

# Breastfeeding and the Risk of Childhood Obesity

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## ABSTRACT

*Breastfeeding is suggested to be a potential obesity prevention strategy, but the evidence that breast-fed infants have a lower risk of later obesity is equivocal. Fourteen studies published between 2003 and 2006 that considered the relationship between breastfeeding and risk of childhood overweight and obesity were reviewed. Three studies reported a protective effect in children (i.e., increased duration of breastfeeding was associated with a lower risk of childhood overweight/obesity), 4 reported a partial protective effect (i.e., only evident in a subgroup), 6 reported no protective effect, and 1 reported a protective effect in children but not in adults. While there is some evidence that breastfeeding may help to prevent childhood obesity, it should not be viewed as the only preventative nutrition measure. In the U.S., rates of breastfeeding have risen while rates for childhood obesity have increased dramatically. This finding reinforces the view that many factors are involved in maintaining a healthy body weight.*

**Key words:** *Childhood obesity, breastfeeding, infant feeding practices*

## Introduction

The prevalence of overweight and obesity is a public health problem in both developed and developing countries<sup>1,2</sup>. As a consequence, there is growing interest in developing effective public health interventions to address the obesity pandemic. Breastfeeding has been promoted as a potential obesity prevention strategy<sup>3</sup>, but the evidence that breast-fed infants have a lower risk of later obesity is equivocal. To be sure, breastfeeding provides optimal nutrition and many health benefits to babies and mothers. The American Academy of Pediatrics (AAP) and World Health Organization (WHO) recommend that infants should be exclusively breastfed until 6 months of age and that breastfeeding with appropriate complementary foods should be continued for the first year of life or beyond as long as mutually desired by the mother and her child<sup>4,5</sup>.

However, a focus on breastfeeding alone may not prevent overweight or obesity later in life. There is evidence that many infants may be at a higher risk of later obesity if the mother was overweight or obese before becoming pregnant<sup>6</sup>. Other prenatal characteristics, particularly ancestry, weight gain during pregnancy, and maternal smoking during pregnancy place a child at greater risk of becoming overweight<sup>6</sup>.

Infant feeding practices vary by geography and have changed overtime. This review considers the recently published evidence (2003 to 2006) of the relation between the duration of breastfeeding and risk of childhood overweight and obesity. Fourteen publications were identified that met certain selection criteria. In addition, three recently published meta-analyses that considered earlier studies, published from 1966 to 2003, were selected for review. As a point of comparison, trends in the prevalence of overweight among children and adolescents in the U.S. and the corresponding trends in breastfeeding were also considered.

## Prevalence of Overweight among Children and Adolescents in the U.S.

Body Mass Index, expressed as weight/height<sup>2</sup> (BMI; kg/m<sup>2</sup>) is typically used to classify overweight and obesity. In the U.S., cutoff criteria are usually based on the 2000 Centers for Disease (CDC) BMI-for-age-growth charts<sup>7</sup>. Based on current recommendations, overweight rather than obesity is the term preferred for describing children with a BMI-for-age  $\geq$  the 95<sup>th</sup> percentile for BMI

**TABLE 1**  
PREVALENCE OF OVERWEIGHT AMONG CHILDREN AND ADOLESCENTS AGES 6–19 YEARS,  
FOR SELECTED YEARS 1963–1965 THROUGH 2003–2004

Age (years) <sup>a</sup>	NHANES	NHANES	NHANES	NHANES	NHANES	NHANES	NHANES
	1963–65 1966–70 <sup>b</sup>	1971–	1976–80	1988–94	1999–2000	2001–02	2003–04
6–11	4.2	4.0	6.5	11.3	15.1	16.3	18.8
12–19	4.6	6.1	5.0	10.5	14.8	16.7	17.4

<sup>a</sup> Excludes pregnant women starting with 1971–74. Pregnancy status not available for 1963–65 and 1966–70.

<sup>b</sup> Data for 1963–65 are for children 6–11 years of age; data for 1966–70 are for adolescents 12–17 years of age, not 12–19 years.

of the sex-specific BMI growth charts<sup>8</sup>. For adults, BMI values at or above the 97<sup>th</sup> percentile are considered obese.

The most accurate data on overweight and obesity in the U.S. are derived from heights and weights that were measured as part of the National Health and Nutrition Examination Survey (NHANES) and previous health surveys<sup>9</sup>. As Table 1 shows, overweight in children and adolescents (ages 6–19 years) was relatively stable from the 1960s to 1980. From 1976–1980 (NHANES II) to 1988–1994 (NHANES III), the prevalence of overweight nearly doubled, from 7 to 11% in children ages 6–11 years and 5 to 11% in adolescents aged 12–19 years. The most recent data (NHANES 2003–2004)<sup>10</sup> indicate that since 1994, overweight in youths have increased to even higher levels: 19% among 6–11 year olds and 17% among 12–19 year olds. In 1999–2002, among boys, the prevalence of overweight was significantly higher among Mexican Americans (25.5%), than among non-Hispanic blacks (17.9%) or non-Hispanic whites (14.3%). Among girls, in 1999–2002, the prevalence of overweight was significantly lower among non-Hispanic whites (12.9%) than among non-Hispanic blacks (23.2%) or Mexican Americans (18.5%).

One of the U.S. national health objectives for 2010 is to reduce the prevalence of overweight in children to 5%<sup>11</sup>. Clearly, the data for adolescents are of notable concern because overweight adolescents are at increased risk for becoming overweight adults. »The 2003–2004 data for children and adults suggest the likelihood of another generation of overweight adults who may be at risk for obesity related health problems<sup>10</sup>.

