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Breastfeeding And Obesity Among Mothers And Children: A Double-Edged Sword

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BREASTFEEDING AND OBESITY AMONG MOTHERS AND CHILDREN: A DOUBLE-EDGED SWORD

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Abstract

Obesity continues to be a public health issue, especially among children and women of childbearing age. Breastfeeding results in weight loss among postpartum women, as well as protects growing children from obesity. To date, no reviews have simultaneously analyzed the impact of breastfeeding on obesity for mothers and children. In addition, this review is novel in that it provides evidence from both observational and intervention studies. The primary objectives of this systematic review of studies in the United States (2000-2013) are to: (1) describe the association between obesity and breastfeeding across the developmental lifespan (2) identify the impact of breastfeeding interventions for mothers the literature on breastfeeding and obesity interventions for mothers and children. Twenty-three studies met inclusion criteria. There was moderate evidence for intervention studies for obese women to exclusively breastfeed as well as lose weight, with a modest weight loss of 0.49 kilograms on average. Conversely, there was strong evidence for creating future interventions for childhood obesity that incorporate breastfeeding, with a dose-response relationship between the amount of time breastfed and the protective effect against obesity, ranging from 0.39 to 0.90. More emphasis needs to be placed on breastfeeding as beneficial for both mother and child, and this can be done by creating more comprehensive intervention studies with strong designs and large sample sizes.

Introduction

Approximately one half of women of childbearing age are overweight or obese, increasing the likelihood of complications such as gestational diabetes, preeclampsia, stillbirth and fetal macrosomia during pregnancy. [1] Furthermore, children of obese or overweight mothers have a higher risk of overweight and obesity in adulthood. [2] [3] Childhood obesity is a growing epidemic; rates in the United States have escalated to one in every three children being overweight or obese. Health outcomes for these children later in life include cardiovascular health risks, cancer, diabetes, mental health issues, bone and joint pain, and sleep apnea. [4] [5] [6] [7] [8] [9] [10] These girls and young women then have a higher risk of being overweight and obese mothers, which only perpetuates the cycle. [11]

Breastfeeding has numerous health benefits for children. According to The World Health Organization (WHO), "Breastfeeding is the most effective preventative measure to improve childhood health and survival."[12] WHO recommends exclusive breastfeeding for the first six

months of life followed by an appropriate combination of breast milk and complementary foods thereafter until one year of age. [13] Breast milk compared to formula has all of the necessary proteins, fats, carbohydrates, and vitamins that are essential for childhood nutrition and development. [14] There has been evidence that human milk is associated with increased IQ, nutrition, and immunity among children. Breast milk has also been found to result in decreased diabetes, respiratory infections, gastrointestinal infections, as well as a decreased risk of childhood obesity for children. [15] [16]

Breastfeeding also has benefits for women, which include maternity weight loss. [17] This has been attributed to the high energy cost of lactation coupled with normal energy needs that exceed energy intake. [18] It is estimated that lactating women demonstrate an increased metabolic state which results in an elimination of 200-500 extra calories. [19] This can aid mothers in losing fat and weight gained during pregnancy. Women who breastfeed lose more weight up until one year postpartum as compared to women who do not breastfeed. [20] In addition, breastfeeding reduces the risk of type II diabetes, breast cancer, ovarian cancer, and postpartum depression among women. [21] [22]

A recent systematic review found that obese women are less likely to initiate lactation as well as terminate breastfeeding earlier than their lean peers. [23] [24] This can serve as a major barrier to breastfeeding coupled with a lack of body comfort and confidence, as well as difficulty with suckling and attachment that accompanies overweight and obese women. [25] [26] This is a very important issue because weight gain during pregnancy can contribute to obese mothers during subsequent pregnancies as well as birth to children who are at risk of becoming obese due to breastfeeding barriers coupled with the genetic risks of obesity. This phenomenon is what has been deemed in this paper, a "*double-edged sword*," because obese mothers have the potential to create

