

PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Effect of Infant Feeding on the Risk of Obesity Across the Life Course: A Quantitative Review of Published Evidence

Christopher G. Owen, Richard M. Martin, Peter H. Whincup, George Davey Smith
and Derek G. Cook

Pediatrics 2005;115:1367-1377

DOI: 10.1542/peds.2004-1176

The online version of this article, along with updated information and services, is
located on the World Wide Web at:

<http://www.pediatrics.org/cgi/content/full/115/5/1367>

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2005 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™



Effect of Infant Feeding on the Risk of Obesity Across the Life Course: A Quantitative Review of Published Evidence

Christopher G. Owen, PhD*; Richard M. Martin, MFPHM‡; Peter H. Whincup, FFPHM*; George Davey Smith, FFPHM‡; and Derek G. Cook, PhD*

ABSTRACT. *Objective.* To examine the influence of initial infant feeding on obesity in later life.

Methods. A systematic review of published studies investigating the association between infant feeding and a measure of obesity was performed with Medline (1966 onward) and Embase (1980 onward) databases, supplemented with manual searches. Data extraction was conducted by 2 authors. Analyses were based on odds ratios of obesity among initially breastfed subjects, compared with formula-fed subjects, pooled with fixed-effects models.

Results. Sixty-one studies reported on the relationship of infant feeding to a measure of obesity in later life; of these, 28 (298 900 subjects) provided odds ratio estimates. In these studies, breastfeeding was associated with a reduced risk of obesity, compared with formula feeding (odds ratio: 0.87; 95% confidence interval [CI]: 0.85–0.89). The inverse association between breastfeeding and obesity was particularly strong in 11 small studies of <500 subjects (odds ratio: 0.43; 95% CI: 0.33–0.55) but was still apparent in larger studies of ≥500 subjects (odds ratio: 0.88; 95% CI: 0.85–0.90). In 6 studies that adjusted for all 3 major potential confounding factors (parental obesity, maternal smoking, and social class), the inverse association was reduced markedly (from an odds ratio of 0.86 to 0.93) but not abolished. A sensitivity analysis examining the potential impact of the results of 33 published studies (12 505 subjects) that did not provide odds ratios (mostly reporting no relationship between breastfeeding and obesity) showed little effect on the results.

Conclusions. Initial breastfeeding protects against obesity in later life. However, a further review including large unpublished studies exploring the effect of confounding factors in more detail is needed. *Pediatrics* 2005;115:1367–1377; *infant feeding, obesity, systematic review.*

From the *Department of Community Health Sciences, St George's Hospital Medical School, London, United Kingdom; and ‡Department of Social Medicine, University of Bristol, Bristol, United Kingdom.

All authors contributed to formulation of the hypothesis. Dr Martin conducted the literature search, Drs Owen and Martin extracted the data, and Dr Owen conducted statistical analyses, drafted the article, to which all authors contributed, and is guarantor. The guarantor accepts full responsibility for the conduct of the study, had access to the data, and controlled the decision to publish.

Accepted for publication Sep 14, 2004.

doi:10.1542/peds.2004-1176

No conflict of interest declared.

Address correspondence to Christopher G. Owen, PhD, Department of Community Health Sciences, St George's Hospital Medical School, Cranmer Terrace, London SW17 0RE, United Kingdom. E-mail: c.owen@sghms.ac.uk
PEDIATRICS (ISSN 0031 4005). Copyright © 2005 by the American Academy of Pediatrics.

ABBREVIATION. CI, confidence interval.

Obesity represents a major public health problem in both developed and developing countries, which has increased rapidly in prevalence in the past 2 decades.^{1,2} After the suggestion that nutrition in early life might influence the risk of subsequent obesity,³ some reports suggested that initial breastfeeding might protect against obesity in later life,^{4–6} whereas others failed to confirm the association.^{7,8} Inconsistency in results could reflect variation in the statistical power of different studies or differences in the extent of adjustment for potential confounding factors, particularly maternal obesity, smoking, and socioeconomic background.^{5,8} Differences in the age of outcome assessment, calendar year of infant feeding, country, and method of assessment of infant feeding could also be important. Selective reporting or publication, particularly of small studies with extreme results, could also be an important factor. In an attempt to establish the extent to which infant feeding influences obesity, we reviewed the published literature on the relationship between infant feeding and obesity, to examine the overall consistency of reported associations, the extent of potential publication and reporting biases, and the potential contributions of confounding factors.

METHODS

Systematic Review Process

The data retrieved for this review were based on a larger, inclusive, systematic search of all published articles, letters, abstracts, and review articles on infant feeding and cardiovascular disease, cardiovascular disease risk factors, and growth in the Medline and Embase bibliographic databases (Table 1). In addition, the reference lists of all studies that fulfilled our eligibility criteria and those of 3 relevant reviews were examined.^{9–11} The review was restricted to studies conducted with human subjects.

The electronic search (completed in September 2003) yielded 3600 unduplicated references. Three additional articles with relevant data that were published recently were also included.^{7,8,12} One reviewer (R.M.M.) completed the literature search. Abstract review suggested that 97 articles were potentially relevant, and 2 authors (C.G.O. and R.M.M.) extracted data from these studies, with total agreement. Thirty-six articles were excluded; 14 studies duplicated data in other reports and 22 did not compare obesity among formula-fed and breastfed subjects. A list of excluded studies is available from the authors. Therefore, 61 studies that compared a measure of obesity (quantitatively or narratively) among breastfed and formula-fed subjects were considered. Mean BMI differences between breastfed and formula-fed subjects were available for 8 studies,^{6,12–18} 4 of which also provided odds of obesity.^{6,12,13,15} Studies that defined the odds of obesity or being

TABLE 1. Search Strategy Used

Infant feeding
MeSH
exp Infant Nutrition/ Bottle Feeding/ Milk, Human/
Text word terms:
(breast adj3 (feeding or fed)).tw
infant diet\$.tw
(bottle adj3 (feeding or fed)).tw
(artificial adj3 (feeding or fed)).tw
weaning.tw
breast milk.tw
dried milk.tw
(infant adj3 nutrition).tw
infant diet\$.tw
infant feeding.tw
early nutrition.tw
infant food.tw
breastfeeding.tw
breastfed.tw
breastmilk.tw
Cardiovascular disease and risk factors
MeSH
Cardiovascular Diseases/ exp Myocardial Ischemia/ exp Vascular Diseases/ exp Cholesterol/ exp Lipids/ exp Diabetes Mellitus/
Text word terms:
lipid\$.tw.
cholesterol.tw.
triglyceride\$.tw.
cardiovascular.tw.
(coronary adj3 disease\$.tw.
Idl.tw.
lipoprotein\$.tw.
hdl.tw.
hypertension.tw.
blood pressure.tw.
(systolic or diastolic).tw.
diabetes.tw.
(niddm or iddm).tw.
insulin resistanc\$.tw.
glucose intolerance.tw.
Growth
MeSH
"Body Weights and Measures"/
exp Obesity/ exp Growth/
Text word terms:
body mass index.tw.
bmi.tw.
overweight.tw.
(obese or obesity).tw.
leg length.tw.
sitting height.tw.
weight.tw.
height.tw.
child\$ growth.tw.

