ABSTRACT

Background: Breast-milk expression is widely practiced by American mothers, but little is known about who expresses milk, how expression affects breastfeeding, or whether overweight or obese women, who have less breastfeeding success than do normal-weight women, express milk differently.

Objectives: We investigated 1) whether breast-milk expression behavior differed by body mass index (BMI; in \( \text{kg/m}^2 \)) category and 2) whether the different breastfeeding behaviors of overweight (BMI: \( \geq 25 \) and \(< 30\)) and obese (BMI: \( \geq 30\)) women resulted in different breastfeeding outcomes.

Design: The subjects (\( n = 2288\)) provided information on BMI and breast-milk production, feeding, and expression in mail-in questionnaires as part of the Infant Feeding Practices Study II. Longitudinal and cross-sectional data were analyzed by using regression procedures adjusted for confounding.

Results: Women of different BMI categories overall did not differ in whether, when, or why they expressed breast milk. Before 2 mo postpartum, however, obese women were more likely (\( P = 0.04\), unadjusted) to try milk expression and were less likely (\( P = 0.01\), unadjusted) to express milk successfully. In addition, overweight or obesity was associated (\( P < 0.03\), unadjusted) with a shorter duration of breast-milk production only in women who never expressed milk. In overweight or obese women, those who ever expressed milk had longer durations of breastfeeding (\( P < 0.003\), unadjusted) than did those who never expressed milk.

Conclusions: Breast-milk expression behaviors may differ by maternal BMI category only in the early postpartum period. In addition, breast-milk expression may reduce differences between BMI categories in the duration of breastfeeding and support longer durations of breastfeeding.

INTRODUCTION

Human breast milk is recognized as the optimal infant food, and breastfeeding has many benefits for both infants and mothers (1–4). Although there have been improvements in recent years, rates of feeding breast milk have still not met national goals and large variations exist across geographic areas, racial-ethnic groups, and socioeconomic groups (5, 6).

National statistics do not indicate the proportion of women who express breast milk (obtain milk from the breast by hand or with a breast pump device) despite an increase in the availability and efficiency of breast pumps in recent years (7). In the Infant Feeding Practices Study II (IFPS II), a national study of infant feeding, investigators found that 85% of breastfeeding American mothers of infants aged 1.5–4.5 mo had expressed their milk successfully (obtained any milk by pump or hand expression) at some time since their infant was born (7). This finding underscores the importance of increasing our limited knowledge of milk expression practices.

Furthermore, given the high prevalence of overweight and obesity in American women of reproductive age (8), it is important to understand how maternal fatness affects infant feeding practices, including milk expression practices, on which there is currently no information. This is because overweight and obese mothers are less likely to initiate feeding breast milk (9–14) and continue to feed breast milk for shorter periods (9–17) than are normal-weight mothers as the result of a complex of biological and psychosocial factors (10, 14–21).

Researchers have found that breast-milk expression is associated with increased duration of feeding an infant breast milk (22, 23) and increased milk production (24) in normal-weight women. Currently, we have no information about how milk expression may affect feeding an infant at the breast. In addition, we have no information about whether prepregnancy body mass index (BMI) and milk expression are related.

In this study, we used data from the IFPS II to investigate the associations 1) between prepregnancy BMI and breast-milk expression and 2) among prepregnant overweight and obese mothers, between breast-milk expression and breast-milk production and feeding. Given that women differ by BMI in the duration of feeding breast milk (11, 16) and in difficulties producing milk (14), we proposed that, compared with women with a lower prepregnancy BMI, those with a higher BMI would have a greater likelihood of ever trying to express milk, be less successful at obtaining milk by expression, indicate different reasons for milk expression, and also initiate and cease milk feeding.

1 From the Division of Nutritional Sciences, Cornell University, Ithaca, NY (SAL and KMR); the Office on Women’s Health, US Department of Health and Human Services, Washington, DC (JL-W); and Cincinnati Children’s Center for Breastfeeding Medicine, Cincinnati Children’s Hospital, Cincinnati, OH (SRG).

2 Supported in part by the Rawlings Presidential Research Scholars program (to SAL), contract HHSP 223200710810P from the Food and Drug Administration (to KMR), and grant Hatch NYC-399307 from the US Department of Agriculture (to KMR).

