between 1989 and 2001.

Table 2 Breastfeeding history in infancy and risk of adult overweight or obesity among daughters of the Nurses' Mothers' Cohort, in 2001

Breastfeeding	*BMI < 25*	*Being overweight (25 ⩽ BMI < 30 kg/m²)*			*Being obese (BMI ⩾ 30 kg/m²)*		
	No. of women	*No. of women*	*Age-adjusted OR*	*Covariate-adjusted OR*	*No. of women*	*Age-adjusted OR*	*Covariate-adjusted OR*
Ever breastfed							
No or <1 week	10877	5498	1	1	4559	1	1
Yes	7287	3884	1.01 (0.96–1.06)	1.02 (0.97–1.08)	3188	0.99 (0.94–1.04)	1.01 (0.95–1.07)
1 week-3 months	3399	1824	1.01 (0.95–1.08)	1.02 (0.96–1.10)	1537	1.02 (0.95–1.09)	1.03 (0.96–1.12)
3–6 months	1872	1014	1.05 (0.96–1.14)	1.08 (0.99–1.18)	750	0.93 (0.85–1.02)	1.01 (0.91–1.11)
6–9 months	1159	567	0.93 (0.84–1.03)	0.93 (0.84–1.04)	513	1.00 (0.90–1.12)	0.99 (0.89–1.13)
>9 months	857	479	1.04 (0.92–1.17)	1.01 (0.90–1.14)	388	0.99 (0.88–1.13)	0.93 (0.81–1.06)
P for trend			0.92	0.95		0.6	0.38
Exclusively breastfed							
No or <1 week	13810	7097	1	1	5875	1	1
1 week-3 months	2131	1104	0.99 (0.91–1.07)	1.01 (0.93–1.10)	859	0.92 (0.85–1.00)	0.98 (0.89–1.08)
3–6 months	1274	663	0.98 (0.89–1.09)	0.99 (0.90–1.10)	570	1.01 (0.91–1.13)	1.03 (0.92–1.16)
>6 months	949	518	1.01 (0.90–1.13)	0.98 (0.87–1.10)	443	1.03 (0.92–1.16)	0.94 (0.83–1.07)
P for trend			0.95	0.75		0.75	0.63

Abbreviations: BMI, body mass index; OR, odds ratio. Adjusted for age of the nurse at return of questionnaire, year of birth of the nurse, maternal prepregnancy weight, maternal weight gain during pregnancy, birthweight of the nurse, gestational age of the nurse, mother's education, father's education, mother's occupation, father's occupation, home ownership of parents at time of nurse daughter's birth, age of nurse at menarche, parity of nurse, nurse's age at first birth, nurse's physical activity, alcohol consumption, smoking habits, daily energy intake, menopausal status of nurse, income of nurse, and nurse's husband's education.

Table 3 Breastfeeding history in infancy and risk of being overweight or obese at age 18 among daughters of the Nurses' Mothers' Cohort