MeSH indicates Medical Subject Heading.

overweight for breastfed and formula-fed subjects were reported more often and were included in a meta-analysis; 28 studies with 29 estimates (1 study reported results for 2 populations)¹⁹ met this inclusion criterion (Table 2). The definitions of obesity differed among studies (Table 2). However, most studies used a percentile cutoff based on BMI, describing subjects at the tail of the distribution. The 95th or 97th percentile was used most often, although some studies used cutoff values as low as the 85th percentile. A smaller number of studies used absolute BMI values^{15,20,21} or cutoff values based on standardized weight^{22,23} or weight for height.^{19,24,25} Studies involving infants used definitions based on percentiles of weight for length^{25–27} or percentiles of weight only.²³ Initial feeding status was ascertained through maternal

recall at the time of infant feeding or ≥ 3 years after birth. Comparisons were based on breastfed and formula-fed groups.

The World Health Organization defines exclusive breastfeeding as "breastfeeding or formula feeding while giving no other food or liquid, not even water."²⁸ However, few studies report this definition, and exclusive breastfeeding is rarely maintained for the first 4 months and if possible 6 months of life, as advised by the World Health Organization. Therefore, the exclusiveness of infant feeding was based on the classification given in each article, as listed in Table 2. The feeding groups were defined as being mutually exclusive in 4 studies,^{5,29–31} the breastfed group included mixed feeders in 7 studies,^{6,15,19,23,27,32,33} and the formula-fed group included mixed feeders in 7 studies.^{6,13,26,33–36} In 2 studies in which infants were breastfed exclusively, the exclusiveness of formula feeding could not be gauged.^{4,37} The exclusiveness of initial feeding was unclear in 10 additional studies.^{8,12,20–22,24,25,38–40} No studies reported the use of nonstandard commercial formulas. Among studies that reported odds ratios (including 4 studies that reported both odds ratios and mean differences in BMI), 8 studies were based on populations from North America, 15 from Western Europe, 3 from Eastern Europe, 2 from Australasia, and 1 from China.

Statistical Analyses

The odds ratio of being defined as obese (or overweight) among initially breastfed subjects, compared with formula-fed subjects, was used as the principal outcome, with its variance. In many studies, the odds ratios were provided directly. For other studies, we calculated the odds ratios from reported prevalence rates of obesity in different feeding groups or from combinations of odds ratios given for different durations of breastfeeding with fixed-effects models, with formula-fed subjects as the reference group. In 2 studies, data for male and female subjects were combined.^{15,38} The main analysis was based on odds ratios that were unadjusted or adjusted for current age and gender and in some cases ethnic group.^{5,30} Results from fixed-effects models are reported throughout, because these reflect only the random error within each study, are more conservative because they are less affected by results of smaller studies that show stronger associations, and make no assumptions about the representativeness of the available studies. Because heterogeneity across studies was marked, possible sources of heterogeneity were examined. Funnel plots were used to assess whether small studies yielded larger effect estimates than larger studies, raising the possibility of publication bias.^{41,42} Tests described by Begg and Mazumdar⁴³ and Egger et al⁴² for publication bias and funnel plot asymmetry, respectively, were also performed. Meta-regression was used to examine the influence of the following factors (defined a priori) with a test for trend: study size (<500, 500–2500, or >2500 subjects), age group at outcome measurement (infants ≤ 1 year of age, young children >1 to 9 years of age, older children 10 to <16 years of age, or adults ≥ 16 years of age), year of birth, and response rates (analyzed as a continuous variable). The effects of adjustment for factors such as parental body size (mostly BMI), socioeconomic status, and maternal smoking were examined in 6 studies that provided data before and after adjustment for all 3 of these factors. The effects of study methods, particularly the method of ascertainment of infant feeding status (whether contemporary or recalled over a period of ≥ 3 years), study response rate, and definition of obesity (equivalent to <95th percentile, 95th to <97th percentile, or ≥ 97 th percentile of BMI), were examined with meta-regression and sensitivity analyses.

Assessment of Reporting Biases

To establish the likelihood of reporting bias, the directions of reported associations were compared among studies that did or did not provide a quantitative estimate of the relative risk of obesity associated with breastfeeding. A sensitivity analysis examining the potential impact of studies not providing quantitative estimates was then conducted with meta-analyses providing an estimate of the pooled odds ratio, weighting each study estimate by the total number of subjects in that study. This was conducted first for studies providing published estimates and then for all studies. Unpublished odds ratios were derived from information on the direction of effect provided in the article. In all except 2 cases, this was reported to be a null effect and the odds ratio was assumed to be 1 (Table 3). The derivation of an odds ratio in the 2

TABLE 2. Studies Included in the Meta-Analysis, in Alphabetical Order

Study	Design	Source	Source of Information on Feeding	Mean Year Born, Age Measured, y	No. Breastfed, Formula Fed	Exclusive Feeding Groups	Definition of Obesity Used	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)	Adjustments
Armstrong and Reilly ²⁹	HC	Child Health Surveillance Programme of Scottish children, UK	In infancy	1996, 3	8751, 23 449	Yes, for 6–8 wk	BMI \geq 95th %	0.77 (0.71–0.85)	0.72 (0.65–0.79)	Gender, birth weight, SES
Bergmann et al ¹³	PC	German Multicenter Atopy Study	In infancy	1990, 6	329, 151	No, exclusively BrF, FF group never BrF or partly BrF \leq 2 mo	BMI \geq 97th %	0.31 (0.16–0.58)	0.46 (0.23–0.92)	Overweight mother, maternal smoking in pregnancy, SES
Dewey et al ²⁶	PC	Davis Area Research on Lactation, Infant Nutrition, and Growth (DARLING) study, USA	In infancy	NS, 0–2	46, 41	No, BrF or FF \geq 12 mo, FF group not BrF for >3 mo	Weight for length >90th %	0.41 (0.09–1.75)		
Eid ²⁴	PC	Born at the Jessop Hospital, Sheffield, UK	In infancy	1961, 8	55, 83	NS	20% over weight for height and gender	0.42 (0.11–1.61)		
Elliott et al ²⁴	HC	Born at the Mary Imogene Bassett Hospital (Cooperstown, NY)	In infancy	1979, 12–17	73, 63	No, exclusiveness of BrF unclear, FF never BrF of BrF \leq 2 mo	BMI \geq 85th %	0.41 (0.19–0.90)	0.51 (0.22–1.16)	SES
Frye and Heinrich ²⁰	CS	Bitterfeld study, consisting of 3 school surveys, Germany	PQ	1986, 5–14	762, 1955	No, exclusiveness of FF unclear, BrF >12 wk	BMI cutoff similar to 30 kg/m ² in adults	0.60 (0.40–0.90)*		
Gillman et al ⁶	CS	Growing Up Today Study (offspring of the Nurses Health Study II), USA	PQ	1985, 9–14	9633, 4744	No, only or mostly BrF or FF	BMI >95th %	0.66 (0.58–0.76)†	0.78 (0.66–0.91)	Age, Tanner scale, gender, child's energy intake, total physical activity, hours of television watched, current maternal BMI, SES (income), birth weight, birth order, early maternal smoking
Grummer-Strawn and Mei ²	HC	Special Supplemental Nutrition Program for Women, Infants, and Children Retrospective data from the Centers for Disease Control and Prevention Pediatric Nutrition Surveillance System collected in a subsample, USA	HC	1988–92, 4	51 286, 126 018 5503, 7084	No, FF group never BrF, exclusiveness of BrF unclear	BMI >95th % adjusted for age	0.92 (0.90–0.95)		Child's gender, race/ethnicity, birth weight and mother's age, education, prepregnancy BMI, weight gain during pregnancy, postpartum smoking
Hediger et al ⁵	CS	Third National Health and Nutrition Examination Survey, USA	PQ	1987, 3–5	1158, 1498	Yes, BrF \leq 2 mo to \geq 9 mo	BMI \geq 95th %	0.85 (0.64–1.13)	0.84 (0.62–1.13)	Birth weight, race/ethnicity, gender, age group, mother's BMI, timing of introduction to solid foods