3 Address reprint requests and correspondence to KM Rasmussen, 111 Savage Hall, Division of Nutritional Sciences, Cornell University, Ithaca, NY 14853-6301. E-mail: kathleen.rasmussen@cornell.edu.

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expression earlier. In addition, we proposed that, compared with overweight and obese women who never expressed milk successfully, those who did would have longer durations of producing milk, longer durations of feeding at the breast, longer durations of feeding breast milk (any and exclusively), be more likely to be satisfied with their duration of breastfeeding, and have different reasons for cessation of milk production.

SUBJECTS AND METHODS

Subjects

Data were collected for the IFPS II—a longitudinal study based on subjects recruited through a consumer panel—using 11 questionnaires that were mailed to 4900 women throughout the United States beginning in the seventh month of pregnancy through their infant’s first year of life. At 2, 5, and 7 mo postpartum, detailed data on milk expression behavior were collected, which we used for cross-sectional analyses regarding breast-milk expression. The study data were collected from May 2005 to June 2007. Detailed information on the study’s methods can be found elsewhere (25).

Of the 4900 women, 3033 completed the first postnatal questionnaire and met the criteria to be available for the study: the mother was ≥18 y of age, the infant was a full or nearly full-term singleton who weighed ≥2.27 kg at birth, both mother and infant were healthy at birth, and the infant did not have at birth or develop during the first year of life an illness or condition likely to affect feeding. To be eligible for this study, women needed to meet several additional criteria: have self-reported data on prepregnancy height and weight, have ever produced breast milk, and have answered questions regarding breast-milk expression (n = 2311). From this group, we excluded women who had extreme prepregnancy BMI (in kg/m²) values (≤15 or ≥60) that could violate their anonymity or inconsistent information about breast-milk production, expression, or feeding (n = 23); as a result 2288 women were included in the analyses presented here. This research was reviewed by the Institutional Review Board for Human Participants at Cornell University and was declared exempt.

Breastfeeding variables

New terms and related variables were created to differentiate several breastfeeding behaviors that occur simultaneously in dyadic breastfeeding but not necessarily when a woman expresses milk. Collectively, we will refer to these variables as “breast milk production and feeding.” The variable “fed at the breast” (FAB) refers to an infant ingesting human milk at the breast. Expressed breast milk and other liquids or solids may also have been ingested during the FAB period.

The variable “produced milk” (PM) refers to the time during which milk was removed from a woman’s breast by her (manually or with a pump) or by her infant. The expressed milk may have been fed to the infant by bottle or cup immediately after expression, stored and fed to the infant later, or may never have been fed to the infant.

In the IFPS II, it was not possible to establish the duration of milk expression, but it was possible to ascertain the time during which an infant was fed breast milk regardless of whether this was ingested at the breast or was expressed milk fed by bottle or cup. The variable “fed breast milk” (FBM) refers to the duration during which an infant received any breast milk. The variable “fed breast milk—exclusively” (FBM-ex) refers to an infant who ingested only breast milk with no other liquids or solids. The milk may have been ingested at the breast or fed with a bottle or cup if it had been expressed.

Variable creation

Seventeen additional variables were created by using existing variables in the IFPS II data set through categorization and combining variables from multiple questionnaires. These variables were used as, or to construct, explanatory and outcome variables, which are identified below in Statistical analyses. Each new variable and its creation are described in detail elsewhere (see Supplemental Table 1 under “Supplemental data” in the online issue).

Statistical analyses

We evaluated associations 1) between maternal prepregnancy BMI and breast-milk expression and production outcomes and 2) among overweight and obese women, between breast-milk expression and breast-milk production and feeding outcomes. We tested the former set of associations with longitudinal data (ie, whether the mother ever indicated expressing milk) and the latter set with cross-sectional data from months 2, 5, and 7 postpartum (ie, whether the mother indicated expressing milk on the month 2, 5, or 7 questionnaires, considered separately)—the times when detailed data on breast-milk expression were collected. We performed the cross-sectional analyses to consider the specific time periods when women expressed milk and their reasons for doing so.