Breastfeeding	*BMI < 25*	*Being overweight (25 ⩽ BMI < 30 kg/m²)*			*Being obese (BMI ⩾ 30 kg/m²)*		
	No. of women	*No. of women*	*Age-adjusted OR*	*Covariate-adjusted OR*	*No. of women*	*Age-adjusted OR*	*Covariate-adjusted OR*
Ever breastfed							
No or < 1 week	19010	1474	1	1	482	1	1
Yes	13050	1033	1.02	1.02	286	0.89	0.92
1 week-3 months	6153	484	1.01 (0.91–1.12)	1.01 (0.91–1.13)	130	0.86 (0.71–1.05)	0.88 (0.73–1.09)
3–6 months	3313	245	0.95 (0.83–1.09)	0.97 (0.84–1.12)	76	0.92 (0.72–1.17)	0.99 (0.77–1.27)
6–9 months	2034	165	1.04 (0.88–1.23)	1.05 (0.88–1.25)	39	0.78 (0.56–1.08)	0.82 (0.58–1.14)
>9 months	1550	139	1.15 (0.96–1.38)	1.09 (0.90–1.32)	41	1.09 (0.79–1.51)	1.04 (0.74–1.44)
P for trend			0.27	0.42		0.63	0.74
Exclusively breastfed							
No or < 1 week	24340	1898	1	1	590	1	1
1 week-3 months	3725	270	0.93 (0.81–1.06)	0.95 (0.83–1.09)	90	1.01 (0.81–1.27)	1.09 (0.87–1.37)
3–6 months	2278	182	1.02 (0.87–1.19)	1.01 (0.82–1.18)	46	0.85 (0.63–1.15)	0.86 (0.63–1.17)
>6 months	1717	157	1.16 (0.98–1.38)	1.12 (0.94–1.33)	42	1.04 (0.76–1.44)	1.01 (0.73–1.39)
P for trend			0.16	0.35		0.76	0.72

Abbreviations: BMI, body mass index; OR, odds ratio. Adjusted for age of the nurse at return of questionnaire, year of birth of the nurse, maternal pre-pregnancy weight, maternal weight gain during pregnancy, birthweight of the nurse, gestational age of the nurse, mother's education, father's education, mother's occupation, father's occupation, home ownership of parents at time of nurse daughter's birth, age of nurse at menarche, parity of nurse, nurse's age at first birth, nurse's physical activity, and daily energy intake.

A history of breastfeeding in infancy was not associated with becoming overweight or obese as an adult in either age- or covariate-adjusted analyses (Table 2). Women who were breastfed for at least a week had a risk of being overweight or obese in 2001 similar to that of participants who were bottle-fed. Duration of breastfeeding did not influence adult BMI; women who were breastfed for more than 9 months had a risk of becoming overweight or obese similar to that of women who were breastfed for less than 1 week or exclusively bottle-fed. Having been exclusively breast-fed, even for more than 6 months, similarly did not affect the risk of becoming overweight or obese compared with having been bottle-fed (Table 2). Adjustment for predictors of adult obesity did not modify these results. Results were similar when a GEE model was used to update information on body weight between 1989 and 2001 (data not shown). A lack of association between infant feeding and being overweight or obese at age 18 was also apparent (Table 3). Results were similar when we modeled current BMI or BMI at age 18 as a continuous dependent variable.

Table 4 Breastfeeding history in infancy and body shape at ages 5 and 10

Breastfeeding	*Body shape at age 5 Highest vs lowest category*				*Body shape at age 10 Highest vs lowest category*			
	No. of women with body shape 1[a]	*No. of women with body shape 5+*[a]	*Age-adjusted OR (95% CI)*	*Covariate-adjusted OR (95% CI)*[b]	*No. of women with body shape 1*[a]	*No. of women with body shape 5+*[a]	*Age-adjusted OR (95% CI)*	*Covariate-adjusted OR (95% CI)*[b]
Ever breastfed								
No or < 1 week	4776	1355	1	1	3686	2345	1	1
Yes	3011	861	1.00 (0.91–1.10)	0.94 (0.85–1.04)	2371	1626	1.07 (0.99–1.17)	1.03 (0.94–1.12)
1 week – 3 months	1430	425	1.04 (0.91–1.17)	0.99 (0.87–1.12)	1122	778	1.08 (0.98–1.21)	1.05 (0.94–1.17)
3–6 months	755	216	1.01 (0.85–1.18)	0.95 (0.81–1.12)	587	421	1.13 (0.98–1.29)	1.08 (0.94–1.24)
6–9 months	446	120	0.94 (0.76–1.16)	0.88 (0.71–1.09)	361	225	0.98 (0.82–1.16)	0.92 (0.78–1.11)
>9 months	380	100	0.92 (0.73–1.15)	0.84 (0.66–1.06)	301	202	1.05 (0.87–1.27)	0.97 (0.81–1.18)
P for trend			0.39	0.06			0.49	0.75
Exclusively breastfed								
No or < 1 week	6012	1708	1	1	4685	3009	1	1
1 week – 3 months	851	254	1.05 (0.90–1.22)	1.00 (0.86–1.16)	659	463	1.09 (0.96–1.24)	1.05 (0.92–1.20)
3–6 months	499	148	1.04 (0.86–1.26)	0.98 (0.81–1.19)	387	292	1.17 (1.00–1.37)	1.12 (0.95–1.31)
>6 months	425	106	0.87 (0.70–1.08)	0.81 (0.65–1.01)	326	207	0.98 (0.82–1.18)	0.93 (0.77–1.11)
P for trend			0.44	0.1			0.32	0.92