TABLE 2. Continued

Study	Design	Source	Source of Information on Feeding	Mean Year Born, Age Measured, y	No. Breastfed, Formula Fed	Exclusive Feeding Groups	Definition of Obesity Used	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)	Adjustments
Kramer ¹⁹	CC	Obese and nonobese pupils recruited from the Montreal West High School, Canada	PQ	NS, 12–15	45, 284	No, exclusiveness of FF unclear, BrF group allowed 1 FF per day	Weight for height and age >120% and skinfold >95th %	0.44 (0.21–0.93)		
Kramer ¹⁹	CC	Obese and nonobese children recruited from the Adolescent Clinic of the Montreal Children's Hospital, Canada	PQ	NS, 12–15	60, 332	No, exclusiveness of FF unclear, BrF group allowed 1 FF per day	Weight for height and age >120% and skinfold >95th %	0.24 (0.09–0.63)	0.29 (0.11–0.75)	Parental obesity
Li et al ⁸	CS	Offspring of the 1958 Birth Cohort, UK	PQ	1983, 4–18	1655, 976	NS, FF group BrF <1 wk	BMI SD score >1.64	0.95 (0.77–1.18)	0.98 (0.78–1.23)	Gender, parental BMI, maternal smoking during pregnancy, birth weight, social class
Liese et al ³⁰	CS	Part of the International Study of Asthma and Allergies in Childhood in 2 German cities	PQ	1987, 9–10	1754, 354	Yes, BrF <2 to >6 mo	BMI >90th %	0.55 (0.41–0.74)	0.66 (0.52–0.87)	Age, gender, city, nationality, SES, number of siblings, parental smoking
Maffei et al ³⁸	CS	Recruited from schools in 6 areas of northeast Italy	PQ	1980, 4–12	864, 499#	NS	BMI >95th %	0.91 (0.69–1.21)**		
Neyzi et al ³¹	HC	Children monitored in private practice, Turkey	In infancy	NS, 5	56, 150	Yes, BrF or FF in the first 3 mo of life	PI >1 SD from mean	0.70 (0.27–1.82)		
O'Callaghan et al ⁴⁰	PC	Mater University Study of Pregnancy, Australia	In infancy	1983, 5	1244, 790	NS, FF not BrF at all, BrF for ≥6 mo, exclusiveness unclear	BMI >94th %	0.72 (0.48–1.10)	0.71 (0.43–1.25)	Birth weight, gender, small for gestational age, feeding problems, sleeplessness, parental BMI, maternal education, household income
Parsons et al ¹⁵	PC	1958 British Birth Cohort Study, UK	PQ at 7 y	1958, 33	4164, 2767#	No, wholly or partly BrF for >1 mo	BMI ≥30 kg/m ²	0.76 (0.65–1.25)	0.88 (0.75–1.04)	SES, maternal BMI and smoking during pregnancy
Poulton and Williams ²¹	PC	Dunedin Multidisciplinary Health and Development Study, New Zealand	PQ at 3 y	1973, 26	912§	NS, BrF for ≤6 to >6 mo	BMI >25 kg/m ²	0.98 (0.78–1.25)	1.11 (0.83–1.47)	Gender, birth weight, mother's education, overweight parents
Richter ²²	PC	Gorlitz-born children, Germany	In infancy	1957–1959, 7	1998, 387	No, exclusiveness of FF unclear, BrF <3 to ≥7 mo	≥20% of standardized weight	0.73 (0.51–1.07)		
Scaglioni et al ³²	PC	Born at San Paolo Hospital, Italy	In infancy	1991, 5	124, 23	No, exclusively or predominantly BrF for 2.7 mo (SD, 2.6)	BMI >90th % for age and gender	0.64 (0.24–1.70)		
Strbak et al ³⁵	PC	Healthy children studied from birth to age 7 years, Slovak Republic	In infancy	NS, 1–7	741, 165	No, FF group BrF <2 wk, BrF for 1 to >6 mo, exclusiveness of BrF unclear	Definition of obesity not given	0.84 (0.41–1.72)		

TABLE 2. Continued

Study	Design	Source	Source of Information on Feeding	Mean Year Born, Age Measured, y	No. Breastfed, Formula Fed	Exclusive Feeding Groups	Definition of Obesity Used	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)	Adjustments
Sung et al ³⁹	CS	Hong Kong primary school children, China	PQ	1990, 9–12	271§	NS	Definition of obesity not given	0.45 (0.27–0.78)		
Taitz ²³	CS	Born at the Jessop Hospital, Sheffield, UK	In infancy	NS, 0.1	21, 240	No, predominantly BrF for 6 wk	Weight >90th %	0.37 (0.12–1.14)		
Thorogood et al ²⁵	PC	Infants from 2 market towns in Oxfordshire, UK	In infancy	1976, 1	39, 50	NS	>110% of standardized weight/height	0.25 (0.05–1.21)		
Toschke et al ³³	CS	Nationwide Anthropometric Survey of Children and Adolescents, Czech Republic	PQ	1992, 6–14	30 641, 3127	No, BrF ≤1 to >6 mo, no distinction between exclusive and partial feeding	BMI >97th %	0.70 (0.59–0.84)	0.80 (0.66–0.96)	Parental education and obesity, current maternal smoking, birth weight, daily television watching, sports outside school, number of siblings
Tuuldahl et al ³⁶	PC	Representative sample of adolescents near Goteborg, Sweden	In infancy	1979, 16	390, 391	No, FF never BrF of BrF for ≤2 mo, BrF exclusively for >2 mo	BMI >85th %	0.66 (0.44–0.98)		
Von Kries et al ⁴	CS	School entry health examination, Germany	PQ	1992, 5–6	5184, 4022	No, exclusiveness of FF unclear, BrF exclusively for ≤2 to >12 mo	BMI >97th %	0.61 (0.50–0.76)	0.75 (0.57–0.98)	Parental education, maternal smoking during pregnancy, low birth weight, own bedroom, consumption of butter
Wadsworth et al ³⁷	PC	MRC National Survey of Health and Development, UK	In infancy	1946, 6	2873, 858	No, FF group were never BrF, exclusiveness of ever BrF unclear	BMI >97th %	0.88 (0.60–1.28)	0.83 (0.65–1.04)	SES in childhood, birth weight, people per room, fat intake
Yeung et al ²⁷	PC	Pregnant mothers recruited from Toronto and Montreal, Canada	In infancy	NS, 0.5	74, 280	No, BrF >2 mo, supplemented with cow's milk and FF	Weight/length at 95th %	1.09 (0.35–3.40)		
Overall pooled estimate based on a fixed effects model from 29 estimates from 28 studies					298 900§			0.87 (0.85–0.89)		
Overall pooled estimate based on fixed effects models from 6 studies with and without adjustment for all 3 major confounders (parental obesity, maternal smoking, SES)					70 774§			0.86 (0.81–0.91)	0.93 (0.88–0.99)	

HC indicates historical cohort; PC, prospective cohort; CS, cross sectional; CC, case control; PQ, parental questionnaire at least 3 years after birth; BrF, breastfed; FF, formula fed; NS, not stated; UK, United Kingdom; USA, United States; MRC, Medical Research Council; PI, ponderal index; %, percentile; SES, socioeconomic status.

* Adjusted for age, gender, and survey.

† Adjusted for age, Tanner scale, and gender.

‡ Odds ratio derived from only 7% of the entire sample and used to compare with adjusted analysis where data on potential confounders were available.

§ Total number only.

|| Data for 2 age groups combined.

