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BREAST FEEDING AND OBESITY PREVENTION IN CHILDREN

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Breast feeding is strongly supported by both governmental and medical professional organizations because of the numerous acknowledged benefits to both mother and infant. The American Academy of Pediatrics states that breast feeding is ideal nutrition and sufficient to support optimal growth and development for approximately the first 6 months of life and recommends that breast feeding be continued for at least 12 months of life (AAP, 1997).

With regard to the benefits to the breast fed infant, research in developed countries including the United States provides strong evidence that human milk decreases the incidence and severity of infectious diseases including diarrhea, lower respiratory infection, otitis media, bacteremia, urinary tract infection, and necrotizing enterocolitis due to immunologic components transferred from mother to child. There are a number of studies that show a possible protective effect of human milk feeding against sudden infant death syndrome, insulin-dependent diabetes mellitus, Crohn's disease, ulcerative colitis, allergic diseases, and obesity. Breastfeeding has also been related to possible enhancement of cognitive development (United States Breast Feeding Committee, 2007).

There are a plethora of studies that support health benefits to breast feeding mothers (La Leche League, 2008). Breast feeding stimulates the release of oxytocin from the pituitary, resulting in uterine contraction allowing for less postpartum bleeding and more rapid uterine involution. Lactational amenorrhea causes less menstrual blood loss over the months after delivery decreasing risk for anemia. Lactating women have an earlier return to prepregnancy weight over their non-breast feeding peers, delayed resumption of ovulation with increased child spacing, improved bone remineralization postpartum with reduction in osteoporotic hip fractures in the postmenopausal period, and reduced risk of ovarian and breast cancer. Prolactin, the hormone produced to sustain breast feeding, promotes a sense of well-being, reduction in stress-response, and feelings of attachment between mother and child. Breastfeeding offers the financial benefit of being essentially without cost, compared to the estimated cost of artificial feeding that is approximately \$1200 per child per year for the least expensive form that is powdered formula.

The focus of this paper is to provide a review of current research regarding the possible protective effect of breast feeding against childhood obesity. This relationship is of importance as the United States is not immune to the obesity epidemic in children (Institute of Medicine, 2008). Over the past 30 years, the childhood obesity rate defined as at or greater than the 95th percentile for age has tripled in children aged 2-5 years old and adolescents aged 12-19 years old, and doubled in children aged 6-11 years old. In 2000, the prevalence of obesity was 10% for age 2-5 year olds, and 15% for 6-11 and 12-19 year olds. The negative impacts of obesity and overweight on health and wellness during childhood are recognized to have negative health consequences that include diabetes mellitus, precocious puberty, fertility problems, hyperlipidemia, hypertension,

LITERATURE REVIEW

Von Kries et al., 1999:

A study by Von Kries et al. in 1999 supports a protective effect of breast feeding on childhood obesity in children 5 and 6 years old. This study specifically aimed to assess the impact of breast feeding on the prevalence of being overweight (defined by BMI above the 90th percentile) or obese (defined by BMI above the 97th percentile) in children entering school at the age of 5 or 6 in 1997 in rural Bavaria, Germany.

This cross-sectional study used data that was obtained at the time of a national obligatory health examination and questionnaires completed by the parents at the time of examination. Height and weight were measured as part of the routine examination allowing for calculation of body mass index (BMI = kg/m²). The questionnaire asked the child’s breast feeding history and duration of exclusive breast feeding such that exclusive breast feeding was defined as the child being fed no food other than breast milk. To assess additional confounders, questions were asked about the number of siblings, parents’ ages, child’s health, introduction of solids to the child’s diet, dietary habits, and parental smoking habits. The highest level of education attained by either parent was used as a marker for social class. The prevalence of obese children was calculated according to the duration of breast feeding. The appropriate chi-squared tests were used to compare several items in breast fed and non-breast fed children and their association with the child being overweight or obese. Logistic regression models were used to assess the impact of variables that were significantly associated (P<0.05) with both breast feeding and being overweight or obese. Confounding was assumed to have occurred if the odds ratio (OR) changed by greater than 10%. Confounders and independent risk factors were included in the final logistic regression model. Data was available for 9206 children, 4022 children who had never been breast fed and 5124 children who had ever been breast fed, and represented a 76.7% response rate.

Analysis of crude data before adjustment for potentially confounding variables showed a dose-dependent effect of the duration of breast feeding on the prevalence of overweight and obese in children at time of entry to school (table 1).