### Breastfeeding Trends in the United States

The Department of Health and Human Services *Healthy People 2010* breastfeeding goals for the U.S. are: 75% in the early postpartum period and 50% at 6 months of age<sup>12</sup>. One of the main instruments used to monitor progress in meeting these goals is the Ross Laboratories Mothers Survey (RMS)<sup>13</sup>. The RMS is the longest-running and largest U.S. survey of breastfeeding trends. The survey has documented infant feeding trends since 1954 and the data from 1965 to 2003 are described here. Details of survey methodology and design have been pub-

lished elsewhere<sup>14–17</sup>. Two categories of breastfeeding are considered: (any) breastfeeding and exclusive breastfeeding. The breastfeeding category included all infants fed human milk or a combination of human milk and formula or cow’s milk (i.e., any breastfeeding). Exclusive breastfeeding included the subset of infants who were fed only human milk; no supplemental formula and/or cow’s milk were used. Information about the introduction and types of solid foods fed to infants was not collected. Rates of breastfeeding in the hospital and 6 months after delivery were evaluated.

As shown in Figure 1, initiation of breastfeeding and exclusive breastfeeding increased from 1971 to a high point in 1982 (61.9 and 55.0%, respectively). The prevalence of the initiation of breastfeeding and exclusive breastfeeding declined from 1983 to 1990. Since 1990, the prevalence of the initiation of breastfeeding dramatically increased 36%, from 51.5% in 1990 to 70.1% in 2002. In 2003, the initiation of breastfeeding declined to 66.0%. Initiation of exclusive breastfeeding increased slightly from 43.5% in 1990 to 46.3% in 2001 and declined to 44.0% in 2003. From 1997 to 2003, exclusive breastfeeding in the hospital held steady at around 44–46%.

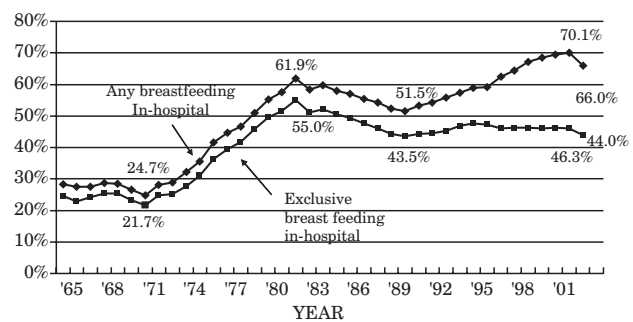


Fig. 1. Frequency of any and exclusive in-hospital breastfeeding, 1965–2003.

Trends in breastfeeding and exclusive breastfeeding at 6 months after delivery were similar to those seen in the hospital. As shown in Figure 2, breastfeeding and exclusive breastfeeding at 6 months after delivery increased from 1971 to a high point in 1982 (27.1 and 19.8%, respectively). The prevalence of continued breastfeeding

and exclusive breastfeeding at 6 months after delivery declined from 1984 to 1990. Since 1990, the prevalence of breastfeeding at 6 months after delivery nearly doubled to 33.2% in 2002, surpassing its previous high level in 1982. From 2002 to 2003, the rate of breastfeeding at 6 months after delivery declined to 32.8%. Since 1990, exclusive breastfeeding at 6 months after delivery increased steadily from 10.4% to 17.9% in 2003.

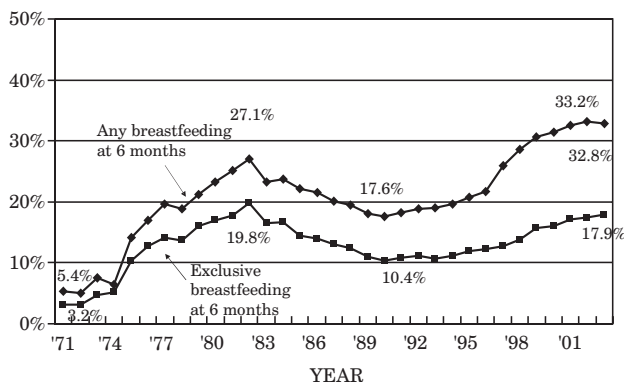


Fig. 2. Frequency of any and exclusive breastfeeding at 6 months of age, 1971–2003.

Ryan et al.<sup>16</sup> described rates for initiation of breastfeeding (any breastfeeding and exclusive breastfeeding) and continued breastfeeding to 6 months after delivery according to demographic characteristics in 2001 (similar findings are also observed in 2003). As in the initiation of any breastfeeding, exclusive breastfeeding in the hospital was most common among mothers who were Asian, older in age, college-educated, employed part-time, primiparous, residing in the Mountain and Pacific states, and did not participate in the Special Supplemental Food Program for Women, Infants and Children (WIC). The WIC program provides nutrition education, supplemental foods (including free infant formula), and referrals for health and social services for women and children who are income eligible and nutritionally at risk<sup>18</sup>.

At 6 months after delivery, as in the hospital, any and exclusive breastfeeding was most common among women who were Asian, older, college-educated, did not participate in the WIC program, and living in the Western and Pacific regions of the U.S. Any and exclusive breastfeeding at 6 months after delivery was also more common among women who had more experience (multiparous) or who were not working full-time outside their home.