Abbreviations: CI, cofidence interval; OR, odds ratio. [a]Participants who did not report their body shape where excluded. [b]Adjusted for age at return of questionnaire, year of birth, maternal pre-pregnancy weight, maternal weight gain during pregnancy, birthweight, gestational age, mother's education, father's education mother's occupation, father's occupation, and home ownership.

Infant feeding history was not related to self-reported body shape at ages 5 and 10 (Table 4), except that longer durations of breastfeeding were slightly inversely related to body shape at age 5 in covariate-adjusted analyses (*P* for trend = 0.06), but not at age 10 (Table 4). Similarly, exclusive breastfeeding for more than 6 months was associated with a reduced risk of being in the highest body shape category at age 5, but the association was of borderline statistical significance and no significant trend was apparent (covariate-adjusted OR = 0.81; 95% confidence interval (CI) 0.65–1.01) (Table 4). No such associations were observed for body shapes at age 10.

Results did not differ when analyses were restricted to nurses who were an only child (data not shown).

Discussion

In this large observational cohort study of mostly premenopausal women, infant feeding was not associated with BMI at any age during adolescence or adulthood. Neither any nor exclusive breastfeeding predicted the likelihood of being overweight or obese later in life. Women who were breastfed for several months had a slightly lower risk of being overweight during early childhood. The women in this cohort had mean and range of BMI values representative of the general US population in the same age group.

Few studies have considered the role of infant feeding for adult obesity. In two early studies, breastfeeding experience in the first half of the twentieth century and its relation with obesity among adults in their 20s and 30s was considered.[15,24] In a retrospective study including 366 individuals in the USA, having been breastfed was not related to being overweight or obese at ages 20–30 years, where overweight was defined as being more than 10% above the median weight for height and age and obese as being more than 20% above.[15] Marmot *et al*.[24] in the UK found that men who were exclusively breastfed during the first 5 months of life were heavier in their 30s than men who were bottle-fed, but no difference was observed among women.In the 1958 British birth cohort, breastfeeding and BMI were unrelated in childhood, inversely related in unadjusted analyses at age 33, but no longer related after adjustment for confounding factors.[25] Since then, some studies relating infant feeding and adult body weight have been conducted in the UK, Amsterdam, Copenhagen, New Zealand and Brazil.[26–32] Studies were limited in size, and, although some found an association with infant or childhood weight, all but one found no association with BMI in adulthood. In the Caerphilly study, breastfeeding was associated with greater BMI than bottle feeding among men ages 45–59 years.[26] Our study is to date the largest study on infant feeding and obesity; among its strengths besides the large sample size are the availability of maternal reports of infant feeding and the repeated assessment of body mass throughout life course.