TABLE 1: DURATION OF BREAST FEEDING AND PREVALENCE (95% CI) OF BEING
OVERWEIGHT (BMI >90%ILE) OR OBESE (BMI >97%ILE) AMONG 5 AND 6 YEAR OLDS
LIVING IN RURAL BAVARIA

Duration of Breast feeding	Overweight	Obese
Never (n=4022)	12.6 (12.4-12.9)	4.5 (4.4-4.6)
Ever (n=5184)	9.2 (9.0-9.3)	2.8 (2.7-2.8)
Exclusively Breast fed for:		
≤2 months (n=2084)	11.1 (10.6-11.6)	3.8 (3.6-4.0)
3-5 months (n=2052)	8.4 (8.1-8.8)	2.3 (2.2-2.4)
6-12 months (n=863)	6.8 (6.1-7.6)	1.7 (1.6-1.9)
>12 months (n=121)	5.0 (1.1-8.8)	0.8 (0.2-1.5)

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The study assessed several indicators of the family's lifestyle in relation to the child being breast fed or not, as well as the tendency to being overweight or obese. Higher levels of parental education (≥ 10 year) and low birth weight were inversely associated with being overweight or obese, whereas maternal smoking during pregnancy and the child having his or her own bedroom were positively correlated. Full fat milk products were less frequently consumed by overweight children, and the consumption of low fat milk products was higher. Overweight children also ate less butter than children who were not overweight. All of these effects were modest when compared to parental education. This was the only factor that accounted for a shift of the OR toward unity by at least 10% which related breast feeding to being overweight or obese supporting a confounding effect of parental education as a marker for SES on tendency to breast feed.

Table 2 shows the dose dependent impact of breast feeding on being overweight or obese with calculation of the OR adjusted for level of parental education, maternal smoking during pregnancy, low birth weight, own bedroom, and frequent consumption of full fat products and butter. In children who had been breastfed for 6 months or more, the risks of being overweight or obese were reduced by $>30\%$ and $>40\%$, respectively, though this trend was not generally statistically significant.

TABLE 2: AOR (95% CI) OF THE DOSE DEPENDENT IMPACT OF BREAST FEEDING ON BEING OVERWEIGHT OR OBESE IN CHILDREN AGED 5 OR 6 IN RURAL BAVARIA

Duration of Breast feeding	Being Overweight	Being Obese
Exclusively Breast fed for:		
≤ 2 months (n=2084)	0.89 (0.73-1.07)	0.90 (0.65-1.24)
3-5 months (n=2052)	0.87 (0.72-1.05)	0.65 (0.44-0.95)
6-12 months (n=863)	0.67 (0.49-0.91)	0.57 (0.33-0.99)
>12 months (n=121)	0.43 (0.17-1.07)	0.28 (0.04-2.04)
Ever breast fed (n=5184)	0.79 (0.68-0.93)	0.75 (0.57-0.98)

There are some strengths and weaknesses to this study that must be considered when interpreting the results. Regarding the strengths of this study, data available through the existing infrastructure of a nationally obligatory health examination allows for less expense while obtaining a large sample size that strengthens the power of the study. Though the information was not specifically recorded for the purpose of the study, height and weight are objective measures allowing for accurate classification of overweight or obese, protecting the outcome variable from significant error. A limitation of most cross-sectional studies is ability to determine causation between exposure and outcome such that it is often difficult to determine if the exposure caused the outcome or exists concurrently with the outcome. Due to the nature of this particular exposure, breast feeding, being in the remote past and not ongoing, the measured outcome is known to occur temporally after the exposure strengthening the argument for causation and the conclusions of the study.

There were several limitations in the study design. Information obtained through questionnaires about the independent variable, breast feeding history, relies on the memory of the parents to obtain information about past events which is subject to recall

bias. Further, it is not possible to determine from this study if there is a culture that favors or opposes breastfeeding in the general population in Germany that might cause participants to consciously or unconsciously report more favorable results, a halo effect. There was a possibility of significant non-response bias as the response rate was 76.7%. It should be noted that the potential effect of non-response bias was found to be limited as the investigators analyzed differences between the responders and non-responders and found that the responders were more likely to have attended all well baby visits (70.6% versus 64.0%), but the mean BMI and the 90th and 97th percentiles for BMI were similar between groups (mean 15.36 versus 15.34, 90th percentile 17.70 versus 17.75, 97th percentile 20.12 versus 20.07) decreasing the possibility of potential error.