Chi-square tests were used to compare key categorical variables and Student’s t tests, and analysis of variance was used to compare continuous variables among milk-expression and prepregnancy BMI groups, respectively. Chi-square tests were also used to compare the likelihood of being satisfied with the duration of breastfeeding as well as reasons indicated for both starting milk expression and ceasing milk production by BMI. Adjusted binary logistic regression models were also used to confirm results from the chi-square tests. For the dichotomous outcomes of ever trying to express milk and ever expressing milk successfully, binary logistic regression was used for analysis. For the analysis of infant age at cessation of milk expression, a dependent variable with ranked classes, ordinal logistic regression was used. When the assumption of proportional odds was violated, generalized logit modeling was used instead. For the time-to-event analyses of the PM, FAB, FBM, and FBM-ex and infant age at the start of milk expression, Cox proportional hazards regression was used. The proportional hazards assumption was checked by visually inspecting Kaplan-Meier log survival plots for each covariate for proportionality of the curves (26). When the assumption appeared to be violated, an interaction between the covariate and time was added to the regression model to account for nonproportionality.

All variables that differed significantly between subgroups or were important on the basis of past findings were initially retained in the regression models. The models were then reduced by using
backwards. The covariates that were used in analyses were maternal postpartum work status, education, race, age, and parity; household income as a percentage of the Poverty Income Ratio; delivery method; intended duration of breastfeeding; infant birth weight; and breast pump problem or injury. The covariates and their interactions with the main predictor variable of the model were also adjusted for in the regression models. All statistical analyses were conducted with SAS (version 9.2; SAS Institute Inc, Cary, NC). Differences for all tests were considered significant at \( P < 0.05 \).

**RESULTS**

No significant differences in baseline characteristics, such as socioeconomic status and prepregnancy BMI, were detected between women excluded from and included in the study. Women who ever expressed breast milk were of a higher socioeconomic status than were those who never expressed milk, based on household income and maternal education, and had longer intended durations of breastfeeding (see Supplemental Table 2 under “Supplemental data” in the online issue). A higher proportion of women who ever expressed milk was white, primiparous, or planned to feed only breast milk postpartum.

As BMI increased, socioeconomic status, based on household income and maternal education, decreased (see Supplemental Table 3 under “Supplemental data” in the online issue). A higher proportion of overweight and obese women than of normal-weight women was white or multiparous. Also, as BMI increased, maternal age, infant birth weight, and the proportion of women who had a cesarean delivery increased.

**Associations of prepregnancy BMI with breast-milk expression and production outcomes: longitudinal analyses**

Breast-milk expression was very common: \( \approx 80\% \) of women ever expressed or tried to express milk in every BMI category (Table 1, model a). No difference in trying to express milk was observed across BMI categories.

More than 90% of women who ever tried to express milk were able to obtain milk successfully in every BMI category (Table 1, model b). However, obese women had a lower odds of expressing milk successfully [unadjusted odds ratio (OR): 0.35; 95% CI: 0.16, 0.73] than did overweight or normal-weight women unadjusted (OR: 0.57; 95% CI: 0.34, 0.99). This difference was not significant after adjustment for covariates.

Expression began soon after delivery. Most women who ever tried to express milk began doing so by 1 wk postpartum. The infant’s age when a mother first expressed milk did not differ by her BMI category (Table 1, model c).

Once started, milk expression often continued for several months. Most women who ever expressed milk stopped doing so by 5 mo postpartum, but 40% continued to express after 5 mo (data not shown). No difference was observed between BMI categories in infant age when a mother last expressed milk (Table 1, model d).

Only 1 of 9 possible reasons for milk expression differed by prepregnancy BMI (see Supplemental Table 4 under “Supplemental data” in the online issue). Among women who ever expressed milk, a smaller proportion of obese (41.5%) than of overweight (50.5%) or normal-weight (49.9%) women indicated expressing milk so that someone else could feed their infant (\( P = 0.005 \)). The difference between BMI groups was not significant after adjustment for covariates in logistic regression.