Results from studies on the relation between infant feeding and childhood weight have been equivocal.[3,4] In one meta-analysis including nine studies, the summary OR for being obese in childhood was 0.78 (95% CI 0.71–0.85) comparing breast-fed with formula-fed children.[3] Obesity was defined as a BMI ⩾90th, 95th or 97th percentile based on internal or national reference populations. In another

meta-analysis including 17 studies, the duration of breastfeeding was inversely related to the risk of overweight in childhood.[4] Having been breastfed for more than 9 months vs never having been breastfed was associated with an OR of being overweight as a child of 0.68 (95% CI 0.50–0.91). A meta-analysis of 28 published studies, breastfeeding was associated with a reduced risk of obesity compared with breastfeeding (OR = 0.87; 95% CI 0.85–0.89).[33] Among studies, that explored potential confounding by SES, paternal BMI and maternal smoking, the OR of 0.86 was reduced to 0.93 (95% CI 0.88–0.99) after combined adjustment. In the largest quantitative review to date of 36 published and unpublished observational studies, breastfeeding was associated with a slightly lower BMI than bottle-feeding (−0.04; 95% CI –0.05 to –0.02), but the difference vanished after adjustment for SES, maternal smoking during pregnancy and maternal BMI.[34] Confounding by lifestyle factors has to be considered as a possible explanation for the inverse association between having been breastfed and childhood overweight and obesity observed in several studies.

Infant feeding practices are substantially influenced by secular trends. During the first part of the twentieth century when evaporated milk and other cow's milk-based bottle-feeding was introduced, bottle feeding was a privilege mostly available to the wealthy and promoted as 'scientifically advanced' baby feeding by parents' magazines. Breastfeeding was at its lowest in 1970 and gradually became popular among non-hispanic white women with higher SES by the 1980s.[11] Few studies have were able to adjust for indicators of SES, and residual confounding is likely even in studies that attempted to capture differences in SES associated with infant feeding practices.

Time trends have also affected the content of bottle feed. Cow's milk was used in the earlier part of the previous century, evaporated milk was the primary alternative to breastfeeding in the 1950s, and prepared infant formula reached its peak use in 1970.[35,36] Similar proportions of our study participants who were bottle-fed were fed evaporated milk or commercial infant formula. Any change in association due to the difference in bottle content would be difficult to disentangle from cohort effects due to other environmental or behavioral changes.

Evidence has been inconsistent about whether growth rates during the first year of life are related to overweight during subsequent years. In the present study we found that women who were breastfed reported being somewhat leaner at age 5, but any differences for bottle-fed infants did not persist in later childhood, adolescence or adulthood. Even if the association between infant feeding and body shape in early childhood is real, the effect does not appear to influence body weight throughout the life course. Conversely, although childhood obesity increases the risk for obesity in adulthood the correlation is imperfect which may explain differences in the association between infant feeding and childhood and adult BMI.

We were able to rely on maternal reports of breastfeeding, which are likely superior to self-reports.[37] Mothers were asked to recall several decades later how long they had breast fed their nurse daughters. Although this might introduce some random misclassification, events surrounding pregnancy and birth are special in a mother's life and likely to be recalled with good accuracy.[25] Approximately 20% of the mothers indicated that they kept a baby book for their nurse daughter and may have recorded breastfeeding information there. A mother who has one child may report her child's breastfeeding history more accurately than a mother who has several children; however, our results did not differ for nurses who were an only child from those who had siblings. Body shape during childhood and adolescence was recalled by the nurse herself and may have been influenced by current BMI. A major strength of our study was its large sample size and the repeated measure of BMI during adult life.

In this longitudinal study with maternal reports of infant feeding and repeated assessment of BMI, we did not find that being breastfed affected women's likelihood of becoming overweight or obese throughout the life course. Although breastfeeding promotes the health of mother[38] and child, it is unlikely to play an important role in controlling the obesity epidemic.