Confounding variables present a challenge for any study assessing an association with breast feeding, as the decision to breast feed is viewed as a personal choice but is believed to be influenced by attitudes, motivation, and personal circumstances. Further, confounding elements are not always obvious to the participant or the investigator and can lead to inaccurate conclusions about the results of a study. The investigators of this study obtained information about a variety of potentially confounding elements with regard to lifestyle, diet, exercise, medical history, smoking exposure, and SES. Indeed, it was found that parental education, a variable used as a surrogate for SES, shifted the OR by greater than 10%. In addition, the investigators believed that potential for confounding was substantial for maternal smoking during pregnancy, low birth weight, own bedroom, and frequent consumption of full fat products and butter products, so each of these elements were adjusted for in the final results. However, parental obesity was not accounted for in this study and has been demonstrated to be associated with childhood obesity, weakening the results of this study due to a potentially confounding effect (Whitaker, 1997).

Lastly, this study shows a visible and consistent trend of a dose dependent protective effect of breast feeding on overweight and obesity, but it must be noted that the CIs cross 1.00 and are wide in most cases, which weakens this proposed relationship. In general, this study was well done and sought to control for many potentially confounding factors to strengthen the validity of the conclusions.

Liese et al., 2001:

A second cross-sectional study was published in Germany in 2001 by Liese et al. and supported a protective effect of breast feeding on childhood obesity in children 9 and 10 years old. This study specifically aimed to assess the impact of breast feeding on the prevalence of being overweight defined by the 90th age and sex-specific percentile of the German BMI-for-age reference values in children attending fourth grade during the 1995/1996 academic year in Munich and Dresden, Germany.

Community-based random samples of children were studied using schools as sampling units for the International Study of Asthma and Allergies in Childhood (ISAAC). Data was obtained through a parental questionnaire that reported on infant nutrition such as breast feeding, current dietary habits, birth weight in categories, preterm birth, and twin status to name a few variables. With regard to breast feeding history, parents were asked if the child had ever been breast fed, the duration of breast

feeding, and the duration of exclusive breast feeding, worded to exclude formula, solid food, and juice. Kappa statistics were used to assess the reproducibility of the breast feeding questions. Recall for breast feeding information was highly reliable in Dresden ($k=0.69$) and Munich ($k=.84$), as was the information on duration (Dresden $K=0.84$, Munich $k=0.75$), while duration of exclusive breast feeding was moderate in recall accuracy (Dresden $k=0.57$, Munich $k=0.48$). In addition to completing the questionnaire, parents were asked to consent separately to a physical examination that measured height and weight. In Dresden and Munich, 34% of children in each city had complete data from both questionnaires and physical examinations and were eligible for inclusion in the study. The analysis included 1256 children from Dresden and 1332 children from Munich selected randomly from the eligible subjects. All analyses were conducted stratified by gender and city first before being presented in summary, only after ruling out major differences. Multivariate logistic regression was used to model the association between breast feeding and prevalent overweight and derive prevalence odds ratios and confidence intervals. All variables on breast feeding duration were included as design variables in the models, with the non-breast fed category serving as the reference group. Confounders considered in the study included German nationality, SES, environmental tobacco smoke, dietary habits, birth order, birth weight, preterm birth, and mother's and father's age at birth. Variables retained in the final multivariate model had to be statistically significant at the 0.05 level.

Analysis of demographic, socioeconomic and anthropometric characteristics of children stratified by city and gender yielded some notable differences. Almost all children in Dresden were of German nationality compared to Munich (>99% versus 86%, respectively). The average age at birth of Dresden parents tended to be substantially lower than that of Munich parents (25 years versus 28 years, respectively). There were no differences in the prevalence of low birth weight or preterm births. At age 9 to 10 years old, children in Dresden were lighter and taller than their Munich peers. Consequently, the prevalence of overweight was markedly lower in Dresden (girls 9.1%, boys 12.5%) than in Munich (girls and boys 17%). For breastfeeding history, a larger proportion of children were breast fed as infants in Dresden than Munich (87% versus 80%, respectively) though the breast feeding duration at each measured interval was shifted toward a shorter time in Dresden. Overall, the prevalence of overweight was higher in children who had never breast fed (Dresden 16.4%, Munich 24.3%) than those who had been breast fed (Dresden 9.9%, Munich 15.2%). Children who had ever been breast fed in both Dresden and Munich had about half the odds of being overweight, or a 40% reduction, compared to those who had never been breast fed (adjusted for age, sex, city, nationality, SES, and tobacco smoke exposure) (Table 3). Additional factors were considered, specifically preterm birth, birth weight, and dietary habits, but these factors did not influence the results and were therefore omitted from the final analysis. Note the strength of the afore-mentioned relationship diminished slightly when the cities were combined. A dose response-like relationship was observed between breastfeeding and overweight, regarding each city individually and combined, though the trend was not consistent in the Dresden population or consistently statistically significant in the Munich population or the combined population.