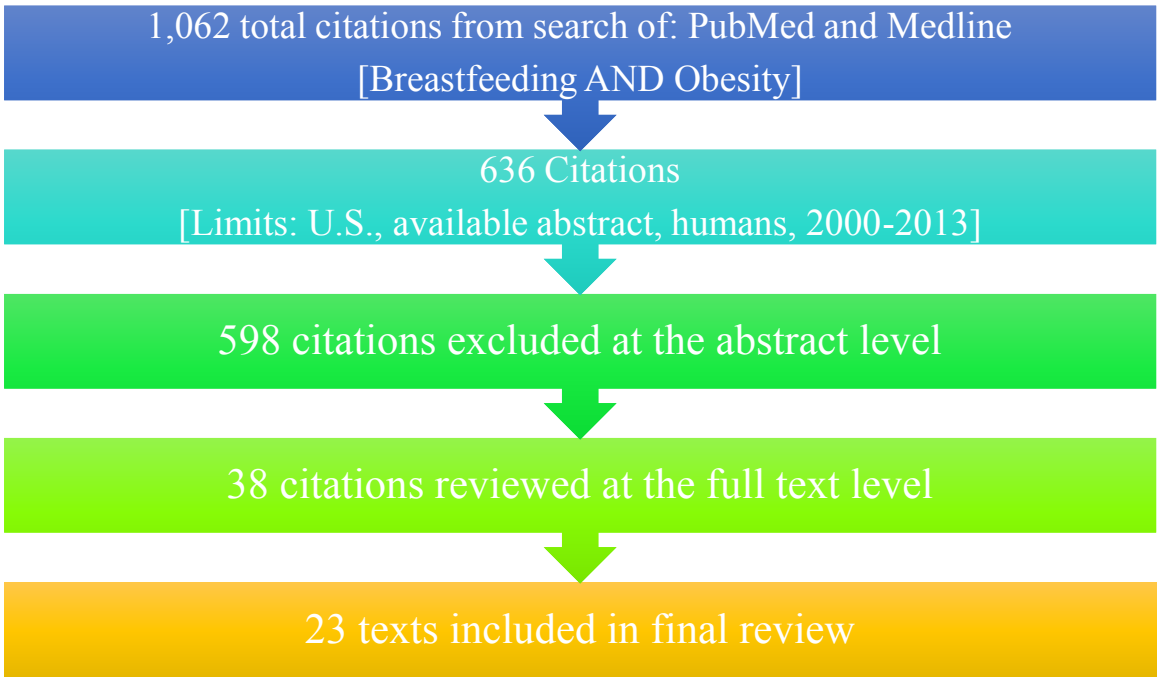
a vicious cycle of obese daughters, who later give birth to future generations of obese and overweight children by not breastfeeding. Mothers who do not breastfeed and have poor adherence due to difficulties latching as well as body image may forgo the benefits of weight loss from breastfeeding and remain overweight or obese mothers. Also, by not breastfeeding their children, children may forgo the protective effects of breastmilk and become overweight and obese daughters later in life. We must not look only at breastfeeding as beneficial for children, but also for mothers in terms of maternity weight loss. It is hypothesized in this systematic review that breastfeeding can have health benefits for both mothers and children in terms of lowering weight and decreasing obesity.

Observational studies have documented an association between breastfeeding and preventing childhood obesity. A meta-analysis by Weng et al. 2012 found that when comparing studies among breastfed infants to non-breastfed infants, there was a 15 percent decrease (95% CI 0.74 to 0.99) in the odds for childhood overweight for children who were breastfed. For mothers, the most recent systematic review in 2004 by Dewey and colleagues found that 6 of the 7 studies in the review demonstrated a higher weight and fat loss in women who breastfed longer, especially those who fed for at least 3-6 months postpartum. [27] No reviews to date are available on breastfeeding interventions for mothers and children. Few studies have approached breastfeeding as a means to intervene to address both maternal obesity as well as future childhood obesity. The purpose of this systematic review is to critically assess and review the evidence of breastfeeding benefits on weight status and retention to see if a combined intervention can work in the future. The two main aims are as follows: (1) describe the association between obesity and breastfeeding across the developmental lifespan (2) identify the impact of breastfeeding interventions for mothers the literature on breastfeeding and obesity interventions for mothers and children.

Methods

Ovid: Medline, Pubmed, and Google Scholar were searched using a combination of the MeSh terms *breastfeeding*, AND *obesity*. This search generated a total of 1,062 papers. These were screened and limited to: humans, English, the United States, available abstract, and years 2000 to 2013, which generated a total of 636 citations for review at the title and abstract level (*Figure 1*). From those citations, 598 were excluded for not meeting specific criteria in regards to breastfeeding as the exposure and the outcome of interest, obesity. Thirty-eight papers underwent full text review, which then led to 23 included studies for the systematic review. Papers were excluded for not measuring the exposure of interest, breastfeeding (4), taking place in a country besides the United States (7), and not measuring the outcome of interest, obesity (4). A more in-depth analysis of the 38 texts found that 23 articles specifically examined breastfeeding and obesity in one of the following contexts: maternal obesity, childhood obesity, or mother-child dyads. Eighteen studies were observational (78%), whereas 5 were intervention studies (22%). All of the interventions were randomized control trials with a control group. Obesity and overweight resulting from breastfeeding results from studies are reported by the following categories: pregnant and postpartum women (n=6) and infants and children (n=17).

Figure 1



Results

I. Pregnant and postpartum women

Table 1 describes the 6 papers that studied breastfeeding and obesity among pregnant and postpartum women. [28] [29] [30] [31] [32] [33] Four studies were randomized control trials (RCTs) and 2 were observational. The four RCTs specifically recruited overweight and obese women while the remaining two studies examined women regardless of weight status.

Weight retention between pregnancies:

The two observational studies that addressed weight retention between pregnancies by women via breastfeeding found a modest effect on weight loss from breastfeeding. The studies found less weight retention among women who breastfed. Krause et al. 2010 reported a retention of 1.38 kg less in exclusive breastfeeders than formula-feeders (0.89, 1.87; $p<0.0001$) and Ostybe

et al. 2010 found that breastfeeding for at least 20 weeks resulted in 0.39 kg less weight retention before a second pregnancy, p=0.025. These two studies were notable in that they recruited low-income women. Both included large samples of women enrolled in the North Carolina WIC program.