Among those who never expressed milk, overweight or obese women had significantly (\( P < 0.05 \), unadjusted) shorter durations of PM than did those who were normal-weight (Figure 1). In contrast, no significant differences were observed by prepregnancy BMI in the duration of PM among women who ever expressed milk (Figure 2). Among women who never expressed milk, the median duration of PM was 11.0 wk in normal-weight women, 8.0 wk in overweight women, and 8.0 wk in obese women. Among women who ever expressed milk, the median duration of PM was 30.4 wk in normal-weight women, 30.1 wk in overweight women, and 25.8 wk in obese women. The differences in the duration of PM by prepregnancy BMI among women who never expressed were not significant after adjustment for covariates.

**Associations of prepregnancy BMI with breast-milk expression and production outcomes: cross-sectional analyses at 2, 5, and 7 mo**

Before 2 mo postpartum, obese women had a higher odds of expressing or trying to express milk (unadjusted OR: 1.55; 95% CI: 1.10, 2.18) than did overweight women (OR: 0.72; 95% CI: 0.54, 0.96). This difference was not significant after adjustment for covariates.

**Table 1**

<table>
<thead>
<tr>
<th>BMI Category</th>
<th>Model a: Ever expressed or tried to express milk</th>
<th>Model b: Median infant age at initiation of milk expression</th>
<th>Model c: Median infant age at cessation of milk expression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% yes</td>
<td>wk</td>
<td>mo</td>
</tr>
<tr>
<td>Normal weight (n = 1144)</td>
<td>82.2 (940)</td>
<td>1.0 [2.6] (443)</td>
<td>&lt;5 (397)</td>
</tr>
<tr>
<td>Overweight (n = 607)</td>
<td>81.9 (497)</td>
<td>1.0 [2.6] (322)</td>
<td>&lt;5 (207)</td>
</tr>
<tr>
<td>Obese (n = 357)</td>
<td>83.1 (446)</td>
<td>0.9 [1.6] (191)</td>
<td>&lt;5 (197)</td>
</tr>
</tbody>
</table>

\[ n \text{ in parentheses; interquartile range in brackets. Model a: binary logistic regression model, adjusted for maternal education and parity, household income as a percentage of the Poverty Income Ratio, and intended duration of breastfeeding. Model b: binary logistic regression model, adjusted for maternal education, race, and breast pump problem or injury. Model c: Cox proportional hazards regression model, adjusted for maternal parity. Model d: ordinal logistic regression model, adjusted for maternal education and postpartum work status, breast pump problem or injury, and intended duration of breastfeeding. There is no interquartile range for this model because of the categorical nature of the outcome variable.} \]
Table 2

(unadjusted OR: 1.50; 95% CI: 1.07, 2.12) than did overweight or normal-weight women.

Tables 3
gories in trying to express milk (\( \text{Table 2, model a} \)).

Among women who tried to express milk before 2 mo postpartum, obese women had a lower odds of expressing milk successfully (unadjusted OR: 0.38; 95% CI: 0.19, 0.79) than did overweight or normal-weight women (unadjusted OR: 0.54; 95% CI: 0.31, 0.29) (\( \text{Table 2, model b} \)).

In addition, no difference were observed between BMI categories in expressing milk successfully before 2 mo after adjustment for covariates. No differences between BMI categories in infant age were observed when a mother first expressed milk and in infant age when a mother last expressed milk at 2, 5, and 7 mo (Tables 2–4, models c and d).

Before 2 mo postpartum, women differed by BMI in 2 of 9 reasons for milk expression: a smaller proportion of obese (42%) than of overweight (51.2%) or normal-weight (50.7%) women indicated expressing milk so someone else could feed their infant (\( P = 0.006 \)) and a larger proportion of overweight (30.5%) and obese (30.4%) women than of normal-weight women (23.6%) indicated expressing milk to keep up their milk supply when their infant could not breastfeed (\( P = 0.03 \)). Using logistic regression, only the second difference was significant among BMI groups, and it remained significant after adjustment for covariates. No significant differences in the reasons for milk expression were observed between BMI groups after 2 mo postpartum.

Before 2 mo postpartum, obese women had significantly (\( P < 0.05 \), unadjusted and adjusted) shorter durations of PM than did normal-weight women among those who had never expressed milk, but not among those who ever expressed milk. This difference was not observed in cross-sectional analyses at 5 and 7 mo.