TABLE 3: AOR (95% CI) OF THE DOSE DEPENDENT IMPACT OF BREAST FEEDING ON

Duration of Breast Feeding	Dresden (n=1256)	Munich (n=1332)	Total (n=5288)
Never	1.0	1.0	1.0
Ever	0.55 (0.34-0.91)	0.54 (0.38-0.79)	0.66 (0.52-0.87)
Exclusive Breast Feeding Duration:			
None	1.0	1.0	1.0
<2 months	0.50 (0.28-0.88)	0.73 (0.48-1.11)	0.70 (0.49-0.99)
2-4 months	0.66 (0.38-1.13)	0.48 (0.31-0.76)	0.68 (0.48-0.98)
>5 months	0.40 (0.18-0.90)	0.40 (0.24-0.67)	0.51 (0.33-0.80)

Liese’s study has many strengths and weaknesses that need to be mentioned. As in Von Kriese’s study, this study was a cross-sectional study that utilized a large sample size and preexisting information to determine BMI affording similar strengths and weaknesses specific to these methods of data collection as previously discussed. It also utilized a parental questionnaire to obtain information about breastfeeding history and other history pertinent to the patient affording similar weaknesses (recall bias and halo effect), as previously discussed. Another problem present in the study was the possibility of significant non-response bias, though the investigators demonstrated moderate to strong accuracy of the data through kappa statistical analysis methods. The study adjusted for many possibly confounding variables. However, this study, as in the study by Von Kriese et al, did not account for parental obesity and weakened the validity of the study results as parental obesity is the strongest known risk factor for obesity in offspring (Whitaker, 1997). It should be noted that both German studies demonstrated an effect of breastfeeding on childhood obesity of similar order of magnitude, an approximately 40% reduction of odds, in two different age groups and in two different cities, strengthening the validity of the conclusion that a protective effect exists for breast feeding on adverse childhood weight. Lastly, there was a visible though inconsistent trend of a dose dependent protective effect of breast feeding on overweight, but it must be noted that the CIs frequently crossed 1.00 and were wide. In general, this study was well done and sought to control for many potentially confounding factors to strengthen the validity of the conclusions.

Hediger et al., 2001:

An American study by Hediger et al., in 2001 showed a risk reduction of being at risk for overweight (BMI 85th to 94th percentile) with a history of having been breast fed in children 3 to 5 years old. A similar relationship was shown with regard to being overweight (BMI >95th percentile), though the relationship was not as strongly supported by the data.

Information and child overweight status were taken from the National Health and

Nutrition Examination Survey IPI, a cross-sectional survey conducted by the National Center for Health Statistics/CDC from 1988 to 1994. Information was taken from birth certificates including sex, birth plurality, birth weight, birth order, and length of gestation. Region of residence was determined using US Census Bureau categories and definitions serving as a marker for SES. A questionnaire was completed by parents that allowed for report on parental level of education, mother's age at time of child's birth, smoking during pregnancy, maternal current weight and height allowing for calculation of BMI, and neonatal hospitalization. Information about infant feeding practices were obtained specifically to report breast fed children as those who were fully breast fed (no liquids daily other than breast milk or water), and duration of full breast feeding (less than 2 months, 3 to 5 months, 6 to 8 months, and 9 months or longer). Timing of introduction of solid foods was considered separately. Body weight and mass allowing for calculation of BMI was obtained using standard anthropometric techniques. BMI for age and sex was chosen as the primary dependent variable with a BMI between the 85th and 94th percentile corresponding to being at risk for overweight, and BMI >95th percentile as overweight. A sample of 2685 children were selected for inclusion as they were singleton pregnancies, appropriate birth weight (10th to 89th percentile by race), without significant medical problems that could have affected growth, and information was complete from the questionnaire and examination, representing 93.3% of the population for which any information was obtained. SUDAAN software, which incorporates the heterogeneity in survey weight along with the clustering effect in survey design, was used for statistical analysis and to estimate errors. The effect of duration of full breast feeding on child BMI was examined by multiple regression. The likelihood of being at risk of overweight and overweight among fully breastfed as compared with never breast fed children was estimated using the SUDAAN MULTILOG procedure that is an extension of traditional logistic regression. Possible confounding variables were selected for inclusion based on both forward selection and backward deletion, with the decision to include or delete based on changes in the significance and β values of the duration of breast feeding.