Interventions:

The RCTs shared a common thread of including some type of support for mothers to breastfeed. Some studies such as Wilthesis et al. 2013, mailed informational kits on dietary habits, while others like Rasmussen et al. and Ostbye et al. 2012 included calls from lactation specialists, or prenatal and postpartum visits as well as breastfeeding support in the study by Chapman et al. 2013. Exact protocol and specifics of the interventions can be found in the original papers. Two studies focused on exclusive breastfeeding rates and the remaining two focused on maternal weight loss.

Exclusive breastfeeding:

Two studies examined the effect of breastfeeding promotion interventions on exclusive breastfeeding among pregnant obese women; Chapman et al. 2013 and Rasmussen et al. 2011. Both studies found no effect in breastfeeding duration among obese women. In addition, both interventions were similar in that they were "baby-friendly" hospital based interventions and women were randomized to an intervention group or control group with standard of care. Subjects in both studies were recruited during pregnancy.

The intervention by Chapman et al. 2013 and colleagues included 3 prenatal visits, and up to 11 postpartum visits which promoted exclusive breast feeding as well as obesity-related breastfeeding barriers. The control group received standard of care from the hospital staff and

counselors. This study found that at 2-weeks postpartum, mothers enrolled in the intervention group were 3.67 times more likely to exclusively breastfeed than their control counterparts (1.07, 13.22), however there was not effect observed at months 1, 3, or 6. This study was notable in that it recruited low income and predominantly Hispanic women from Hartford, Connecticut. It is important to mention that low-income minority women have also been found less likely to breastfeed and are faced with barriers such as a lack of social support that may interfere with breastfeeding initiation and maintenance. Other factors such as postpartum fatigue, breast discomfort, anxiety, depression, and breastfeeding experience also impact these women. [34]

Rasmussen et al. 2013 is the first RCT that has been designed to improve breastfeeding among obese women. This study was broken into two RCTs: BIBS1 and BIBS2. The purpose of BIBS1 was to determine whether or not breastfeeding support, which included telephone calls from lactation consultants improved breastfeeding among obese women, and the second part, BIBS2 distributed an electric breast pump as the intervention versus manual control pumps to see if there was improved breastfeeding rates among obese women who intended on breastfeeding.

Analyses of BIBS1 found that Exclusive breastfeeding duration was 4.7 weeks shorter in the targeted-care than in the usual-care group, however it was not significant ($p=0.08$). And At 7 and 30 days postpartum, the proportion of women exclusively breastfeeding did not differ between the targeted and usual-care groups. Among women in the targeted-care group, the probability of still breastfeeding at this time increased with increasing BMI at delivery, while it decreased among those in the usual-care group. Analyses of BIBS2 found that women who received a pump breastfed for a shorter period than those who did not receive a pump ($p<0.04$) at 30 days postpartum. However, it is important to note that this study failed to randomize women of differing

BMIs to the intervention and control groups, which can explain this effect in the opposite direction as expected.

Weight loss:

Two additional RCTs examined the effect of breastfeeding on weight loss; Wilthesis et al. 2013 and Ostbye et al. 2012. The intervention by Wilthesis et al. 2013 included eight monthly educational kits via mail which focused on breastfeeding, managing stress, and making healthy changes in the home. In addition, the kits focused primarily on appropriate portion sizes, increasing fruit and vegetable consumption, reading labels, healthy and nutritious snacks, how to read food labels, grocery shopping lists with meal plans. Intervention women were also provided with a 20- to 30-minute telephone call from health coach in order to address the content of the kit's as well as motivation and barriers to change.

The intervention by Ostbye et al. 2012 contained 10 physical activity group sessions, 8 healthy eating classes, and 6 telephone counseling sessions over a 9-month period. Women were also given a workbook and an exercise stroller.

Wilthesis et al. 2013 found no difference in weight loss between the intervention (2.3 ± 5.4 kg) and control (1.5 ± 4.7 kg) groups as evident by the overlapping confidence intervals. Ostbye et al. 2012 found a modest weight loss of 0.49 kg by 2 years after giving birth. In addition, the range of weight loss found in this study had a maximum weight loss of 24.5 kg to a weight gain of 21.5 kg with a standard deviation of 7.4. When baseline weight was controlled for in this study, breastfeeding was associated with weight loss.

II. Infants and Children

Table 2 describes 17 papers that examined obesity among children who were breastfed or not. All studies reported some type of protective effect against obesity via breastfeeding which had a dose response effect more potent during infancy.[35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51] The majority of studies found that the longer that a child was exclusively breastfed or mixed feeding, the lower the risk of obesity. Follow-up ranged from 1 year of age up until adulthood. The majority of papers classified mothers as: exclusive breastfeeding, mixed breastfeeding and formula, or formula only.