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References

1 Centers for Disease Control and Prevention. *Nutrition, Physical Activity, and Obesity Prevention Program* 2003. CDC, Atlanta.
2 US Department of Health and Human Services. www.woman.gov/breastfeeding/adcouncil/ice_cream.pdf.
3 Arenz S, Ruckerl R, Koletzko B, von Kries R. Breast-feeding and childhood obesity – a systematic review. *Int J Obes Relat Metab Disord* 2004; **28**: 1247–1256.
4 Harder T, Bergmann R, Kallischnigg G, Plagemann A. Duration of breastfeeding and risk of overweight: a meta-analysis. *Am J Epidemiol* 2005; **162**: 397–403.
5 Heinig MJ, Nommsen LA, Peerson JM, Lonnerdal B, Dewey KG. Energy and protein intakes of breast-fed and formula-fed infants during the first year of life and their association with growth velocity: the DARLING Study. *Am J Clin Nutr* 1993; **58**: 152–161.
6 Stettler N, Zemel BS, Kumanyika S, Stallings VA. Infant weight gain and childhood overweight status in a multicenter, cohort study. *Pediatrics* 2002; **109**: 194–199.
7 Whitehead RG. For how long is exclusive breast-feeding adequate to satisfy the dietary energy needs of the average young baby? *Pediatr Res* 1995; **37**: 239–243.
8 Lucas A, Sarson DL, Blackburn AM, Adrian TE, Aynsley-Green A, Bloom SR. Breast vsbottle: endocrine responses are different with formula feeding. *Lancet* 1980; **1**: 1267–1269.