Table 4 shows a 37% reduction in risk of overweight (BMI 85th to 94th percentile) if ever breastfed, although the protective effect did not appear dose dependent. For overweight (BMI >95th percentile), a 16% reduction in risk was shown, though the relationship was not statistically significant, nor was there a clear dose dependent effect with duration. Adjustment for potential confounding by race/ethnicity, sex, age group, mother's BMI status, and the timing of introduction of solid foods was performed.

TABLE 4: PREVALENCE AND ADJUSTED ODDS RATIOS (95% CI) OF THE DURATION OF BREAST FEEDING AND WEIGHT STATUS FOR 3 TO 5 YEAR OLD CHILDREN FROM THE NHANES III STUDY.

Breast Feeding	Prevalence At Risk of Overweight	At Risk of Overweight	Prevalence Overweight	Overweight
Never (n=1398)	13.0 (1.2)	1.00	8.8 (1.1)	1.00
Ever (n=1158)	9.2 (1.3)	0.63 (0.41- 0.96)	7.6 (1.3)	0.84 (0.62- 1.13)
Duration in months:				
≤ 2months (n=567)	8.6 (2.1)	0.57 (0.32 1.02)	9.6 (2.2)	0.98 (0.67- 1.43)
3-5 months (n=231)	10.3 (2.9)	0.69 (0.35- 1.33)	6.2 (2.4)	0.70 (0.33- 1.48)
6-8 months (n=162)	8.1 (2.4)	0.55 (0.27- 1.12)	5.3 (1.8)	0.65 (0.34- 1.24)
≥ 9 months (198)	10.6 (3.1)	0.76 (0.32- 1.80)	6.7 (2.2)	0.75 (0.29- 1.95)

However, the study reports that there were factors that were significantly associated with child overweight in the multiple logistic regression models. Mexican American children were at significantly increased risk of overweight (AOR 1.76, 95% CI 1.05-2.94). Children were at moderately increased risk for being overweight with an overweight mother (AOR 1.54, 95% CI 0.93 – 2.57), but nearly 3 times more likely to be at risk of overweight with maternal obesity (AOR 2.97, 95% CI 1.88-4.69).

This study includes the smallest sample size of the studies discussed in this paper, and may account for the failure to find a statistically significant association and dose dependent protective effect of breast feeding on childhood weight problems. Information obtained from questionnaires was subject to recall bias and a halo effect, limitations discussed in the study by Von Kries. A notable strength of the study is that it obtained information about maternal obesity that has been shown to positively affect child weight in other studies and was found to hold true in this study. Also, the study utilized a design that accounted for many potentially confounding variables. Though the data did not support a statistically significant association between the study variables, the association was of a similar order of magnitude to the other studies discussed and supports a protective effect of breast feeding on childhood weight problems that is consistent with another American study with a larger subject population, addressed next.

Gillman et al., 2001:

This American study, in 2001, addressed the risk of overweight in relation to breast feeding as well as duration of breast feeding in older children and adolescents age 9 to 14 years old.