Adiposity levels & BMI:

Crume et al. 2012 used adiposity levels as a proxy for BMI and found via a retrospective cohort that adiposity levels and visceral fat was lower in those with higher percentiles between the ages of 6-13 years old, however no effect was found for individuals under the 50th percentile. This may be good for those who are less lean. Toschke et al. (2007) also found that there was an inverse relationship between breastfeeding and body trunk fat mass percentage at the age of 9-10 years old with an odds ratio of 0.81 (95% CI: 0.75, 0.88) for total fat levels and an odds ratio of 0.78 (95% CI: 0.71, 0.84) for body trunk fat.

Weight gain:

Li et al. 2012 examined weight gain among infants who were exclusively breastfed versus those who received formula. Compared with infants fed at the breast, infants fed only by bottle gained 71to 89 grams more per month. This study also found that a 10 percent increase in the proportion of breastmilk feedings among children was associated with a 3.6 gram decrease in weight gain per month (P = .07), while a 10 percent increase in proportion of bottle-feedings was

associated with a 4.1 gram increase in weight gain per month ($P = .05$). Children were followed up until one year of age in this study. The study by Lindberg et al. 2012 also found that obese and overweight children at age 1 had 3.42 times the odds of being overweight and 3.36 times the odds of being obese and having unhealthy levels of body fat at ages 5–8.

Dose Response:

Twelve studies (71%) specifically calculated an odds ratio of obesity or adiposity in relation to breastfeeding. Overall studies found that children grouped in the categories with the longest breastfeeding duration and intensity exhibited the strongest protective effect via breastfeeding. The minimum duration for protective effects was found to be at least 4 months according to Bogen et al 2004 and up to 7 months and 9 months according to Gillman et al 2004 and Nelson et al. 2005. Li et al. 2008 found that the threshold for protective effects was at 80% of feeds via breastfeeding, with lower intensities exhibiting higher odds of obesity in childhood. The risk of obesity due to breastfeeding demonstrated a protective effect in all of the studies in which an odds ratio was reported, which ranged from 0.49 to 0.94. The studies by Lindberg et al. 2012 and Davis et al. 2012 had the greatest protective effects of 0.44 and 0.49 respectively. What was notable about studies on the lower end of the spectrum was that they were comprised of large samples of minority populations; Native American children ages 5-8 in the study by Lindberg et al. 2012 and Hispanic children in the study by Davis et al. 2012. The studies on the higher end of the spectrum were conducted by Michaels et al. 2007 which found an OR of 0.94 for women ages 18 and older who were breastfed for at least 6 months. The mothers of these women were part of the Nurses' Health Study and were predominantly white. This study was notable in that it had the longest amount of follow up time; did not measure BMI in childhood, but rather in adulthood.

Classification of mothers as obese or normal weight:

Two observational studies by Andres et al. 2012 and Mayer-Davis et al. 2006 were especially notable in that they specifically examined the effect of breastfeeding on children of overweight mothers. These studies were unique in that children were classified as being born to lean or overweight mothers, and were examined for breastfeeding behavior. The two studies differed in the time at which they assessed the children's weight, one was during infancy and the other was during adolescence.

The study hypothesis by Andres et al. 2012 was that body fat mass at age 2 weeks and 3 months would be higher in infants born to overweight mothers compared to infants born to lean mothers. This study found that infants born to overweight mothers had a higher body fat mas at 2 weeks and 3 months of age. The study by Mayer-Davis et al. 2006 classified mothers as either, "nondiabetes and normal weight," "nondiabetes and overweight", or "diabetes." Similarly this study found that breastfeeding was protective against obesity at 9 to 14 years of age with an odds ratio of 0.66 (95% CI: 0.53-0.82.). However, when examining maternal overweight and diabetes status, the study found no effect of maternal weight status on children's weight status at 9 to 14 years old.

Racial disparities:

It must also be noted that despite studies finding a protective effect against weight gain among children who were breastfed, it is important to note that two studies by Bogen et al. 2004 and Grummer-Strawn et al. 2004 found that these effects did not extend to black and Hispanic children, but only for white children. This must be addressed when creating culturally competent interventions for minority mothers and children in the future.

Intervention:

The only intervention study by Karanja et al. 2010 also found that BMI-Z scores among children decreased by 0.75 in Native American tribes B and C (P=0.016) which were randomized to nutritional home visits compared to tribe A which was randomized to only the community based media intervention. Despite the fact that the BMI's of the intervention group were on average higher than the pretest sample, the average BMI for tribes B and C were less than the BMI in tribe A. It is also important to note that it has been found that the population of American Indian children grow at faster rates than the general population. Because of this, for the purpose of this review, the results from the TOTS intervention study were interpreted as protective.

Discussion

Overall, this review found moderate supportive evidence that breastfeeding has the potential to protect both mothers and children from the troubling outcome of obesity. When analyzing the most recent literature of both intervention and observational studies and categorizing the results into studies of mothers and children, this review found that there was a moderate effect for breastfeeding for mothers and a strong effect among children to combat overweight and obesity. This review has found substantial support for the need of more intervention studies specifically for obese and overweight mothers to breastfeed for the health of their children as well as their own health. There is a need for stronger and more methodological studies, especially RCTs to promote breastfeeding to obese women while simultaneously addressing the barriers that accompany it.