¶ Adjusted for age, gender, and city.

Male and female data combined.

** Adjusted for age.

TABLE 3. Studies Used to Examine the Role of Reporting Bias, Which Examined the Relationships Between Breastfeeding and Obesity But Did Not Provide a Risk Estimate

Study	Design	Source	Source of Information on Feeding	Mean Year Born, Age Measured, y	No. Breastfed, Formula Fed	Exclusive Feeding Groups	Assumed Odds Ratio
Agostomi et al ⁵⁵	PC	Born in San Paolo Hospital maternity ward, Italy	In infancy	NS, 1	73, 65	No	1
Baranowski et al ⁵⁶	CS	Studies of Child Activity and Nutrition in Texas, USA	Parental interview	1982, 4	246*	No	1
Baxter-Jones et al ⁵⁷	HC	Aberdeen birth cohort study, UK	In infancy	1921, 1	463, 53	No	1
Birkbeck et al ⁵⁸	PC	Dunedin Multidisciplinary Health and Development Study, New Zealand	In infancy	1973, 7	283, 383	Yes	1
Boulton ⁵⁹	PC	Born at Queen Victoria's Hospital, Adelaide, Australia	In infancy	1978, 2	10, 172	NS	1
Butte et al ⁶⁰	PC	Infants recruited at the Children's Nutrition Research Center, USA	In infancy	NS, 2	29, 43	No	1
Chan et al ⁶¹	PC	Infants from the University Medical Center and a pediatric private practice, USA	In infancy	NS, 1	51, 40	Yes	1
Charney et al ⁶²	HC	Infants in groups of infant weight identified retrospectively from pediatrician records in the Rochester, NY, area, USA	In infancy	1945–1950, 20–30	366*	NS	1
de Bruin et al ⁶³	PC	Infants recruited at the Sophia Children's Hospital, Netherlands	In infancy	1992, 1	23, 23	Yes	1
Dine et al ⁶⁴	PC	Recruited from a pediatric practice, USA	In infancy	NS, 5	406, 70	No	1
Dubois et al ⁶⁵	CC	Infants from private practices and the Hospital for Sick Children, Toronto, Canada	In infancy	NS, <1	89*	NS	1
Fall et al ¹⁸	HC	Adults born in Hertfordshire, UK	In infancy	1925, 64	344, 25	Yes	1
Fawzi et al ⁶⁶	PC	North African Infant Feeding Study, Israel	In infancy	1982–1986, 0.5	21, 126	Yes	1
Fomon et al ¹⁴	PC	Infants from a maternity unit, USA	In infancy	1966–1971, 8	F, 83, 105; M, 73, 171	No	1
Harrison et al ⁶⁷	PC	Born at the University of Arizona Medical Center, USA	In infancy	NS, <1	30, 60	Yes	1
Hitchcock and Coy ⁴⁴	CS	Recruited from children health centers in Western Australia and Tasmania	In infancy	1984, 1	1371*	No	0.69†
Jooste et al ⁶⁸	PC	Recruited from 3 communities, South Africa	In infancy	1981–1986, 1	110, 201	Yes	1
Kramer et al ⁵⁰	Nested PC from a RCT	Promotion of Breastfeeding Intervention Trial, Republic of Belarus	In infancy	NS, 1	1271, 1378	No	1
Leeson et al ¹⁶	CS	Born in the Cambridge Maternity Hospital, UK	PQ in adulthood	1972, 20–28	149, 182	No	1
Marmot et al ⁴⁵	PC	MRC National Survey of Health and Development, UK	In infancy	1946, 32	F, 68, 27; M, 57, 20	Yes	1
Michaelsen ⁶⁹	PC	Copenhagen Cohort Study on Infant Nutrition and Growth, Denmark	In infancy	1978–1988, 1	150*	No	1
Morgan and Mumford ⁷⁰	PC	Sample of children living in the south of England, UK	NS	NS, 5	56*	NS	1
Oakley ⁷¹	PC	Infants seen at the Jessop Hospital Well-Baby Clinic, UK	In infancy	NS, 0	87, 173	Yes	1
Ong et al ⁷²	PC	Avon Longitudinal Study of Parent and Children in Focus study, UK	In infancy	1992, 5	425, 440	No	1
Patterson et al ⁷³	CS	Recruited from day care centers, schools, and birth announcements in newspapers, USA	PQ	1981, 4	94*	NS	1
Persson ⁷⁴	PC	Recruited from 3 geographical areas in Sweden	In infancy	1980, 1.5	312*	No	1
Ravelli et al ¹⁷	HC	Dutch Famine Birth Cohort Study	Postnatal medical records	1945, 48–53	520, 105	No	1
Saarinan and Stimes ⁷⁵	PC	Born at the Helsinki University Central Hospital, Finland	In infancy	1975, 1	56, 76	No	1
Vobecky et al ⁷⁶	PC	Recruited from a prospective longitudinal study on nutrition and health, Canada	In infancy	NS, 3	170*	No	1
Wilkinson et al ⁷⁷	CC	Newcastle Study of Child Development, UK	PQ	1962, 10	262*	NS	1
Wilson et al ⁷⁸	PC	Dundee Infant Feeding Study, Scotland, UK	In infancy	1986, 6–10	103, 148	Yes	1
Wolman ⁷⁹	PC	Recruited from a pediatric group practice, USA	In infancy	NS, 4	46, 118	No	1
Zive et al ⁸⁰	CS	Study of Children's Activity and Nutrition Project, USA	PQ	NS, 4	361*	No	1
Total number					12 505*		

HC indicates historical cohort; PC, prospective cohort; CS, cross sectional; CC, case control; PQ, parental questionnaire; NS, not stated; UK, United Kingdom; USA, United States; RCT, randomized, clinical trial.

* Total number only.

† Given the total number of participants and that those breastfed were more likely to be overweight than those formula fed ($P = .05$), an odds ratio was derived assuming that equal numbers were breastfed and formula fed and that 10% of the formula-fed subjects were overweight.

‡ Derived from the ratio of weight between those breastfed and formula fed.

studies that reported a direction of effect is outlined in a footnote to Table 3.^{44,45}

RESULTS

Among 61 observational studies that reported on the effects of infant feeding on a measure of adiposity in later life, 28 studies (298 900 subjects) provided 29 unadjusted odds ratios relating the initial infant feeding method and obesity (Table 2). Four observations were for infants, 23 for children, and 2 for adults (Table 2). Twenty-eight of 29 estimates related breastfeeding to a lower risk of obesity. There was evidence of marked heterogeneity among studies ($\chi^2_{28} = 111, P < .001$). In a fixed-effects model including all studies, breastfed subjects were less likely to be defined as obese than were formula-fed subjects (odds ratio: 0.87; 95% confidence interval [CI]: 0.85–0.89) (Fig 1 and Table 2). This estimate was unaltered by exclusion of 4 studies with outcome measurement in infancy. In the fixed-effects model, the statistical weight given to the largest study amounted to 73%.¹² Exclusion of this study strengthened the protective effect of breastfeeding on obesity to an odds ratio of 0.73 (95% CI: 0.70–0.77). Additional exclusion of the next 2 largest studies (accounting for 10% of the statistical weight) had little additional effect.^{29,33}

Small studies reported the strongest relationships

between breastfeeding and reduced risk of obesity (Figs 1 and 2), although the association was still present in larger studies. An odds ratio of 0.43 (95% CI: 0.33–0.55) was observed in 11 small studies (<500 participants), whereas odds ratios of 0.78 (95% CI: 0.69–0.89) and 0.88 (95% CI: 0.86–0.90) were observed in 7 studies of intermediate size (500–2500 participants) and in 10 large studies (>2500 participants), respectively. This trend can be seen in the funnel plot (Fig 2); not surprisingly, the results of the Egger test for funnel plot asymmetry were statistically significant ($P < .001$). The results of the Begg test were not statistically significant ($P = .96$). There was no clear evidence that the protective effect of breastfeeding altered with increasing age of outcome measurement. Odds ratios of 0.50 (95% CI: 0.26–0.94) for infants, 0.90 (95% CI: 0.87–0.92) for young children, 0.66 (95% CI: 0.60–0.72) for older children, and 0.80 (95% CI: 0.71–0.91) for adults were observed (test for trend, $P = .85$, adjusted for study size; $P = .99$ with the exclusion of infants). The smaller effect with narrow CIs observed for young children is attributable to the inclusion of the largest study with a small effect.¹² Year of birth was unrelated to the odds ratio.