The subjects in the Growing Up Today Study are children of subjects in the ongoing Nurses' Health Study II, a cohort study of over 116,000 registered nurses. Children completed a survey in the fall of 1997 detailing report of age, sex, race or ethnicity, height, weight, Tanner Stage of sexual maturity, age of menarche for girls,

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television watching, diet and physical activity in the previous 12 months. The mothers of these children completed a supplemental questionnaire in 1997 reporting on child's birth weight, birth length, gestation, medical conditions during childhood, and infant feeding practices. Regarding feeding, mothers reported the predominant liquid feeding method in the first 6 months of life and the duration of any breast feeding. Mothers also provided information about introduction of solid foods, cow's milk, infant formula and type of formula. Mother's height and weight at age 18 years of age and in 1989, 1991, 1993 and 1995 were also reported. Maternal smoking habits, dietary restraint, history of weight cycling, diet, and physical activity were addressed. Estimates of household income were obtained as a measure of SES by mapping the subject's address using the US Census data from 1990. Subjects were excluded from the study if information was missing, mothers reported a gestation of less than 34 weeks, or the child had a history of a medical condition that might have interfered with growth, such that 15,341 study subjects were utilized. The 2 exposures of interest were predominance of breast feeding (mostly or only fed breast milk versus mostly or only fed formula) in the first 6 months and duration of breast feeding (less than 3 months versus at least 7 months). The outcome of interest was overweight defined as BMI exceeding the age- and sex-specific 95th percentile of US children. Logistic regression models were used to adjust for covariates including Tanner Stage, age, sex, television and physical activity, daily energy intake, mother's BMI in 1995, birth weight, birth order, household income, mother's smoking history, dietary restraints, weight cycling, and weight concerns. as these variables were known to be associated with adolescent obesity or statistical analysis suggested a high likelihood of a confounding effect. Of note, menarcheal status of female subjects did not suggest a confounding effect and was not included as a covariate. Information on overweight prevalence, ORs and 95% CIs were reported.

Table 5 shows age-adjusted mean adolescent BMI and proportions of subjects who were overweight by type of infant feeding in the first 6 months of life. In both sexes, mean BMI and prevalence of overweight generally rose across categories, with the lowest values in the breast milk only category, though no indication of statistical significance was reported in the study.

TABLE 5: MEAN AGE-ADJUSTED BMI AND PREVALENCE OF SUBJECTS CLASSIFIED AS OVERWEIGHT AT AGE 9 TO 14 YEARS, BY CATEGORY OF INFANT FEEDING IN THE FIRST 6 MONTHS

Category	Boys n=7155		Girls n=8186	
	Mean BMI	Prevalence Overweight	Mean BMI	Prevalence Overweight
Br Milk Only	18.9	7.1	18.8	4.1
Br Milk>Formula	19.1	7.9	18.9	4.4
Both Equally	19.3	10.8	19.0	4.5
Formula>Br Milk	19.5	12.0	19.1	6.2
Formula Only	19.3	10.0	19.3	6.8

Adolescents who were breast fed longer had lower age-adjusted mean BMI and generally had lower risks of overweight, though no indication of statistical significance was reported (Table 6).

TABLE 6: MEAN AGE-ADJUSTED BMI AND PREVALENCE OF SUBJECTS CLASSIFIED AS OVERWEIGHT AT AGE 9 TO 14 YEARS, BY DURATION OF BREAST FEEDING IN INFANCY

	Boys n=7155		Girls n=8186	
Months Duration	Mean BMI	Prevalence Overweight	Mean BMI	Prevalence Overweight
0	19.4	9.9	19.3	6.4
<1	19.4	15.5	19.1	6.6
1-3	19.4	11.6	19.1	5.2
4-6	19.1	8.6	19.0	5.0
7-9	19.1	7.9	19.0	5.3
>9	18.9	6.8	18.7	3.8

Using multivariate models, the study found that adolescents who were mostly or only fed breast milk versus mostly or only fed infant formula in the first 6 months of life were an approximately 22% lower risk of overweight (fully adjusted OR 0.78, 95% CI 0.66-0.91). Inverse associations were present between duration of breast feeding versus risk of overweight such that infants breast fed for at least 7 months were approximately 20% less likely to be overweight than those breast fed less than 3 months when adjusted for potentially confounding variables of Tanner stage, age, sex, television and physical activity, daily energy intake, mother's BMI in 1995, birth weight, birth order, household income, mother's smoking history, dietary restraints, weight cycling, and weight concerns (AOR 0.80, 95% CI 0.67-0.96). Mothers who fed their infants only breast milk in the first 6 months of life had the lowest mean BMI of 24.5, whereas those who fed their infants only formula had the highest mean value of 25.7 in a consistently dose-dependent relationship. Mothers' BMI was a strong predictor of offspring overweight when comparing mothers with BMI less than 25 versus greater than 30 (AOR 0.27, 95% CI 0.21-0.33). Variables not mentioned, such as solid foods, cow's milk, and infant formula choice, neither predicted the outcomes nor confounded (data not shown in study).