Several mechanisms have explained the protective effect of breastfeeding against obesity. The first mechanism deals with regulation of appetite. There has been evidence that children who

breastfeed are able to learn how to control the amount of calories that they consume. Bottle-fed infants are sometimes forced to continue drinking despite being satisfied; therefore they have the potential to obtain more calories than they actually need. In addition, infant formula is extremely energy dense which arouses the body in response to secrete more insulin than what human milk does. This increase in insulin secretion then leads to increased body fat in formula fed children.[52] A combination of these factors is the current hypothesis as to how breastfeeding is protective against later childhood obesity.

In terms of weight loss from breastfeeding for mothers, must be noted that several studies found decreased weight from 0.39 kg to 1.3 kg among mothers, which is 0.86 pounds to 2.9 pounds, however this does not seem to be a significant amount of pre-pregnancy weight loss nor enough weight to change one's obesity status. We must further investigate how significant at this weight loss is for women of childbearing age and if these changes are enough to reduce BMI and cancel out deleterious health hazards of obesity. Research suggests that losing 10 percent of one's body weight can result in a decreased risk of breast cancer and cardiovascular disease. [53] It is not known exactly how much one's BMI must be decreased for lowered health risks, however the Department of Health and Human Services classifies weight by the following characteristics: healthy (18.5-24.9), overweight: (25-29.9), and obese (30 and greater). [54] These guidelines are generally used by physicians, and individuals are encouraged to move from the heavier categories to the lighter ones, however for children weight change percentages and BMI changes will be different and must be determined appropriate by physicians. Further investigation is needed to determine what amount of BMI loss is significant for health benefits, especially with children's differing needs for growth and nutrition than adults. However, it must be noted that these are some of the first studies to intervene on overweight and obese mothers and contained small sample sizes

with randomization that failed to distribute women equally to the control and study group. The very small samples and failure to randomize correctly can decrease the power and generalizability of the findings. Future studies in this area must address this limitation.

This systematic review was faced with several other limitations. First there is a scarcity of literature on interventions with a breastfeeding component and maternal childhood obesity in the United States. Much of this was due to a large proportion of studies that are still in progress or have recently ended and have unpublished results. [55] [56] [57] [58] [59] [60] Synthesis of results from these studies will be beneficial to designing future interventions.

In addition, other limitations include the self-report of weight for both mothers and children in a large proportion of these studies, which has the potential to bias the odds ratios towards the null and attenuate the effect size of the intervention. Breastfeeding status was also self-reported and due to social desirability bias, the actual rates of breastfeeding may differ than what was reported, therefore biasing the effect sizes away from the null and making breastfeeding appear to have a higher impact on weight status for both women and children. Also, in RCTs promoting breastfeeding duration and weight loss for mothers, we must take into account the baseline rates of breastfeeding among the control groups, which were not discouraged from breastfeeding, but rather were supplied with information and support on issues not related to breastfeeding. This may have diminished the effect between the intervention and control group, which was examined in this systematic review. Future studies should take this into account for the study design.

We must also address minority populations and the challenges that they have for breastfeeding and obesity related issues. In this systematic review, there was a mix of studies that analyzed breastfeeding and obesity among Native American tribes and individuals receiving

government assistance for food such as WIC and SNAP, however the majority of studies took place among predominantly white populations, such as the Nurses' Health Study, which enrolled women and children who were predominantly white, educated, and middle class. Within this review, several studies addressed the existence of health disparities, in which breastfeeding was not protective for all children, namely black and Hispanics. Future studies must address this need when creating interventions to promote breastfeeding.

In terms of generalizability of these concepts into practice we must think if these types of programs have potential in the U.S. where breastfeeding rates are lower. This is especially found among disadvantaged low-income minority women such as African-Americans and Latinos. Breastfeeding rates have been found to be higher among older women of higher SES. [61] Perhaps future interventions to target obesity should be tailored to these groups. If rates are lower in different settings, it may be difficult to encourage and then sustain prolonged breastfeeding for a minimum of 6 months by the WHO standards. An example is the TOTS intervention study which acknowledged the specific needs among the Native American women in the study and especially noted the fact that Native American children seem to grow and gain weight faster than their white counterparts. [62] Because of this, the intervention looked not for a decreased BMI compared to WHO standard growth curves, but between the intervention groups. Though the children in the study were heavier than the pretest sample and WHO standards, they gained less weight than the comparison group in the study, which was significant. Future studies will need to do the same when addressing specific communities, especially those with limited resources as well as those who are more susceptible to overweight and obesity. The designs of the three studies in this review overwhelmingly took place in disadvantaged areas which can be a model for other interventions in similar settings.

In conclusion, further studies are needed in which peer counselors educate mothers about breastfeeding in the specific context of measuring childhood overweight and obesity as well as maternal weight loss. Emphasis should also be placed on a standard protocol for these interventions as well as address adherence to breastfeeding. Further research needs to address this gap in the literature to develop sound methodological studies that are culturally appropriate for various settings and populations.