Since the RMS began tracking breastfeeding in the U.S., the percentage of mothers who nursed their infants has fluctuated considerably. However, now, the RMS indicates that breastfeeding is more common than ever. Thus, rates for breastfeeding in the U.S. are at their highest levels, while at the same time, the prevalences of overweight among U.S. children and adolescents are also at their highest levels.

### The Evidence for a Possible Protective Effect of Breastfeeding on Risk of Childhood Overweight/Obesity

In an attempt to determine the extent to which breastfeeding may influence obesity, this paper considered recently published literature on the relationship between breastfeeding and overweight/obesity, and evaluated the overall consistency of reported associations, the consistency of definitions and variables considered, and the potential contribution of confounding variables.

The data retrieved for this review were based on a systematic search of all articles and review articles that were published between 2003 and 2006. Fourteen articles were identified (Table 2). Two of the studies evaluated sibling data to account for genetic and environmental factors. Three recent meta-analyses that reviewed studies published from 1966 to 2003 were also considered. Because the focus of the present study was on possible long-term protective effects, articles that only considered weight gain or BMI status during the first year of life were excluded. A list of excluded articles is available from the authors.

The definitions of obesity varied considerably among studies (Table 2). However, most studies used a percentile cutoff based on BMI, describing subjects at the tail of the distribution. The 90<sup>th</sup> or 95<sup>th</sup> percentile was used most often to describe the population as overweight or obese, respectively. Some studies used cutoff values as low as the 85<sup>th</sup> percentile and some used absolute BMI values, or levels of adiposity. Initial feeding status was ascertained through maternal recall of infant feeding, sometimes many years after birth.

The WHO defines exclusive breastfeeding as exclusive breastfed infants who did not receive any other food or liquid<sup>6</sup>. However, few studies reported or used this definition. The exclusiveness and duration of breastfeeding varied considerably and was based on the classification given in each article (Table 2). Seven studies were based on populations from North America, 5 from Western Europe, 1 from South America, and 1 from Australia.

#### Studies from North America (United States and Canada)

Bogen and her colleagues considered 73,458 low-income children enrolled in the WIC program in Ohio, U.S. from 1994 to 2001<sup>19</sup>. Height and weight were measured at 6-month intervals when recertification was required. Obesity at 4 years of age was defined as BMI  $\geq$  the 95<sup>th</sup> percentile of the 2000 CDC growth reference. Seventy-seven percent ( $n=56,361$ ) of the children were not breastfed, 7% ( $n=5,188$ ) were breastfed  $<8$  weeks, and 16% ( $n=11,913$ ) were breastfed  $\geq 8$  weeks. At 4 years of age, 11.5% of the children were obese. Breastfeeding was associated with a reduced risk of obesity only in white children whose mothers had not smoked during pregnancy. In this group, the reduction in the risk of obesity compared with those who were never breastfed, occurred only for children who were breastfed at least 16 weeks

TABLE 2  
STUDIES INCLUDED IN THE REVIEW OF THE ASSOCIATION BETWEEN BREASTFEEDING AND SUBSEQUENT OBESITY

First Author, location	Study design, sample size	Definition of breastfeeding	Definition of obesity	Results <sup>1</sup>
Bogen <sup>19</sup> , U.S.	Retrospective cohort study of 73,458 children who were enrolled in WIC program from 1994 to 2001. Subjects were followed from birth to 4 years of age.	Breastfed <8 weeks with or without formula; breastfed 8 to 15 weeks with formula; breastfed 8 to 15 weeks without formula; breastfed 16 to 26 weeks with formula; breastfed without formula; breastfed >26 weeks with formula; breastfed >26 weeks without formula vs. never breastfed	BMI $\geq$ 95 <sup>th</sup> percentile of CDC growth reference= obesity	Reduced risk of obesity only in white children whose mothers had not smoked in pregnancy. Reduction occurred only in children who were breastfed >16 weeks without formula or >26 weeks with formula.
Grummer-Strawn <sup>20</sup> , U.S.	Longitudinal study of 177,304 children included in WIC who were followed to 4 years of age. Links to pregnancy data in 7 states permitted analyses mother's age, education, prepregnancy BMI, weight gain during pregnancy, and postpartum smoking	Breastfed <1 month; 1–2 months; 3–5 months; 6–11 months; >12 months; vs. never breastfed	BMI >95 <sup>th</sup> percentile of CDC growth reference= overweight	Prolonged breastfeeding (>6 months) was associated with reduction in risk of overweight among non-Hispanic whites but not among non-Hispanic Blacks, or Hispanics.
Salsberry <sup>6</sup> , U.S.	6,283 women included in the National Longitudinal Survey of Youth were followed from 1979 until 2002. Children who were born to these women between 1982 to 1996 (n=3,022) were followed to the age of 7 years.	Ever breastfed; vs. no breastfeeding	BMI >95 <sup>th</sup> percentile of CDC growth reference=overweight	Breastfeeding was not associated with childhood obesity. Race, ethnicity, maternal, prepregnancy obesity, maternal smoking during pregnancy, and later birth years were associated with childhood obesity.
Burdette <sup>21</sup> , U.S.	Prospective cohort study of 313 children 5 years of age. Body composition was measured using dual-energy X-ray absorptiometry (DEXA)	Breastfed but also fed formula before 4 months; breastfed $\geq$ 4 months and fed formula after 4 months; breastfed 12 months and never fed formula; never fed formula; vs. never breastfed	Percent body fat in sex-specific highest quartile for cohort (>29% for females; 24% for males)	Neither breastfeeding nor the timing of the introduction of complementary foods was associated with adiposity.
Kuperberg <sup>22</sup> , Canada	Prospective cohort study of 102 First Nation children from Walpole Island, Ontario. The children were followed from 3 months to 48 months.	Exclusively breastfed $\geq$ 3 months; partially breastfed (exclusively breastfed <3 months); exclusively formula-fed from birth to 3 months.	BMI >85 <sup>th</sup> percentile of CDC reference= overweight	Overweight in children was associated with maternal BMI >25 and not infant feeding.
Bergmann <sup>23</sup> , Germany	Longitudinal study of 480 children included in the German Atopy Study (MAS), and followed from birth to 6 years of age.	Breastfed >3 months vs. bottle feeding	BMI, skinfold thickness >90 <sup>th</sup> percentile = overweight; >97 <sup>th</sup> percentile=adiposity	Maternal BMI $\geq$ 27, bottle feeding, maternal smoking during pregnancy, and low social status were associated with overweight and obesity.
Parsons <sup>24</sup> , UK	Cohort study that included all children born in England, Scotland, and Wales, March 1958 (n=12,857). Children followed from age 7 to 33 years.	Breastfed exclusively or partially >1 month; breastfed exclusively or partially <1 month; no breastfeeding; Unknown	BMI $\geq$ 30 in adulthood; BMI >95 <sup>th</sup> percentile in childhood	Breastfeeding was unrelated to BMI in childhood, to age 16 years in males, and 11 years in females. After adjustment for confounding factors, breastfeeding was unrelated to adult obesity.