In 6 studies, it was possible to examine the effect of

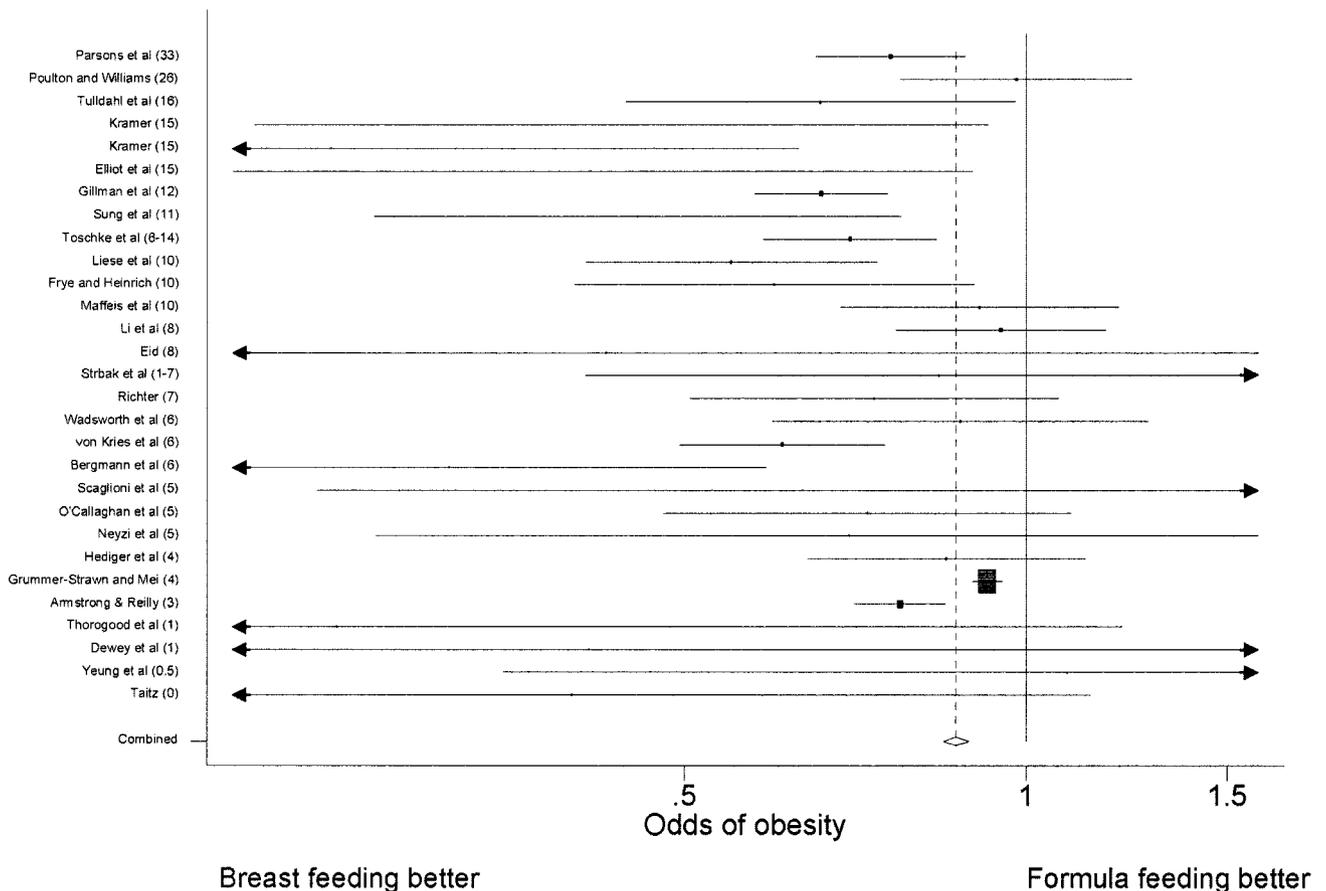
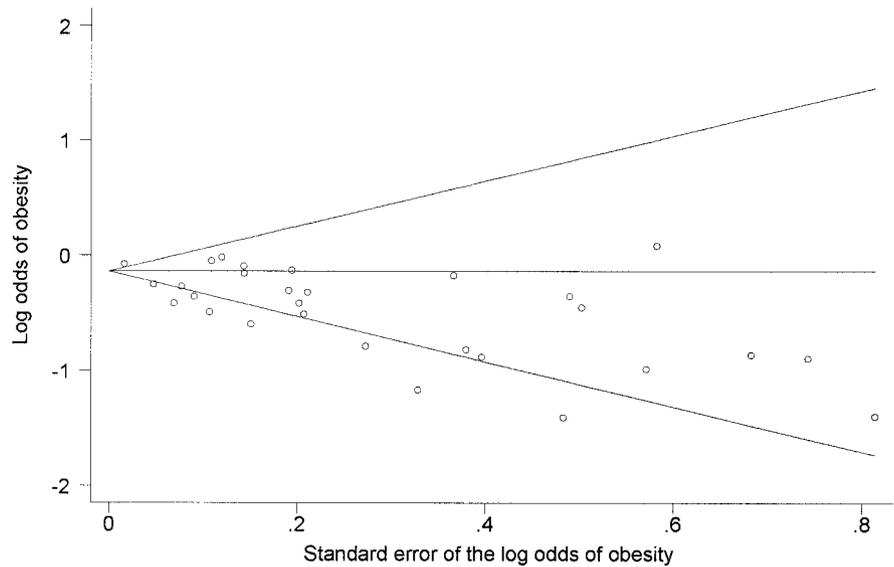


Fig 1. Odds ratio and 95% CIs of being defined as obese, comparing those who were breastfed versus formula fed (values of <1 show a protective effect of breastfeeding against obesity). The box area of each study is proportional to the inverse of the variance, with horizontal lines showing the 95% CI of the odds ratio. The study authors are indicated on the y-axis in ascending order of age at which obesity status was measured. Mean ages (in years) are shown in parentheses. The pooled estimate based on a fixed-effects model is shown with a dashed vertical line and diamond (95% CI).

Fig 2. Begg funnel plot (with pseudo 95% CI), showing the logarithmically transformed odds ratio of the effect of infant feeding on obesity versus the SE of the logarithmically transformed odds ratio.



adjustment for the following potentially important confounders: socioeconomic status (based on parental education in 2 studies),^{12,33} parental BMI, and current maternal smoking³³ or maternal smoking in early life.^{6,8,12,13,15} The pooled odds ratio in these studies was reduced from 0.86 (95% CI: 0.81–0.91) before adjustment to 0.93 (95% CI: 0.88–0.99) after combined adjustment. The effect of adjustment for size at birth (based on either birth weight or prevalence of low birth weight) was examined in 10 studies; this had no appreciable effect on the odds ratios.