Table 1

Studies examining breastfeeding among women (n=6)

Study	Sample	Recruitment Site	Design	Assessment Interval	Breastfeeding measurement	Findings
Krause et al. (2010)	4,922 postpartum low-income women enrolled in the NC Supplemental Nutrition Program for Women, Infants, and Children.	NC Supplemental Nutrition Program for Women, Infants, and Children database.	Retrospective cohort	3 and 6 months postpartum	Full breastfeeding, mixed feeding, and formula feeding.	There was no association between breast-feeding and weight retention at 3 months postpartum. At 6 months postpartum, as compared to formula-feeders, mean weight retention was 0·84 kg lower in mixed feeders (95 % CI 0·39, 1·29; P = 0·0002) and 1·38 kg lower in full breast-feeders (95 % CI 0·89, 1·87; P ≤ 0·0001).
Ostbye et al. (2010)	32,920 racially diverse, low-income women ages 18 or older with at least one pregnancy and enrolled in the NC Supplemental Nutrition Program for Women, Infants, and Children.	NC Supplemental Nutrition Program for Women, Infants, and Children database.	Retrospective cohort	Time between the first pregnancy and the second pregnancy.	Self-report of duration and amount of breastfeeding. Weight and height were collected by staff.	Breastfeeding for 20 weeks or more resulted in 0.39kg (standard error (SE) 0.18) less weight retention at the beginning of the second pregnancy relative to no breastfeeding (p=0.025).
Chapman et al. 2013	206 pregnant, overweight/obese, low-income women.	Baby friendly hospital in Hartford, CT.	RCT	1, 3, and 6 months postpartum.	Exclusive (100% breast milk) or non-exclusive breastfeeding.	At 2 weeks postpartum, intervention mothers were 3.76 times more likely to EBF [95% confidence interval (CI): 1.07-13.22]) but no effect at 1, 3, or 6 months.
Ostbye et al. (2012)	450 overweight and obese postpartum women from the Active Mothers Postpartum (AMP) Study	Obstetric clinics in the Durham, North Carolina, area.	RCT	6 weeks, 12, 18, and 24 months postpartum.	Self-report. Full breastfeeding, breastfeeding and formula feeding [mixed feeding], or formula feeding only	The mean weight loss was 0.49 kg by 24 months with a maximum weight loss of 24.5 kg.
Rasmussen et al. (2011)	40 postpartum, obese women from the Bassett Improving Breastfeeding Study (BIBS) (BMI > 29 kg/m2) who intended to breastfeed and were at least 19 years old.	Hospital in rural NY with a breastfeeding friendly atmosphere.	RCT	90 days postpartum.	Duration of any breastfeeding and exclusive breastfeeding.	BIBS1: Exclusive BF was 4.7 weeks less in the intervention groups. At 7 and 30 days postpartum, EBF did not different between the intervention and control groups (p=0.08). At 90 days postpartum, the duration of breastfeeding was 4.3 weeks shorter in the intervention group (p<0.08). BIBS2: Women who received a pump consistently breastfed for a shorter period than those who did

						not get a pump ($p<0.04$). The proportions of women who breastfed at 30 days were no different among the intervention and control group ($p<0.004$).
Wilthesis et al. (2013)	400 overweight/obese postpartum women from 14 counties in the Piedmont region of North Carolina.	KAN-DO study	RCT	5 to 15 months postpartum.	Exclusive BF, mixed feeding, or formula- self report.	There were no significant differences in changes in diet quality, decreases in energy intake, or weight loss between the intervention (2.3 ± 5.4 kg) and control (1.5 ± 4.7 kg) arms.

Table 2

Studies examining breastfeeding and obesity among infants and children (n=17)

Study	Sample	Recruitment Site	Design	Assessment Interval	Breastfeeding measurement	Findings
Bogen et al. (2004)	73,458 white and black low-income children.	Ohio Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).	Retrospe ctive cohort study	Birth to 4 years old	Breastfeeding was categorized via WIC records as: ever breast-fed (yes/no), duration of breast-feeding (weeks), and age (weeks) when formula first began. Child weight came from medical records.	Only in white children was breast-feeding associated with a reduced risk of obesity: the reduction in obesity risk (adjusted odds ratio, 95% confidence interval), compared with those never breast-fed, occurred only for children who were breast-fed at least 16 weeks without formula (0.71, 0.56 to 0.92) or at least 26 weeks with concurrent formula (0.70, 0.61 to 0.81).
Crume et al. (2012)	442 children and adolescents (age 16-13)	Exploring Perinatal Outcomes Among Children Study (EPOCH)	Retrospe ctive cohort study	Birth to 13 years of age.	Breastfeeding was collected via recall and categorized as: adequate (≥6 breast milk-months) and low (<6 breast milk-months) neonatal breastfeeding status. Weight was collected via doctor records.	Adequate breastfeeding was associated with lower levels of adiposity levels for those in the upper percentiles (>60th percentile for VAT, 85th and 95th percentiles for BMI, and 95th percentiles for SAT and STR) and a null effect for those at the 50th percentile or lower.
Davis et al. (2012)	1,483 children between 2 to 4 years old; Hispanic.	Los Angeles WIC program.	Retrospe ctive cohort study.	Birth to 2-4 years old.	Breastfeeding was collected via recall and categorized as never breastfed, >1 week <6 months, 6 to <12 months, and ≥12 months. Weight was collected via WIC doctors' records.	In comparison with the no-BF participants, the odds of obesity were lower in the ≥12-mo-BF participants (OR: 0.55; 95% CI: 0.37, 0.83; P = 0.004).
Gillman et al. (2001)	8,186 girls and 7,155 boys.	Growing Up Today Study/Nurses' Health Study.	Retrospe ctive Cohort.	9-14 years old.	Self report: Children were classified as never breastfed, < 1 month, 1-3 months, 4-6 months, 7-9 months, or at least 9 months. Child weight was obtained via self-report.	Those who had been breastfed for at least 7 months had an adjusted OR for being overweight of 0.80 (95% CI, 0.67-0.96).
Nelson et al. (2005)	11,998 sibling pairs.	National Longitudinal	Retrospe ctive	Age 12-18.	Breastfeeding was categorized as never breastfed or breastfed	Among girls in the full cohort, the odds of being overweight declined among