TABLE 2  
CONTINUED

First Author, location	Study design, sample size	Definition of breastfeeding	Definition of obesity	Results <sup>1</sup>
Danielzik <sup>26</sup> , Germany	Prospective cohort study of 2,631 5–7-year-old children included in the Kiel Obesity Prevention Study (KOPS)	Breastfed 0 to <1 month; 1 to <3 months; 3 to <6 months; >6 months; vs. no breastfeeding	90 <sup>th</sup> –97 <sup>th</sup> percentile = overweight; >97 <sup>th</sup> percentile = obese	Overweight and obesity of children were associated with overweight and obesity of mothers, fathers and siblings. Parents of obese children smoked more cigarettes than parents of leaner children. A low SES was also a significant risk factor for overweight and obesity. For girls breastfeeding to 3 months had a small positive effect.
Kalies <sup>26</sup> , Germany	Prospective birth cohort of 2,624 children followed from birth until 2 years of age.	Exclusive breastfeeding <6 months; ≥6 months.	Elevated weight gain = weight gain ≥90 <sup>th</sup> percentile of sex-specific cohort	Children exclusively breastfed for <6 months had a significant greater risk of elevated weight gain than children breastfed for 6 months and more.
Kvaavik <sup>27</sup> , Norway	Prospective cohort study of 352 children included in the Oslo Youth Study. Data collected in the 1960s with follow-up data collected in 1979 (mean age of 13 years)	Breastfed 1–3 months; ≥4 months vs. never	BMI > 90 <sup>th</sup> age- and gender-specific reference = overweight; >97 <sup>th</sup> percentile = obese	Adolescents (age 11–16 years) who were breastfed ≥4 months had a lower risk of being overweight or obese. As adults (age 31–35 years) breastfeeding was not significantly associated with risk of overweight obesity.
Araujo <sup>28</sup> , Brazil	Cohort study that included 1,273 children from Pelotas Brazil followed from birth to 4 years of age.	Duration of any breastfeeding; Duration of predominant breastfeeding; ever breastfed vs. no breastfeeding	Weight-height Z-score >2 using NCHS reference = overweight	None of the 3 breastfeeding variables was associated with overweight.
Burke <sup>29</sup> , Australia	Longitudinal cohort study of 2087 children included in The Western Australian Pregnancy Cohort Study who were followed from 16–20 weeks gestation to 8 years of age.	Breastfed ≤4 months; 5–8 months; 9–12 months; >12 months vs. never breastfed	BMI >95 <sup>th</sup> percentile of CDC reference = overweight	From 1 to 8 years BMI scores associated with breastfeeding tended to converge and showed no statistically significant differences after adjustment for maternal factors.
Nelson <sup>30</sup> , U.S.	Prospective cohort study of 11,998 participants from the National Study of Adolescent Health aged 12 to 21 years. Subset of sibling pairs (n=850) was used to account for unmeasured genetic and environmental factors.	Breastfed <3 months; 3–5.99, 6–8.99, 9–11.99, 12–23.99; ≥24 months vs. never breastfed	BMI ≥85 <sup>th</sup> percentile of CDC reference=overweight	Odds for being overweight decreased as breast-feeding increased in girls. Breast-feeding among sibling pairs did not predict weight status.
Gillman <sup>31</sup> , U.S.	Prospective study of 5614 siblings included in The Growing Up Today Study. Study considered within-family analysis of siblings that were breastfed for different lengths of time. Children were followed until age of 9 to 14 years.	Breastfed 0, 0.5, 5, 8, and 11 months vs. no breastfeeding	BMI >85 <sup>th</sup> percentile of CDC reference=overweight	Breastfeeding protects against adolescent obesity. Adjusted odds ratio was 0.94 for each 3.7 month increment in breastfeeding duration.

without formula (odds ratio 0.71; 95% Confidence Interval [CI] 0.56–0.92) or at least 26 weeks with concurrent formula (odds ratio 0.70; 95% CI 0.61–0.81). Among white children whose mothers smoked during pregnancy and among black children, breastfeeding was not associated with a reduced risk of obesity at 4 years of age after adjusting for several covariates.