9 Stocker CJ, Arch JR, Cawthorne MA. Fetal origins of insulin resistance and obesity. *Proc Nutr Soc* 2005; **64**: 143–151.
10 Chellakooty M, Juul A, Boisen KA, Damgaard IN, Kai CM, Schmidt IM *et al*. A prospective study of serum insulin-like growth factor I (IGF-I) and IGF-binding protein-3 in 942 healthy infants: associations with birth weight, gender, growth velocity, and breastfeeding. *J Clin Endocrinol Metab* 2006; **91**: 820–826.
11 Forman MR, Fetterly K, Graubard BI, Wooton KG. Exclusive breast-feeding of newborns among married women in the United States: the National Natality Surveys of 1969 and 1980. *Am J Clin Nutr* 1985; **42**: 864–869.
12 Ryan AS. The resurgence of breastfeeding in the United States. *Pediatrics* 1997; **99**: E12.
13 Ryan AS, Wenjun Z, Acosta A. Breastfeeding continues to increase into the new millennium. *Pediatrics* 2002; **110**: 1103–1109.
14 Nelson MC, Gordon-Larsen P, Adair LS. Are adolescents who were breast-fed less likely to be overweight? Analyses of sibling pairs to reduce confounding. *Epidemiology* 2005; **16**: 247–253.
15 Charney E, Goodman HC, McBride M, Lyon B, Pratt R. Childhood antecedents of adult obesity. Do chubby infants become obese adults? *N Engl J Med* 1976; **295**: 6–9.
16 Deshmukh-Taskar P, Nicklas TA, Morales M, Yang SJ, Zakeri I, Berenson GS. Tracking of overweight status from childhood to young adulthood: the Bogalusa Heart Study. *Eur J Clin Nutr* 2006; **60**: 48–57.
17 Tro LM, Hunter DJ, Manson JE, Colditz GA, Stampfer MJ, Willett WC. The validity of recalled weight among younger women. *Int J Obes Relat Metab Disord* 1995; **19**: 570–572.
18 Rimm EB, Stampfer MJ, Colditz GA, Chute CG, Litin LB, Willett WC. Validity of self-reported waist and hip circumferences in men and women. *Epidemiology* 1990; **1**: 466–473.
19 Stunkard AJ, Sorensen T, Schulsinger F. Use of the Danish Adoption Register for the study of obesity and thinness. *Res Publ Assoc Res Nerv Ment Dis* 1983; **60**: 115–120.
20 Must A, Willett WC, Dietz WH. Remote recall of childhood height, weight, and body build by elderly subjects. *Am J Epidemiol* 1993; **138**: 56–64.
21 Must A, Phillips SM, Naumova EN, Blum M, Harris S, Dawson-Hughes B *et al*. Recall of early menstrual history and menarcheal body size: after 30 years, how well do women remember? *Am J Epidemiol* 2002; **155**: 672–679.
22 Munoz KA, Ballard-Barbash R, Graubard B, Swanson CA, Schairer C, Kahle LL. Recall of body weight and body size estimation in women enrolled in the breast cancer detection and demonstration project (BCDDP). *Int J Obes Relat Metab Disord* 1996; **20**: 854–859.
23 Tehard B, van Liere MJ, Com Nougue C, Clavel-Chapelon F. Anthropometric measurements and body silhouette of women: validity and perception. *J Am Diet Assoc* 2002; **102**: 1779–1784.
24 Marmot MG, Page CM, Atkins E, Douglas JW. Effect of breast-feeding on plasma cholesterol and weight in young adults. *J Epidemiol Community Health* 1980; **34**: 164–167.
25 Parsons TJ, Power C, Manor O. Infant feeding and obesity through the lifecourse. *Arch Dis Child* 2003; **88**: 793–794.
26 Martin R, Ben-Shlomo Y, Gunnell D, Ellwood P, Yarnell J, Davey S. Breastfeeding and cardiovascular disease risk factors, incidence and mortality: the Caerphilly Study. *J Peidmiol Community Health* 2005; **59**: 121–129.
27 Martin R, Davey Smith G, Mangtani P, Frankel S, Gunnell D. Association between breast feeding and growth: the Boyd-Orr cohort study. *Arch Dis Child Fetal Neonatal Ed* 2002; **87**: F193–F201.
28 Leeson CP, Kattenhorn M, Deanfield JE, Lucas A. Duration of breast feeding and arterial distensibility in early adult life: population based study. *BMJ* 2001; **322**: 643–647.
29 Ravelli AC, van der Meulen JH, Osmond C, Barker DJ, Bleker OP. Infant feeding and adult glucose tolerance, lipid profile, blood pressure, and obesity. *Arch Dis Child* 2000; **82**: 248–252.
30 Schack-Nielsen L, Michaelsen KF, Mortensen EL, Sorensen TI, Reinisch JM. Is duration of breastfeeding influencing the risk of obesity in adult males? *Adv Exp Med Biol* 2004; **554**: 383–385.
31 Poulton R, Williams S. Breastfeeding and risk of overweight. *JAMA* 2001; **286**: 1449–1450.
32 Victora CG, Barros F, Lima RC, Horta BL, Wells J. Anthropometry and body composition of 18 year old men according to duration of breast feeding: birth cohort study from Brazil. *BMJ* 2003; **327**: 901.
33 Owen CG, Martin RM, Whincup PH, Smith GD, Cook DG. Effect of infant feeding on the risk of obesity across the life course: a quantitative review of published evidence. *Pediatrics* 2005; **115**: 1367–1377.
34 Owen CG, Martin RM, Whincup PH, Davey-Smith G, Gillman MW, Cook DG. The effect of breastfeeding on mean body mass index throughout life: a quantitative review of published and unpublished observational evidence. *Am J Clin Nutr* 2005; **82**: 1298–1307.
35 Martinez GA, Dodd DA, Samartgedes JA. Milk feeding patterns in the United States during the first 12 months of life. *Pediatrics* 1981; **68**: 863–868.
36 Lawrence R. *Breastfeeding – A Guide for the Medical Profession*. St. Louis: Mosby, 1999.
37 Troy LM, Michels KB, Hunter DJ, Spiegelman D, Manson JE, Colditz GA *et al*. Self-reported birthweight and history of having been breastfed among younger women: an assessment of validity. *Int J Epidemiol* 1996; **25**: 122–127.
38 Stuebe AM, Rich-Edwards JW, Willett WC, Manson JE, Michels KB. Duration of lactation and incidence of type 2 diabetes. *JAMA* 2005; **294**: 2601–2610.