The protective effect of breastfeeding over obesity was stronger and more homogeneous among 4 studies in which initial feeding groups were exclusive (odds ratio: 0.76; 95% CI: 0.70–0.83; test for heterogeneity between estimates, $\chi^2_3 = 5.4$, $P = .143$), compared with all other studies.^{5,29–31} In addition, a longer duration of breastfeeding appeared to show a slightly greater protective effect on obesity. In 14 studies with information on breastfeeding duration, the protective effect of breastfeeding over formula feeding was greater among subjects breastfed for ≥ 2 months (odds ratio: 0.81; 95% CI: 0.77–0.84), compared with those breastfed for any duration (odds ratio: 0.89; 95% CI: 0.86–0.91) in the same studies. The combined odds ratio was little affected by particular obesity cutoff values used in different studies, by whether infant feeding status was recorded in infancy or retrospectively, or by response rate.

Thirty-three studies (12 505 participants), although they examined relationships between breastfeeding and obesity, did not provide an estimate of relative risk (Table 3). However, they provided 35 reports of directions of association; of these, breastfeeding was unrelated to risk of obesity in 33, related to a reduced risk in 1, and related to an increased risk in 1. Therefore, studies that did not provide odds ratios were much less likely to report that breastfeeding was associated with a reduced risk of obesity, compared with studies that did provide odds ratios (1 of 35 studies and 18 of 29 studies, respectively; $\chi^2 = 26.9$, $P < .001$). However, including these additional stud-

ies (which included fewer than one twentieth of the numbers of subjects in the studies that provided odds ratios) appeared to make little difference in the results. In a meta-analysis of the 29 odds ratios from 28 studies with published estimates, weighted according to the total number of subjects in each study, the summary odds ratio was 0.83, close to that reported for the main analysis above. The inclusion of 35 estimates from the 33 studies with no published odds ratio (Table 3) had a minimal effect on the summary estimate (summary odds ratio: 0.84). The difference in the summary estimates was similar when the largest published study, representing nearly three fourths of the combined statistical weight, was excluded from the analyses.¹² Studies equivalent in statistical size to this largest study ($N = 177\ 304$)¹² and showing an overall protective effect of formula feeding over breastfeeding on obesity, with an odds ratio of 1.4 (far greater than any effect observed in the current meta-analysis), would be needed to nullify these combined results (ie, to produce an estimated odds ratio of 1).

DISCUSSION

In this overview of published studies relating infant feeding and obesity, studies reporting a quantitative estimate provided consistent evidence of a relationship between breastfeeding and reduced risk of obesity. Although the association was particularly strong among the smallest studies (consistent with the possibility of publication bias), it was also observed among larger studies. The association appeared stronger among prolonged breastfeeders and was unaltered by age at outcome measurement.

An important potential limitation of the evidence presented here is that it is based on observational studies; experimental studies are generally impracticable in this context, except in highly specific circumstances.⁴⁶ Confounding is therefore an important possibility, and maternal factors are of particular potential importance. Low maternal social class and maternal obesity are related to a tendency to formula

feed and to greater risk of obesity among offspring.^{5,8} Birth size may also be an important confounder, especially because lower mean birth weight may be associated with formula feeding and with an increased risk of later central obesity.^{5,47} The effect of confounding by maternal factors and birth weight may exaggerate an association between breastfeeding and obesity. In a subset of studies that examined the effect of adjustment for these factors, the association between breastfeeding and reduced risk of obesity was markedly attenuated.^{6,8,12,13,15,33}

The association between breastfeeding and obesity could reflect selective reporting and/or publication. Our results indicated selective reporting of odds ratios by studies that showed a relationship between breastfeeding and reduced risk of obesity. However, because the studies that did not present odds ratios were on average much smaller than those that presented data, their inclusion had a minimal impact on effect estimates. The influence of publication bias is more difficult to assess. The results suggested that there was some selective publication of small studies showing strong associations between breastfeeding and obesity. However, the association remained, although it was weaker, among the larger published studies. It remains possible that, among large unpublished data sources, there is little or no association. However, studies equivalent in statistical size to the largest study ($N = 177\ 034$)¹² would need to show a highly improbable protective effect of formula feeding over breastfeeding to nullify the pooled results presented in this review.

Overall, our results suggest that breastfeeding is protective against obesity, although the precise magnitude of the association remains unclear. Increasing uptake of breastfeeding could form an important part of population strategies to prevent obesity. Several biological mechanisms may explain the association. Breastfeeding affects intakes of calories and protein,⁴⁸ insulin secretion,⁴⁹ and modulation of fat deposition and adipocyte development.⁴ If the effects of breastfeeding are sustained through either habituation or more-complex programming mechanisms, then the association could persist into adult life, as our results suggest. The consistency of the association with increasing age (as observed in the analyses) suggests that the protective effects of early breastfeeding are independent of dietary and physical activity patterns that emerge in later life.

In investigating the presence of a dose-response relationship, it was possible to show, from published data, only that prolonged breastfeeding was associated with an additional reduction in obesity, compared with any breastfeeding in the same studies. Additional data are needed to examine systematically the effects of duration of breastfeeding on obesity in adulthood. Additional studies are also needed to examine the effects of confounding and publication biases in more detail. Additional evidence regarding the effects of confounding factors on the relationship between breastfeeding and obesity, from both published and unpublished studies, is needed. Studies involving populations for which breastfeeding is socially patterned in a way that is

different from that for European or North American populations (the predominant source of studies in the present meta-analysis) would be particularly valuable. Follow-up data for participants in randomized, controlled trials of breastfeeding promotion would provide particularly reliable evidence of the association.⁵⁰ To address the influence of publication biases, additional data on the relationship between breastfeeding and obesity from large unpublished studies are needed, especially for adults. In addition, examination of the relationship of breastfeeding to markers of average adiposity in the comparison groups (for example, mean BMI) would supplement usefully the information on the prevalence of obesity provided in this study. While more data on these issues and on the relationship between duration of breastfeeding and obesity are being obtained, the case for breastfeeding is already strong and well established, based on a combination of other short- and long-term benefits, including improved neural and psychosocial development,^{51,52} less allergic disease,⁵³ and potentially lower blood cholesterol levels in later life.⁵⁴

ACKNOWLEDGMENTS

C.G.O. was supported by the British Heart Foundation (grant PG/04/072). R.M.M. was supported by the Wellcome Trust.