It is unclear why the relationship between breastfeeding and obesity differed between white children and black children. The authors suggested that the maternal-child relationship or postnatal diet and activity patterns may have differed between groups, but these variables were not considered in the analyses<sup>19</sup>.

Differences in the breastfeeding-obesity relationship between low-income white children and black children were consistent with the findings of Grummer-Strawn and Mei<sup>20</sup> who considered the duration of breastfeeding (up to 2 years of age) and BMI in 177,304 children at 4 years of age. The data were derived from the Centers for Disease Control and Prevention Pediatric Nutrition Surveillance System. The system tracks growth and the incidence of anemia in low-income children who attend public health clinics in the U.S. (such as WIC). The survey included children who were born between 1988 and 1992. Height and weight measurements were taken twice each year. Overweight was defined as >95<sup>th</sup> percentile of the 2000 CDC growth reference. The population studied had a relatively high percentage of overweight children (13.3%). Fewer than 30% of the general population was ever breastfed and only 6% were breastfed for >6 months. After controlling for a variety of potential confounding factors, the duration of breastfeeding showed a protective relationship with the risk of overweight only among non-Hispanic white children but not among non-Hispanic black or Hispanic children. Among non-Hispanic white children the adjusted odds ratio for overweight by breastfeeding for 6 to 12 months vs. never breastfeeding was 0.70 (95% CI 0.50–0.99). The odds ratio for breastfeeding greater than 12 months of breastfeeding vs. never breastfeeding was 0.49 (95% CI 0.25–0.95).

The National Longitudinal Survey of Youth's Child-Mother File included 6,283 women aged 14 to 21 years who were followed annually from 1979 until 1994 and biennially thereafter<sup>6</sup>. In 1986, children who were born to these women were followed from birth to 7 years of age. A total of 3,022 children born between 1982 and 1996 who had three consecutive interviews with complete data for infant feeding practices and BMI were included in the sample. Overweight was defined as >95<sup>th</sup> percentile of the 2000 CDC growth reference. Three age groups were considered: 2–3, 4–5, and 6–7 years. Breastfeeding was defined as yes vs. no in response to the question, »Was your child breastfed?« Approximately half (53%) of the children were ever breastfed. After controlling for several demographic characteristics, black children and Hispanic children were at a higher risk for overweight than white children (odds ratios 1.59; 95% CI 1.14–2.23 and 1.60; 95% CI 1.13–2.25, respectively). The strongest pre-

dictors of childhood overweight at 2–3, 4–5, and 6–7 years were maternal smoking during pregnancy and prepregnancy obesity, not infant feeding practices. The mechanisms by which maternal smoking during pregnancy and prepregnancy obesity may affect child weight status are not fully understood. The authors suggested that maternal smoking during pregnancy and prepregnancy obesity may not represent risk factors but instead serve as markers for an obesity promoting home environment<sup>6</sup>.

Using dual-energy X-ray absorptiometry to measure body composition, Burdette et al<sup>21</sup> considered 313 children 5 years of age. Data for infant feeding, and the timing of the introduction of complimentary foods were obtained from mothers when the children were 3 years of age. Children were classified as having high adiposity if they had a percent body fat in the sex-specific highest quartile (>29% for females and >24% for males). At 5 years of age, after adjusting for potential confounding covariates, there was no significant difference in adjusted fat mass between those ever breastfed and those never breastfed. Children who were breastfed for a longer duration and those who breastfed with supplemental formula did not have significantly lower fat mass than children who were never breastfed. Complementary foods introduced before or after 4 months of age did not affect fat mass. The study was limited by the fact that mothers in the sample had relatively high education levels and none of the subjects were Hispanic.

Kuperberg and Evers<sup>22</sup> considered BMI status and feeding practices among 102 First Nations children born between 1994 and 1995, living in Walpole Island, Canada, and followed from birth to 48 months of age. Infants were divided into three feeding groups: exclusively breastfed >3 months, partially breastfed (exclusively breastfed for <3 months), and exclusively formula-fed for <3 months. Overweight among children was defined as BMI >85<sup>th</sup> percentile of the 2000 CDC growth reference. Most infants were breastfed at birth (75%), but by three months of age 39.7% of mothers discontinued breastfeeding. A maternal BMI >85<sup>th</sup> percentile (odds ratio 6.75; 95% CI 1.1–41.9) was positively associated with a BMI ≥ 85<sup>th</sup> percentile in children. Infant feeding practices were not related to childhood overweight. The authors suggested that the lack of an association between infant feeding practices and BMI status indicates that other factors such as physical activity may have had a greater impact on early childhood obesity<sup>22</sup>.

### *Studies from the Western Europe*

The German Atopy Study (MAS) considered 480 children with complete data for BMI, triceps and subscapular skinfolds, and infant feeding practices. Children were followed to 6 years of age<sup>23</sup>. Infants formula-fed from birth or breastfed for <3 months were classified as »bottle-fed«, and those breastfed for ≥3 months as »breastfed.« A maternal BMI >27 kg/m<sup>2</sup>, »bottle-feeding«, maternal smoking during pregnancy, and low socio-economic status (SES) were risk factors for overweight and

adiposity at 6 years of age. It was unclear how much formula was consumed by infants who were classified as »bottle-fed.« Subjects enrolled had two first-degree relatives suffering from an allergy and/or had an elevated cord blood IgE level ( $>0.9$  KU), thus making comparisons to the general population difficult.