		Study of Adolescent Health	cohort study		<3 months, 3-6 months, 6-9 months, 9-11 months, 12-24 months, or at least 24 months. Child BMI was calculated from clinic visits as normal, at risk for overweight, or overweight.	those who had been breast-fed at least 9 months; odds ratios ranged from 0.90 (95% confidence interval = 0.74-1.09) for <3 months of breast-feeding to 0.78 (0.64-0.96) for > or =9 months. A similar effect was seen in boys, although these trends were less consistent.
Toschke et al. (2007)	4,325 children aged 9-10 years old.	AVON Longitudinal Study of Parents and Children (ALSPAC)	Retrospe ctive cohort study.	9-10 years old.	Breastfeeding was self-report and categorized as never, less than three months and at least 6 months. Child weight was measured at 9-10 years old via clinic visits.	Breastfeeding was inversely associated with total fat mass [%change per category increase (4 categories)] in breastfeeding duration (4.4%; 95% CI: 3.1%, 5.6%) and trunk fat mass (0.5%;95% CI:1.1%, 0.1%); the odds of adiposity were measured by total [odds ratio (OR): 0.81; 95% CI: 0.75, 0.88] and trunk (OR: 0.78; 95% CI: 0.71, 0.84) fat masses in the top decile.
Hediger et al. (2001)	3,461 children with oversampling of black, Hispanic, and ages 2-71 months.	NHANES III.	Retrospe ctive cohort study.	Birth to age 3-5	Ever breastfed or never breastfed.	There was a reduced risk of overweight for "ever breastfed" children, OR=0.63 (0.41-0.96) compared with never breastfed. In addition, maternal BMI influenced risk of childhood overweight.
Nelson et al. (2005)	11,998 sibling pairs.	National Longitudinal Study of Adolescent Health	Retrospe ctive cohort study	Age 12-18.	Breastfeeding was categorized as never breastfed or breastfed <3 months, 3-6 months, 6-9 months, 9-11 months, 12-24 months, or at least 24 months. Child BMI was calculated from clinic visits as normal, at risk for overweight, or overweight.	Among girls in the full cohort, the odds of being overweight declined among those who had been breast-fed at least 9 months; odds ratios ranged from 0.90 (95% confidence interval = 0.74-1.09) for <3 months of breast-feeding to 0.78 (0.64-0.96) for > or =9 months. A similar effect was seen in boys, although these trends were less consistent.
Toschke et al. (2007)	4,325 children aged 9-10 years old.	AVON Longitudinal Study of Parents and Children (ALSPAC)	Retrospe ctive cohort study.	9-10 years old.	Breastfeeding was self-report and categorized as never, less than three months and at least 6 months. Child weight was measured at 9-10 years old via clinic visits.	Breastfeeding was inversely associated with total fat mass [%change per category increase (4 categories)] in breastfeeding duration (4.4%; 95% CI: 3.1%, 5.6%) and trunk fat mass (0.5%;95% CI:1.1%, 0.1%); the odds of adiposity were measured by total [odds ratio (OR): 0.81; 95% CI: 0.75, 0.88] and trunk (OR: 0.78; 95% CI: 0.71, 0.84) fat masses in the top decile.
Mayer-Davis et al. 2006	15,253 girls and boys and their mothers.	Growing Up Today Study (GUTS) participants were offspring of women who participated in the Nurses' Health Study II.	Retrospe ctive cohort	Age 9-14.	Maternal and child BMI was classified by self-report.	Compared with exclusive use of formula, the odds ratio of obesity (OR) for exclusive breast-feeding was 0.66 (95% CI 0.53-0.82). Results did not differ according to maternal status (nondiabetes/normal weight OR 0.73 [95% CI 0.49 –1.09]; nondiabetes/overweight 0.75 [0.57–0.99]; and diabetes 0.62 [0.24 –1.60]).
Grummer-Strawn et al. (2004)	246,371 low-income children who	Pediatric Nutrition	Prospecti ve cohort study.	Birth to 4 years old.	Weight and breastfeeding status was obtained from the Special Supplemental Nutrition Program for Women, Infants,	The duration of breastfeeding showed a dose-response, protective relationship with the risk of overweight only among non-Hispanic whites; no significant