This study was a very thorough study showing the protective effect and dose dependent relationship of breast feeding on childhood obesity in 9 to 14 year old children in United States offspring of nurses, though specific strengths and weaknesses should be mentioned. Regarding study weaknesses, the study utilized questionnaires to obtain information from the mother about feeding history, medical history, and pregnancy circumstances. Children reported information about their own height and weight that was used to determine BMI, physical activity, eating habits, energy expenditure, and stage of puberty. Information from these questionnaires was subject to recall bias and a halo effect, limitations discussed in the study by Von Kries. The calculation of BMI in this study also depended on a child's recall of recent height and weight and was not objectively measured at the time of the questionnaire, which

added another potential source of error compared to the German studies previously discussed. Lastly, data reported with adjustment for potentially confounding variables demonstrated wide confidence intervals in most cases, weakening the strength of the proposed conclusions.

There are two concerning elements regarding the study population. Like the German studies, these investigators utilized an existing cohort of subjects being studied for another purpose. This allowed for a large sample size and increased power that strengthened the conclusions drawn by the investigators. However, no mention was made about the response rate, which is important when considering non-response bias. Also, considering the individuals studied, the subject population was not inclusive of the general population or a random selection of the general population. The initial study population was a group of registered nurses implying middle-class SES and a more homogenous group, minimizing variability of education and occupation that can make generalizability of the data to the general US population difficult.

Regarding strengths of the study, a notable strength of the study is adjustment for a large number of potentially confounding variables. In contrast to the German studies, a more direct measure of SES was obtained and analyzed for possible confounding, as SES has been shown to be independently associated with breast feeding (directly correlated) and obesity (indirectly correlated) (Ford, 2000). Also, maternal BMI was taken into account, and found that maternal overweight is correlated with child overweight, as has been shown in previous studies (Whitaker, 1997). Even after consideration for potentially confounding variables, substantial associations remained between breastfeeding and overweight and duration of breastfeeding and overweight after adjustment for potentially confounding variables. Also, a similar order of magnitude of protection was found regarding the effect of breast feeding on childhood overweight and obesity compared to German studies previously described, strengthening the validity of the conclusions.

Toschke et al., 2002:

A cross-sectional survey published in 2002 by Toschke et al. found a reduced prevalence of overweight and obesity associated with breastfeeding in individuals age 6 to 14 from the Czech Republic. The study subjects live in a setting where socioeconomic status was homogenous and the vast majority of infants are breast fed, affording less potential confounding compared to studies previously discussed.

Data was obtained in a nationwide anthropometric survey in 1991 from a representative sample of schools that were randomly selected across the Czech Republic. Parents completed a questionnaire that included information about breast feeding history and other life style factors. Additional information reported on the questionnaire included parental heights and weights, allowing for calculation of BMI, educational level, maternal smoking at time of data collection, child birth weight, presence of siblings in the home, physical activity of the child, and consumption of fruit. An anthropometric examination of children that included measurement of height and weight was performed in a standardized manor in physical education classes by teachers. Complete information was available for 33,768, or 97.7%, of the subjects and included

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in the study. BMI was calculated and dichotomized at age and gender-specific percentiles in overweight (>90th percentile) and obesity (>97th percentile) based on the examined population sample, which served as a reference sample for the Czech population. The prevalence of overweight and obesity were calculated by the duration of breastfeeding according to four categories: less than one month, >1 - ≤3 months, >3 - ≤6 months, and >6 months, though no distinction was made between exclusive and partial breast feeding. Confidence limits were based on binomial distributions at parental BMI ≥ 30 kg/m², educational level ≥ 10 years, maternal smoking, birth weight ≥ 4000 grams, daily television > 1 hour, having siblings, sport participation outside of school, and daily consumption of fruit. Crude odds ratios were estimated using chi-squared testing. Confounding was defined by a change of at least 10% of the odds ratio for breast feeding and overweight or obesity. All variables associated with overweight or obesity at a level of P<0.1 in the bivariate analyses were considered in logistic regression modeling.

Table 6 shows that 90.7% of children in the study were ever breast fed, and 9.3% of children were never breast fed. The prevalence of obesity was 3.2% (95% CI 3.0-3.4) in breast fed children, compared with 4.4% (95% CI 3.7-5.2) in non-breast fed children. Longer duration of breast feeding was associated with decreased prevalence of overweight, though no such duration-dependence effect was observed for obesity.