Parsons et al.<sup>24</sup> examined the relationship between breastfeeding and BMI in the 1958 British cohort, which included all children born in England, Scotland, and Wales in March 1958 and followed to 33 years of age ( $n=17,733$ ). BMI was measured at 7, 11, 16, and 33 years of age. BMI  $\geq 30$  kg/m<sup>2</sup> in adulthood, and BMI  $\geq 95^{\text{th}}$  percentile in children were the outcome variables. Breastfeeding was unrelated to BMI status in childhood (7 years), to age 16 years in males, and to age 11 years in females. After adjusting for several confounding factors, breastfeeding was unrelated to adult obesity. One of the limitations of this study was that the breastfeeding category included subjects that were exclusively breastfed or partially formula-fed.

To identify major risk factors for overweight and obesity in German children, the Kiel Obesity Prevention Study (KOPS) was started in 1996<sup>25</sup>. Between 1996 and 2001, 4,997 5-to-7 year old children were recruited and 2,631 completed the questionnaire. Breastfeeding was classified into four categories: 0 –  $<1$  month, 1 – 3 months, 3 –  $<6$  months, and  $>6$  months. Weight status of the child was classified according to German BMI percentiles: 90<sup>th</sup> to 97<sup>th</sup> percentile = overweight and  $>97^{\text{th}}$  percentile = obese. The prevalence of overweight in this population was lower than that observed in the U.S.: 9.2% in boys and 11.2% in girls, respectively. Parental obesity was the strongest predictor for developing overweight and obesity in children. A low SES was also found to be a strong risk factor. For girls, breastfeeding for 1 to 3 months had a small but significant effect on overweight (odds ratio 0.4; 95% CI 0.2–0.9).

In the prospective birth cohort study »LISA« (Influences of life-style factors on the immune system and the development of allergies in childhood) conducted in 4 German cities, 2,664 children were followed from birth to 2 years of age<sup>26</sup>. Height and weight were recorded at 3–10 days, 4–6 weeks, 3–4 months, 6–7 months, 10–12 months, and 21–24 months of age. Elevated weight gain was defined as a weight gain  $\geq 90^{\text{th}}$  sex-specific percentile of the cohort. Duration of exclusive breastfeeding was classified into two categories:  $<6$  months,  $\geq 6$  months. Children exclusively breastfed  $<6$  months had a greater risk of elevated weight gain at 2 years of age than children breastfed for  $\geq 6$  months (odds ratio 1.65; 95% CI 1.17–2.30).

Kvaavik et al.<sup>27</sup> considered BMI and infant feeding data from a cohort of participants ( $n=352$ ) in the Oslo Youth study (Norway) who were examined in 1979/1981 and again in 1999 (mean age 13 years). The participants of the Oslo Youth study were born in the 1960s. The breastfeeding variable was categorized as never, breastfed 1–3 months, and breastfed  $\geq 4$  months. Overweight and obesity in adolescence were defined as BMI  $>90^{\text{th}}$

and 97<sup>th</sup> percentiles, respectively using age- and gender-specific cutoffs derived from the Oslo Youth study. Although the sample sizes were small for adolescents ages 11–16 years ( $n < 30$ ), those who were breastfed  $\geq 4$  months had a lower risk of being overweight (odds ratio 0.27; 95% CI 0.13–0.56) and obese (odds ratio 0.15; 95% CI 0.03–0.72). As adults (age 31–35 years), breastfeeding was not associated with the risk of overweight or obesity. The authors suggested that with increasing age, environmental factors, which lead to obesity, may diminish any protective effect of breastfeeding<sup>27</sup>.

#### *Study from South America*

The effect of breastfeeding duration on the prevalence of overweight and on mean weight for height z-score was evaluated in 4-year-old Brazilian children included in the Pelotas birth cohort study<sup>28</sup>. All hospital-derived newborns during 1993 were enrolled. Breastfeeding duration information was collected at 6, 12, and 48 months of age. Four categories of infant feeding were considered: duration of any breastfeeding, duration of predominant breastfeeding (included teas and water), ever breastfed, and never breastfed. Only 4% of all children were never breastfed, while 18% were breastfed for  $\geq 12$  months. Height and weight measurements were taken at 48 months of age. Overweight was defined as a weight-height z-score  $>2$  using the National Center for Health Statistics (NCHS) reference curve. None of the breastfeeding categories was significantly associated with the prevalence of overweight or mean weight-height z-score. Contrary to most studies, the prevalence of overweight increased with a corresponding increase in breastfeeding duration. The findings provide insight into the relationship between breastfeeding and overweight in a low to middle-income developing country. In the U.S., breastfeeding is more common among more affluent and well-educated women. In Brazil, breastfeeding is not associated with high SES, therefore eliminating the inherent role of an important confounder<sup>28</sup>.

#### *Study from Australia*

Burke et al.<sup>29</sup> evaluated data from 2,087 children included in the Western Australian Pregnancy Cohort (Raine) Study, a birth cohort from Perth, Australia. Children were followed from 16 to 18 weeks of gestation to 8 years of age. Overweight was defined by NCHS 95<sup>th</sup> percentiles for weight-for-length at 1 year and BMI at 3, 6, and 8 years. Categories of any breastfeeding were defined as: breastfed  $\leq 4$  months, breastfed 5 to 8 months, breastfed 9 to 12 months, and breastfed  $> 12$  months. From 1 to 8 years of age, BMI z-scores associated with duration of breastfeeding tended to converge and showed no statistical differences after adjustment for maternal factors.