Associations of breast-milk expression with breast-milk production and feeding outcomes in overweight and obese women

Overweight women

Among overweight women, the median durations of PM, FAB, and FBM in women who ever expressed milk were 3.75 times those of women who never expressed milk (\( \text{Table 5} \)). The median duration of FBM-ex was 5.9 wk in overweight women who ever expressed milk compared with 0 wk in those who never expressed milk. However, parity modified the associations between expression and PM, FAB, FBM, and FBM-ex. Among primiparous women, there were greater increases associated with milk expression in the durations of breastfeeding than among multiparous women. Maternal education modified the associations between expression and PM and FBM. As maternal education decreased, there were greater increases associated with milk expression in the durations of PM and FBM. Maternal education after adjustment for covariates. After adjustment for covariates, there were also no significant differences. The covariates included maternal education, age, parity, and postpartum work status; intended duration of breastfeeding; and infant birth weight.

Before 2 mo postpartum, women differed by BMI in 2 of 9 reasons for milk expression: a smaller proportion of obese (42%) than of overweight (51.2%) or normal-weight (50.7%) women indicated expressing milk so someone else could feed their infant (\( P = 0.006 \)) and a larger proportion of overweight (30.5%) and obese (30.4%) women than of normal-weight women (23.6%) indicated expressing milk to keep up their milk supply when their infant could not breastfeed (\( P = 0.03 \)). Using logistic regression, only the second difference was significant among BMI groups, and it remained significant after adjustment for covariates. No significant differences in the reasons for milk expression were observed between BMI groups after 2 mo postpartum.

Before 2 mo postpartum, obese women had significantly (\( P < 0.05 \), unadjusted and adjusted) shorter durations of PM than did normal-weight women among those who had never expressed milk, but not among those who ever expressed milk. This difference was not observed in cross-sectional analyses at 5 and 7 mo.

Associations of breast-milk expression with breast-milk production and feeding outcomes in overweight and obese women

Overweight women

Among overweight women, the median durations of PM, FAB, and FBM in women who ever expressed milk were 3.75 times those of women who never expressed milk (\( \text{Table 5} \)). The median duration of FBM-ex was 5.9 wk in overweight women who ever expressed milk compared with 0 wk in those who never expressed milk. However, parity modified the associations between expression and PM, FAB, FBM, and FBM-ex. Among primiparous women, there were greater increases associated with milk expression in the durations of breastfeeding than among multiparous women. Maternal education modified the associations between expression and PM and FBM. As maternal education decreased, there were greater increases associated with milk expression in the durations of PM and FBM. Maternal work postpartum modified the association between expression and FBM. Milk expression was only associated with an increased duration of FBM among women who worked postpartum. Finally, infant birth weight modified the association between expression and FBM-ex. As infant birth weight decreased, greater increases in the duration of FBM-ex were associated with milk expression.

Overweight women who ever expressed milk did not differ from those who never expressed milk in whether they were satisfied with their duration of breastfeeding. Those who ever expressed milk (\( n = 487 \)) differed significantly (\( P < 0.05 \)) from those who never expressed milk (\( n = 120 \)) in 5 of 32 possible reasons for cessation of milk production, including the following: mother’s breasts were overfull or engorged (6.3% compared with 14.9%, respectively), breastfeeding was too painful (11.2% compared with 22.4%, respectively), pumping milk no longer seemed worth the effort (21.4% compared with 7.5%, respectively), the infant was old enough (16.1% vs. 6%
respectively), and the infant began to bite (17.8% compared with 6%, respectively).

**Obese women**

Among obese women, the median durations of PM, FAB, FBM, and FBM-ex were 3.2 times as long among those who expressed milk than among those who never expressed milk (Table 5). The median duration of FBM-ex was 3.4 wk in obese women who ever expressed milk compared with 0 wk in those who never expressed milk. Intended duration of breastfeeding modified the associations of expression and the durations of FBM and FBM-ex. As the mother’s intended duration of breastfeeding decreased, there were greater increases associated with milk expression in the durations of FBM and FBM-ex.