REFERENCES

1. World Health Organization. Obesity: preventing and managing the global epidemic: report of a WHO consultation. *World Health Organ Tech Rep Ser.* 2000;894:i-253
2. de Onis M, Blossner M. Prevalence and trends of overweight among preschool children in developing countries. *Am J Clin Nutr.* 2000;72:1032-1039
3. Lucas A. Programming by early nutrition in man. In: Bock GR, Whelan J, eds. *The Childhood Environment and Adult Disease.* New York, NY: John Wiley and Sons; 1991:38-55
4. Von Kries R, Koletzko B, Sauerwald T, et al. Breast feeding and obesity: cross sectional study. *BMJ.* 1999;319:147-150
5. Hediger ML, Overpeck MD, Kuczmariski RJ, Ruan WJ. Association between infant breastfeeding and overweight in young children. *JAMA.* 2001;285:2453-2460
6. Gillman MW, Rifas-Shiman SL, Camargo CA Jr, et al. Risk of overweight among adolescents who were breastfed as infants. *JAMA.* 2001;285:2461-2467
7. 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
8. Li L, Parsons TJ, Power C. Breast feeding and obesity in childhood: cross sectional study. *BMJ.* 2003;327:904-905
9. Butte NF. The role of breastfeeding in obesity. *Pediatr Clin North Am.* 2001;48:189-198
10. Dewey KG. Growth characteristics of breast-fed compared to formula-fed infants. *Biol Neonate.* 1998;74:94-105
11. Parsons TJ, Power C, Logan S, Summerbell CD. Childhood predictors of adult obesity: a systematic review. *Int J Obes Relat Metab Disord.* 1999;23(suppl 8):S1-S107
12. Grummer-Strawn LM, Mei Z. Does breastfeeding protect against pediatric overweight? Analysis of longitudinal data from the Centers for Disease Control and Prevention Pediatric Nutrition Surveillance System. *Pediatrics.* 2004;113(2). Available at: www.pediatrics.org/cgi/content/full/113/2/e81
13. Bergmann KE, Bergmann RL, Von Kries R, et al. Early determinants of childhood overweight and adiposity in a birth cohort study: role of breast-feeding. *Int J Obes Relat Metab Disord.* 2003;27:162-172
14. Fomon SJ, Rogers RR, Ziegler EE, Nelson SE, Thomas LN. Indices of fatness and serum cholesterol at age eight years in relation to feeding and growth during early infancy. *Pediatr Res.* 1984;18:1233-1238
15. Parsons TJ, Power C, Manor O. Infant feeding and obesity through the lifecourse. *Arch Dis Child.* 2003;88:793-794

16. 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
17. 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
18. Fall CH, Barker DJ, Osmond C, Winter PD, Clark PM, Hales CN. Relation of infant feeding to adult serum cholesterol concentration and death from ischaemic heart disease. *BMJ*. 1992;304:801–805
19. Kramer MS. Do breast-feeding and delayed introduction of solid foods protect against subsequent obesity? *J Pediatr*. 1981;98:883–887
20. Frye C, Heinrich J. Trends and predictors of overweight and obesity in East German children. *Int J Obes Relat Metab Disord*. 2003;27:963–969
21. Poulton R, Williams S. Breastfeeding and risk of overweight. *JAMA*. 2001;286:1449–1450
22. Richter J. Influence of duration of breast-feeding on body-weight-development [in German]. *Arztl Jugendkd*. 1981;72:166–169
23. Taitz LS. Infantile overnutrition among artificially fed infants in the Sheffield region. *Br Med J*. 1971;1:315–316
24. Eid EE. Follow-up study of physical growth of children who had excessive weight gain in first six months of life. *Br Med J*. 1970;2:74–76
25. Thorogood M, Clark R, Harker P, Mann JI. Infant feeding and overweight in two Oxfordshire towns. *J R Coll Gen Pract*. 1979;29:427–430
26. Dewey KG, Heinig MJ, Nommsen LA, Peerson JM, Lonnerdal B. Breast-fed infants are leaner than formula-fed infants at 1 y of age: the DARLING study. *Am J Clin Nutr*. 1993;57:140–145
27. Yeung DL, Pennell MD, Leung M, Hall J. Infant fatness and feeding practices: a longitudinal assessment. *J Am Diet Assoc*. 1981;79:531–535
28. World Health Organization, Division of Diarrhoeal and Acute Respiratory Disease Control. *Indicators for Assessing Breast-feeding Practices: Report of an Informal Meeting*. Geneva, Switzerland: World Health Organization; 1991
29. Armstrong J, Reilly JJ. Breastfeeding and lowering the risk of childhood obesity. *Lancet*. 2002;359:2003–2004
30. Liese AD, Hirsch T, von Mutius E, Keil U, Leupold W, Weiland SK. Inverse association of overweight and breast feeding in 9 to 10-year-old children in Germany. *Int J Obes Relat Metab Disord*. 2001;25:1644–1650
31. Neyzi G, Binyildiz P, Gunoz H. Influence of feeding pattern in early infancy on ponderal index and relative weight. In: Borms J, ed. *Human Growth and Development*. New York, NY: Plenum; 1984:603–611
32. Scaglioni S, Agostoni C, Notaris RD, et al. Early macronutrient intake and overweight at five years of age. *Int J Obes Relat Metab Disord*. 2000;24:777–781
33. Toschke AM, Vignerova J, Lhotska L, Osancova K, Koletzko B, Von Kries R. Overweight and obesity in 6- to 14-year-old Czech children in 1991: protective effect of breast-feeding. *J Pediatr*. 2002;141:764–769
34. Elliott KG, Kjolhede CL, Gournis E, Rasmussen KM. Duration of breast-feeding associated with obesity during adolescence. *Obes Res*. 1997;5:538–541
35. Strbak V, Skultetyova M, Hromadova M, Randuskova A, Macho L. Late effects of breast-feeding and early weaning: seven-year prospective study in children. *Endocr Regul*. 1991;25:53–57
36. Tull Dahl J, Pettersson K, Andersson SW, Hulthen L. Mode of infant feeding and achieved growth in adolescence: early feeding patterns in relation to growth and body composition in adolescence. *Obes Res*. 1999;7:431–437
37. Wadsworth M, Marshall S, Hardy R, Paul A. Breast feeding and obesity: relation may be accounted for by social factors. *BMJ*. 1999;319:1576
38. Maffei C, Micciolo R, Must A, Zaffanello M, Pinelli L. Parental and perinatal factors associated with childhood obesity in north-east Italy. *Int J Obes Relat Metab Disord*. 1994;18:301–305
39. Sung RY, Tong PC, Yu CW, et al. High prevalence of insulin resistance and metabolic syndrome in overweight/obese preadolescent Hong Kong Chinese children aged 9–12 years. *Diabetes Care*. 2003;26:250–251
40. O'Callaghan MJ, Williams GM, Andersen MJ, Bor W, Najman JM. Prediction of obesity in children at 5 years: a cohort study. *J Paediatr Child Health*. 1997;33:311–316
41. Light RJ, Pillemer DB. *Summing Up: The Science of Reviewing Research*. Cambridge, MA: Harvard University Press; 1984
42. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315:629–634
43. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. *Biometrics*. 1994;50:1088–1101
44. Hitchcock NE, Coy JF. The growth of healthy Australian infants in relation to infant feeding and social group. *Med J Aust*. 1989;150:306–311
45. Marmot MG, Page CM, Atkins E, Douglas JW. Effect of breast-feeding on plasma cholesterol and weight in young adults. *J Epidemiol Commun Health*. 1980;34:164–167
46. Lucas A, Morley R. Does early nutrition in infants born before term programme later blood pressure? *BMJ*. 1994;309:304–308
47. Barker DJ, Gluckman PD, Godfrey KM, Harding JE, Owens JA, Robinson JS. Fetal nutrition and cardiovascular disease in adult life. *Lancet*. 1993;341:938–941
48. 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
49. Lucas A, Sarson DL, Blackburn AM, Adrian TE, Aynsley-Green A, Bloom SR. Breast vs bottle: endocrine responses are different with formula feeding. *Lancet*. 1980;1:1267–1269
50. Kramer MS, Guo T, Platt RW, et al. Breastfeeding and infant growth: biology or bias? *Pediatrics*. 2002;110:343–347
51. Makrides M, Neumann M, Simmer K, Pater J, Gibson R. Are long-chain polyunsaturated fatty acids essential nutrients in infancy? *Lancet*. 1995;345:1463–1468
52. Fergusson DM, Woodward LJ. Breast feeding and later psychosocial adjustment. *Paediatr Perinat Epidemiol*. 1999;13:144–157
53. Lucas A, Brooke OG, Morley R, Cole TJ, Bamford MF. Early diet of preterm infants and development of allergic or atopic disease: randomised prospective study. *BMJ*. 1990;300:837–840
54. Owen CG, Whincup PH, Odoki K, Gilg JA, Cook DG. Infant feeding and blood cholesterol: a study in adolescents and a systematic review. *Pediatrics*. 2002;110:597–608
55. Agostoni C, Grandi F, Gianni ML, et al. Growth patterns of breast fed and formula fed infants in the first 12 months of life: an Italian study. *Arch Dis Child*. 1999;81:395–399
56. Baranowski T, Bryan GT, Rassin DK, Harrison JA, Henske JC. Ethnicity, infant-feeding practices, and childhood adiposity. *J Dev Behav Pediatr*. 1990;11:234–239
57. Baxter-Jones AD, Cardy AH, Helms PJ, Phillips DO, Smith WC. Influence of socioeconomic conditions on growth in infancy: the 1921 Aberdeen birth cohort. *Arch Dis Child*. 1999;81:5–9
58. Birkbeck JA, Buckfield PM, Silva PA. Lack of long-term effect of the method of infant feeding on growth. *Hum Nutr Clin Nutr*. 1985;39:39–44
59. Boulton J. Nutrition in childhood and its relationships to early somatic growth, body fat, blood pressure, and physical fitness. *Acta Paediatr Scand Suppl*. 1981;284:1–85
60. Butte NF, Wong WW, Hopkinson JM, Smith EO, Ellis KJ. Infant feeding mode affects early growth and body composition. *Pediatrics*. 2000;106:1355–1366
61. Chan GM, Roberts CC, Folland D, Jackson R. Growth and bone mineralization of normal breast-fed infants and the effects of lactation on maternal bone mineral status. *Am J Clin Nutr*. 1982;36:438–443
62. 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
63. de Bruin NC, Degenhart HJ, Gal S, Westerterp KR, Stijnen T, Visser HK. Energy utilization and growth in breast-fed and formula-fed infants measured prospectively during the first year of life. *Am J Clin Nutr*. 1998;67:885–896
64. Dine MS, Gartside PS, Glueck CJ, Rheines L, Greene G, Khoury P. Where do the heaviest children come from? A prospective study of white children from birth to 5 years of age. *Pediatrics*. 1979;63:1–7
65. Dubois S, Hill DE, Beaton GH. An examination of factors believed to be associated with infantile obesity. *Am J Clin Nutr*. 1979;32:1997–2004
66. Fawzi WW, Forman MR, Levy A, Graubard BI, Naggan L, Berendes HW. Maternal anthropometry and infant feeding practices in Israel in relation to growth in infancy: the North African Infant Feeding Study. *Am J Clin Nutr*. 1997;65:1731–1737
67. Harrison GG, Graver EJ, Vargas M, Churella HR, Paule CL. Growth and adiposity of term infants fed whey-predominant or casein-predominant formulas or human milk. *J Pediatr Gastroenterol Nutr*. 1987;6:739–747
68. Jooste PL, Rossouw LJ, Steenkamp HJ, Rossouw JE, Swanepoel AS, Charlton DO. Effect of breast feeding on the plasma cholesterol and growth of infants. *J Pediatr Gastroenterol Nutr*. 1991;13:139–142
69. Michaelsen KF. Nutrition and growth during infancy: the Copenhagen Cohort Study. *Acta Paediatr Suppl*. 1997;420:1–36
70. Morgan JB, Mumford PM. A follow-up study of nutrition and anthropometry in pre-school children. *Proc Nutr Soc*. 1980;39:5A
71. Oakley JR. Differences in subcutaneous fat in breast- and formula-fed infants. *Arch Dis Child*. 1977;52:79–80
72. Ong KK, Preece MA, Emmett PM, Ahmed ML, Dunger DB. Size at birth and early childhood growth in relation to maternal smoking, parity and infant breast-feeding: longitudinal birth cohort study and analysis. *Pediatr Res*. 2002;52:863–867