#### *Studies that Considered Siblings (United States)*

Using nationally representative U.S. data from the National Longitudinal Study of Adolescent Health, 11,998 participants were evaluated to determine the relation be-

tween breastfeeding and adolescent overweight<sup>30</sup>. Breastfeeding was also considered in a subsample of 850 sibling pairs to account for potential unmeasured genetic and environmental factors. Overweight was defined as BMI  $\geq$  85<sup>th</sup> percentile of the CDC growth reference. For the sibling analysis, the prevalence of overweight in siblings who were breastfed longer than the mean duration of their sibship was compared with those who were breastfed for a shorter period. Breastfeeding referred to any breastfeeding, with or without complementary foods and was categorized as never breastfed, or breastfed <3, 3–5.99, 6–8.99, 9–11.99, 12–23.99, or  $\geq$ 24 months. Age of participants ranged from 12 to 21 years. Among girls in the full cohort, the odds for being overweight declined among those who had been breastfed for at least 9 months (odds ratios ranged from 0.90 (95% CI 0.74–1.09) for <3 months of breastfeeding to 0.78 (95% CI 0.64–0.96) for  $\geq$ 9 months. A similar effect for boys was observed, but the trends were less consistent. In contrast, an analysis of sibling pairs indicated no evidence of a breastfeeding effect on weight. The sibling analyses suggested that the relationship between breastfeeding and obesity may not be causal but rather attributable to unmeasured confounding childhood risk factors for overweight<sup>30</sup>.

Gillman et al.<sup>31</sup> evaluated data for 5,614 siblings who were included in the Growing Up Today Study. This is an ongoing cohort study of 16,539 U.S. girls and boys aged 9 to 14 years at baseline in 1996. Mothers of participants were registered nurses. For analysis, duration of breastfeeding was converted to the values 0, 0.5, 5, 8, and 11 months. Overweight was defined as >85<sup>th</sup> percentile of the 2000 CDC growth reference. After adjustment for a wide set of potential confounding variables, the odds ratio for overweight among siblings with longer breastfeeding duration, compared to shorter duration was 0.92 (95% CI 0.76–1.11). The odds ratio was 0.94 (95% CI 0.88–1.00) for each 3.7 month increment in breastfeeding duration.

### *Meta-analyses of Breastfeeding and Childhood Obesity*

Three meta-analyses considered studies that were published from 1966 to 2003. Even though there was much overlap of the studies considered the authors presented different conclusions.

Arenz et al.<sup>32</sup> reviewed nine studies that met their inclusion criteria. Approximately 69,000 children were included in the studies. Only studies with adjustment for at least three of several confounding factors, including birth weight, parental overweight, parental smoking, dietary factors, physical activity, or SES were considered in the meta-analysis. Age at follow-up had to be between 5 and 18 years of age and BMI percentiles  $\geq$ 90<sup>th</sup>, 95<sup>th</sup> or 97<sup>th</sup>. The adjusted odds ratio was 0.78 (95% CI 0.71–0.85) indicating that breastfeeding reduced the risk of obesity in childhood.

Harder and colleagues<sup>33</sup> considered 17 studies that met certain inclusion criteria. To be considered, studies

had to report the odds ratio and 95% confidence interval of overweight associated with breastfeeding, report the duration of breastfeeding, and used exclusively formula-fed subjects as a reference point. Any definition of overweight or obesity was allowed. Results indicated that duration of breastfeeding was inversely associated with the risk of overweight. Each month of breastfeeding was associated with a 4% decrease in risk (odds ratio 0.96/month of breastfeeding; 95% CI 0.94–0.98).

Quigley<sup>34</sup> identified several major methodological problems with the study by Harder et al.<sup>3</sup>. The study did not consider ethnic background and the effect of SES. The definition of breastfeeding varied considerably: four studies used exclusive breastfeeding, eight used any breastfeeding, and five did not specify the definition. The meta-analysis was not conducted on adjusted odds ratios, and only 11 of 17 studies adjusted for possible confounding factors. Studies included in the meta-analysis also varied with respect to the definition of overweight. Quigley<sup>34</sup> repeated the meta-analysis of Harder et al.<sup>33</sup> in children 2 to 14 years of age using adjusted effects and BMI cutoffs. While breastfeeding appeared to be associated with a reduced risk of overweight, it was unclear whether the effect was due to confounding. Quigley<sup>34</sup> indicated that the number of studies analyzed by Harder et al.<sup>33</sup>, particularly those that adjusted for confounding variables, was too small to conduct a meaningful meta-analysis.

Owen et al.<sup>35</sup> examined the relationship between initial breastfeeding and BMI status throughout life. The meta-analysis was based on the mean differences in BMI between those subjects who were initially breastfed and those who were formula-fed. From 70 eligible studies (including data from unpublished studies), 36 mean differences in BMI were obtained. The meta-analysis considered the effect of several confounding variables including SES, maternal BMI, and maternal smoking during pregnancy. Any definition of overweight was allowed. Results indicated that the hypothesized protective effect of breastfeeding was not observed after adjustment for confounding factors. The authors concluded that there was evidence of small sample bias.

## **Discussion and Conclusions**

The strength of the association between breastfeeding and childhood overweight/obesity has been difficult to elucidate. The 14 studies considered here were markedly heterogeneous with respect to the definitions of breastfeeding; overweight and obesity; breastfeeding duration; age at follow-up; timing of introduction of solid foods; and control for confounding variables. Three studies reported a protective effect (i.e., increased duration of breastfeeding was associated with a lower risk of childhood overweight or obesity), four reported a partial protective effect (i.e., only evident in a subgroup), six reported no protective effect, and one reported a protective effect in children but not in adults.