	attend public health clinics.	Surveillance Program			and Children (SNAP) records. Breastfeeding status and duration was used.	association was found among non-Hispanic blacks or Hispanics. Among non-Hispanic whites, the adjusted odds ratio of overweight by breastfeeding for 6 to 12 months versus never breastfeeding was 0.70 (95% confidence interval: 0.50–0.99) and for >12 months versus never was 0.49 (95% confidence interval: 0.25–0.95).
Li et al. (2008)	1,896 mothers	Infant Feeding Practice Study II	Prospecti ve cohort study	Birth to 12 months.	"breastfeeding intensity," was calculated as the percentage of milk feedings in which the infant received breast milk, that is, [number of breast milk feedings/ (breast milk + formula + cow's milk + other milk feedings)] X 100% Breastfeeding was considered "high" if > 80% of milk feedings were of breast milk, "medium" if 20%–80% were of breast milk, and "low" if < 20% were of breast milk Mothers self-reported infants' weight.	Infants fed with low (< 20% of milk feeds being breast milk) and medium (20%-80%) breastfeeding intensity in the first half of infancy were at least 2 times more likely to have excess weight during the second half of infancy than those breastfed at high intensity (> 80%). Infants who often emptied bottles in early infancy were 69% more likely than those who rarely emptied bottles to have excess weight during late infancy.
Li et al. (2012)	1,899 infants.	United States recruitment panel.	Prospecti ve cohort study	Birth to 1 year of age.	Weight measurements were reported on 3-, 5-, 7-, and 12-month surveys. Infants were categorized via self-report as: (1) Breastfed only; (2) Breastfed and human milk by bottle; (3) Breastfed and nonhuman milk by bottle; (4) Human milk by bottle only; (5) Human and nonhuman milk by bottle; and (6) Nonhuman milk by bottle only.	Compared with infants fed at the breast, infants fed only by bottle gained 71 or 89 g more per month when fed nonhuman milk only (P < .001) or human milk only (P = .02), respectively.
Lindberg et al. (2012)	471 American Indian children aged 5-8.	WINGS cohort, Wisconsin Tribes.	Prospecti ve cohort study	Birth to 6 years of age.	Health screening for children weight. WIC records were used for duration of breastfeeding or formula feeding and was categorized into never, less than four months, or formula fed.	Significant predictors of children's BMI category at age 1 included and early termination of breastfeeding (OR 1.66). Children who were overweight/obese at age 1 had greater odds of being overweight (OR 3.42) or obese (OR 3.36), and having unhealthy levels of body fat (OR 2.95) and LDL cholesterol (OR 1.64) at ages 5-8.
Michaels et al (2007)	35,526 females; Predominantly white.	Nurses Health Study II	Prospecti ve cohort study.	Birth to 5, 10, 18, and current weight	Self-report of exclusive breastfeeding, duration, or formula. Self-report of height and weight.	Women who were exclusively breastfed for more than 6 months had a risk of 0.94 (95% confidence interval (CI) 0.83-1.07) of becoming obese as adults compared with women who were not breastfed. Exclusive breastfeeding for more than 6 months was associated with leaner body shape at age 5 (odds ratio (OR)=0.81;

						95% CI 0.65-1.01 for the highest vs the lowest category of body shape) compared to women who were not breastfed or breastfed for less than 1 week, but this association did not persist during adolescence or adulthood. The duration of breastfeeding, including exclusive breastfeeding, was not related to being overweight (25< or = body mass index (BMI) <30 kg/m(2)) or obese (BMI> or =30 kg/m(2)) during adult life.
Andres et al. 2012	65 infants born to lean mothers (n=46) (BMI 18.5 to 24.9) or overweight mothers (n=19) (BMI 25 to 29.9); 92% white.	Arkansas Nutrition Center	Prospecti ve cohort	2 weeks and 3 months.	All mothers were classified as exclusive breastfeeders. Mothers were classified as "lean" (BMI 18.5 to 24.9) or "overweight" (BMI 25 to 29.9) via displacement plethysmography to measure body fat for both mothers and children.	Body fat mass was higher in infants born to overweight mothers compared with infants born to lean mothers at age 2 weeks and 3 months (11.9% versus 15.3% and 24.1% versus 26.8%, respectively; P<0.05).
Karanja et al. 2010	Tribes from Idaho, Oregon, and Washington states Tribe A (n= 63 families) and Tribes B & C (n=142 families); Native American.	The Toddler Overweight and Tooth Decay Prevention Study (TOTS) Community Intervention	Randomi zed Control Trial.	Birth to 18-24 months.	Breastfeeding was defined as full, partial or mixed, as defined by the World Health Organization (WHO). Weight, height, and length of children was collected via clinic visits.	BMI-Z scores decreased by 0.75 in groups B and C (P=0.016) compared to group A. These BMIs were higher than the pretest group and WHO standard curve, but less than the intervention group without home visits.

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