TABLE 6: DURATION OF BREAST FEEDING AND PREVALENCE (95% CI) OF OVERWEIGHT (BMI >90TH PERCENTILE) OR OBESITY (>97TH PERCENTILE) AMONG CZECH CHILDREN AGED 6 TO 14 YEARS.

Duration of Breast Feeding	Prevalence Overweight	Prevalence Obese
Never (n=3127, 9.3%)	12.4 (11.3-13.6)	4.4 (3.7-5.2)
Ever (n=30,641, 90.7%)	9.3 (8.9 – 9.6)	3.2 (3.0-3.4)
Duration:		
≤ 1 mo (n=9468, 28.0%)	9.7 (9.1 – 10.3)	3.3 (3.0-3.7)
>1 mo - ≤ 3 mo (n=14,892, 44.1%)	9.1 (8.6 – 9.5)	3.0 (2.8-3.3)
>3 mo - ≤ 6 mo (n=3869, 11.5%)	9.0 (8.1 – 10.0)	3.2 (2.7-3.8)
>6 mo (n=2412, 7.1%)	9.0 (7.9-10.3)	3.5 (2.8-4.3)

The study found higher prevalence for weight problems in children with parental obesity, maternal smoking, high birth weight and more than one hour of television watching daily. High parental education, sports outside of school, and having siblings were associated with lower prevalence of weight problems in children, though only parental obesity was found to potentially confound the relationship between breast feeding and childhood weight problems (data not shown). A 20% protective effect of breast feeding on overweight (OR 0.80, 95% CI 0.71-0.90) and obesity (OR 0.80, 95% CI 0.66-0.96) were found after adjustment for all of the mentioned variables.

The results of this study concur with those previously described, that breast feeding affords a protective effect against childhood weight problems in children age 6 to 14 in the Czech Republic. A unique element of this study is the homogenous population with

less potential for confounding by SES, as the Czech Republic at that time was a socialist country without major social differences between individuals. Further, the children in the study were overwhelmingly breast fed, providing control for other unascertainable, but potentially confounding, factors relating to personal choice, attitudes, and convenience that further strengthen the conclusions. Lastly, additional strengths of this dataset are its study size, very small degree of nonresponse, and completeness regarding potentially confounding factors, specifically maternal obesity. However, the study is limited by factors relating to cross sectional studies, such as recall bias and the use of the questionnaire as a means to obtain data, as previously discussed. The results of this study provide evidence for a biologically protective effect. An effect that is largely biological is also generalizable to the human population, as it is uncompromised by environmental effects and cultural elements. This study provides, perhaps, the strongest support for the protective relationship between breast feeding and childhood obesity.

CONCLUSION

Currently, there are approximately 20 studies worldwide addressing the effect of breast feeding on childhood obesity published since the 1960's. Five of the most recent publications are discussed in this paper addressing children and adolescents age 3 to 14 years of age in three countries. Each of the five publications utilized similar study designs in the form of a cross sectional survey with information obtained largely through questionnaires requiring parental recall as well as physical examinations. Each study attempted to adjust for factors found to be confounding in previously published papers as well as those that the investigators hypothesized could be confounding. Factors consistently found to confound the relationship between breast feeding and childhood obesity include parental obesity, parental education and SES, though no study was able to adjust for all potentially confounding variables. Each publication was able to provide support for the protective effect of breast feeding on childhood obesity and many provided support of a dose dependent effect regarding duration of breast feeding. The strength of the data to support the relationship varied greatly between studies. It is my impression that it is impossible to perform a study that perfectly accounts for all potential confounding while obtaining the power necessary to provide statistically significant results. However, collectively, the positive effect is shown to exist to some extent in each paper.

I believe a protective effect of breast feeding exists as one piece of many intertwined influences on childhood obesity including genetic makeup, lifestyle, diet, and physical activity. Further, breast feeding has been shown to positively impact other areas of health including disease prevention, bonding between mother and child, and affords a financial benefit to society. It is my opinion that women should be encouraged to breast feed to the extent that they are physically able within the first year of the child's life. This requires support in the form of comfortable and private areas while going into public and accommodations when returning to work. In turn, society will benefit from a populace who experience improved health, well-being, and decreased monetary expenditure for infant formula as breast feeding increasingly becomes the norm.

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