The results of the 3 meta-analyses were also inconclusive. The studies that were included in the meta-analyses had the same limitations as those mentioned above. Meta-analyses cannot be better than the primary studies included in them. The assumption in a meta-analysis is that all the studies are measuring the same exposure and effect<sup>36</sup>. If the confounding variables are not considered in the primary studies, there will be potential bias in the meta-analyses. As a consequence, breastfeeding might be a surrogate for other factors that were not evaluated. Maternal overweight, maternal smoking during pregnancy, and SES are all related to breastfeeding and to childhood overweight/obesity; any of these factors may account for confounding. The meta-analyses considered here are particularly difficult to interpret because classical meta-analysis requires randomized controlled trials. Randomization on breastfeeding on an individual level is not ethical. Thus, there are no standardized randomized controlled trials on breastfeeding and obesity, making it difficult if not impossible to prove a cause and effect. Only cohort, cross-sectional, and case-controlled trials have been published.

Breastfeeding offers many benefits to the infant and provides the ideal balance of nutrients to help an infant grow and maintain a healthy body weight. Research indicates that breastfed infants are more likely to be leaner during the first year of life<sup>37</sup>, but the data are inconclusive as to the protective effects later in life. While breastfeeding may help, it should not be viewed as the only preventative infant nutrition measure against childhood overweight and obesity.

If there is an effect, it is nearly impossible to isolate it from other social and cultural factors associated with a mother's decision to breastfeed. A recent review of potential factors for childhood overweight indicated that parental overweight, rather than not breastfeeding, was the strongest risk factor for childhood overweight<sup>38</sup>. In a large U.S. nutrition survey, risk of overweight among young children 3 to 5 years of age was nearly tripled with maternal overweight<sup>39</sup>.

There is evidence for a significant education »nutrition gap« between recommended infant feeding practices and the average infant's diet. Today, U.S. infants are consuming about 20% more calories than necessary<sup>40</sup>. Twenty-nine percent of infants are fed solid food before reaching 4 months of age, the minimum age recommended for the introduction of solid foods. Seventeen percent of in-

fants drink juice before 6 months and 20% drink cow's milk before 12 months, contrary to the recommendation of the American Academy of Pediatrics<sup>41</sup>. Studies also indicate that almost a third of infants consume no fruit or vegetables, and among those who eat vegetables, french fries are the most common choice. Nearly 10% of infants 9 months to 11 months old eat french fries every day. More than 60% of infants eat dessert or candy at least once a day by the time they reach 12 months of age<sup>42</sup>. Thus, in the U.S., infants are being fed too much too soon of the wrong kinds of foods. All of this is evidence that a broader approach to infant nutrition, going beyond breastfeeding, may be essential to help ensure eating habits that are healthy and do not promote obesity.

As shown in this review, breastfeeding rates in the U.S. have risen steadily across the U.S. while obesity rates have increased dramatically. This finding reinforces the view that many factors are involved in establishing and maintaining a healthy diet and body weight. Unfortunately, the public debate on obesity prevention programs often ignores the importance of maintaining optimal overall infant and childhood nutrition and simply considers one potential factor – breastfeeding. Unless more is done to help parents improve the *total* diet of infants and children, the obesity epidemic is unlikely to recede. For children born in the U.S. in 2000, the risk for being diagnosed with type 2 diabetes in their lifetime is 30% for boys and 40% for girls<sup>42</sup>. While parents play the most important role in providing a healthy balanced diet for their children, other organizations and resources are essential to raise awareness and understanding of optimal nutrition. Parents, health care providers, industry, government agencies, and communities all must take an active role to expand access to nutrition education and create policies that foster optimal nutrition and healthy body weight.

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## DOJENJE I RIZIK OD DEBLJINE U DJETINJSTVU

### S A Ž E T A K

Dojenje se preporučuje kao potencijalna strategija prevencije pretilosti, iako su dokazi da dojena djeca imaju smanjen rizik da kasnije budu pretila, dvosmisleni. Ovaj rad donosi pregled četrnaest istraživanja publiciranih između 2003.g. i 2006.g., koje su razmatrale povezanost između dojenja i rizika od prekomjerne tjelesne težine i pretilosti u djetinjstvu. Tri istraživanja navode zaštitni učinak na djecu (tj. produljen period dojenja povezuju s nižim rizikom od prekomjerne tjelesne težine i pretilosti u djetinjstvu), u četiri je naveden djelomično zaštitni učinak (tj. prisutan samo u podskupini), a u jednom se navodi zaštitni učinak samo u dječjoj, ali ne i u odrasloj dobi. Iako neki dokazi upućuju na to da bi dojenje moglo prevenirati pretilost djece, ono se ne bi trebalo smatrati jedinom preventivnom nutricionističkom mjerom. U SAD-u su povećane stope dojenja, ali su i stope pretilosti djece dramatično porasle. Taj podatak potkrepljuje viđenje da je mnogo čimbenika uključeno u održavanju zdrave tjelesne težine. there is some evidence that breastfeeding may help to prevent childhood obesity, it should not be viewed as the only preventative nutrition measure. In the U.S., rates of breastfeeding have risen while rates for childhood obesity have increased dramatically. This finding reinforces the view that many factors are involved in maintaining a healthy body weight.