73. Patterson RE, Typpo JT, Typpo MH, Krause GF. Factors related to obesity in preschool children. *J Am Diet Assoc.* 1986;86:1376–1381
74. Persson LA. Infant feeding and growth: a longitudinal study in three Swedish communities. *Ann Hum Biol.* 1985;12:41–52
75. Saarinen UM, Siimes MA. Role of prolonged breast feeding in infant growth. *Acta Paediatr Scand.* 1979;68:245–250
76. Vobecky JS, Vobecky J, Shapcott D, Demers PP. Nutrient intake patterns and nutritional status with regard to relative weight in early infancy. *Am J Clin Nutr.* 1983;38:730–738
77. Wilkinson PW, Parkin JM, Pearlson J, Philips PR, Sykes P. Obesity in childhood: a community study in Newcastle upon Tyne. *Lancet.* 1977; 1:350–352
78. Wilson AC, Forsyth JS, Greene SA, Irvine L, Hau C, Howie PW. Relation of infant diet to childhood health: seven year follow up of cohort of children in Dundee infant feeding study. *BMJ.* 1998;316:21–25
79. Wolman PG. Feeding practices in infancy and prevalence of obesity in preschool children. *J Am Diet Assoc.* 1984;84:436–438
80. Zive MM, McKay H, Frank-Spohrer GC, Broyles SL, Nelson JA, Nader PR. Infant-feeding practices and adiposity in 4-y-old Anglo- and Mexican-Americans. *Am J Clin Nutr.* 1992;55:1104–1108

THE INTERNET: IT'S THE NEW TV

“Television has long been a favorite way to pass time. . . . [A]n annual survey by Jupiter Research showed that last year American adults spent as many hours a week in front of another screen—their computer’s. The survey of 2,231 people found that consumers spent an average of 10 hours a week on the Internet in 2004, the same amount as the year before. TV watching declined to 10 hours a week, however, from 11 in 2003. About 35 percent of the people Jupiter surveyed said they watched less TV because of their online habit . . . people with low-speed dial-up Internet connections still put in about 12 hours a week in front of the tube. TV watching wasn’t the only activity that suffered, according to the survey. Thirty-five percent of respondents said they spent less time reading books, 28 percent cut back on magazines and 26 percent picked up a newspaper less frequently. . . . While e-mail messaging provides another way to keep in touch with friends and family, that also seems to be coming at the expense of at least one older technology: 28 percent of the people Jupiter surveyed said they spent less time chatting on the phone because of the Internet.”

Austen I. *New York Times.* March 1, 2005

Noted by JFL, MD

**Effect of Infant Feeding on the Risk of Obesity Across the Life Course: A
Quantitative Review of Published Evidence**
Christopher G. Owen, Richard M. Martin, Peter H. Whincup, George Davey Smith
and Derek G. Cook
Pediatrics 2005;115:1367-1377
DOI: 10.1542/peds.2004-1176

Updated Information & Services	including high-resolution figures, can be found at: http://www.pediatrics.org/cgi/content/full/115/5/1367
References	This article cites 68 articles, 30 of which you can access for free at: http://www.pediatrics.org/cgi/content/full/115/5/1367#BIBL
Citations	This article has been cited by 74 HighWire-hosted articles: http://www.pediatrics.org/cgi/content/full/115/5/1367#otherarticles
Subspecialty Collections	This article, along with others on similar topics, appears in the following collection(s): Nutrition & Metabolism http://www.pediatrics.org/cgi/collection/nutrition_and_metabolism
Permissions & Licensing	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: http://www.pediatrics.org/misc/Permissions.shtml
Reprints	Information about ordering reprints can be found online: http://www.pediatrics.org/misc/reprints.shtml

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