Obese women who ever expressed milk did not differ from those who never expressed milk in whether they were satisfied with their duration of breastfeeding. Those who ever expressed milk (n = 421) differed significantly (P < 0.05) from those who never expressed milk (n = 116) in 5 of 32 possible reasons for cessation of milk production, including the following: mother’s breasts were overfull or engorged (7.7% compared with 20%, respectively), breastfeeding was too painful (8.5% compared with 20%, respectively), mother’s nipples were sore, cracked, or bleeding (13.9% compared with 24.6%, respectively), pumping milk no longer seemed worth the effort (20.9% compared with 9.2%, respectively) and someone else wanted to feed the infant (9.7% compared with 18.5%, respectively).

**DISCUSSION**

Milk expression was not only associated with feeding an infant breast milk longer, but also with longer durations of all breast-milk production and feeding behaviors. These findings confirm the basic observation of Win et al (27) that mothers who expressed their milk were more likely to continue breastfeeding until their infants were 6 mo old than were mothers who did not express their milk. To our knowledge, there has been no previous investigation of an association between maternal BMI and milk expression. We observed, among those who never expressed milk, that overweight and obese women had shorter durations of milk production than did normal-weight women. However, this was not the case for women who ever expressed milk successfully. These results suggest that some of the unique challenges to sustaining milk production experienced by overweight and obese

### TABLE 2

<table>
<thead>
<tr>
<th>BMI category</th>
<th>Model a: Ever expressed or tried to express milk</th>
<th>Model b: Ever obtained milk if ever tried to express milk</th>
<th>Model c: Median infant age at initiation of milk expression</th>
<th>Model d: Median infant age at cessation of milk expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal weight (n = 1040)</td>
<td>% yes 85.2 (886)</td>
<td>% yes 96.6 (856)</td>
<td>wk 1.0 [2.6] (883)</td>
<td>mo &lt;5 (653)</td>
</tr>
<tr>
<td>Overweight (n = 532)</td>
<td>84.8 (451)</td>
<td>97.6 (440)</td>
<td>1.0 [2.6] (450)</td>
<td>&lt;5 (332)</td>
</tr>
<tr>
<td>Obese (n = 473)</td>
<td>89.6 (424)</td>
<td>93.9 (398)</td>
<td>0.7 [1.6] (424)</td>
<td>&lt;5 (292)</td>
</tr>
</tbody>
</table>

P value of model unadjusted for covariates:

- Model a: P = 0.04
- Model b: P = 0.01
- Model c: P = 0.32
- Model d: P = 0.26

1 n in parentheses; interquartile range in brackets. Model a: binary logistic regression model, adjusted for maternal age, education, postpartum work status, and parity; household income as a percentage of the Poverty Income Ratio; and intended duration of BF. Model b: binary logistic regression model, adjusted for maternal education, race, and parity and breast pump problem or injury. Model c: Cox proportional hazards regression model, adjusted for maternal parity. Model d: ordinal logistic regression model, adjusted for maternal education and postpartum work status, breast pump problem or injury, and intended duration of breastfeeding. There is no interquartile range for this model because of the categorical nature of the outcome variable.

### TABLE 3

<table>
<thead>
<tr>
<th>BMI category</th>
<th>Model a: Expressed or tried to express milk in past 3 mo</th>
<th>Model b: Obtained milk if tried to express in past 3 mo</th>
<th>Model c: Median infant age at initiation of milk expression</th>
<th>Model d: Median infant age at cessation of milk expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal weight (n = 622)</td>
<td>% yes 76.2 (474)</td>
<td>% yes 97.5 (462)</td>
<td>wk 1.0 [2.4] (473)</td>
<td>mo &gt;5 (404)</td>
</tr>
<tr>
<td>Overweight (n = 326)</td>
<td>82.8 (270)</td>
<td>98.9 (267)</td>
<td>2.0 [3.4] (270)</td>
<td>&gt;5 (229)</td>
</tr>
<tr>
<td>Obese (n = 255)</td>
<td>78.4 (200)</td>
<td>99.5 (199)</td>
<td>1.0 [2.4] (200)</td>
<td>&gt;5 (170)</td>
</tr>
</tbody>
</table>

P value of model unadjusted for covariates:

- Model a: P = 0.06
- Model b: P = 0.08
- Model c: P = 0.16
- Model d: P = 0.24

P value of model adjusted for covariates:

- Model a: P (adjusted) = 0.005
- Model b: P (adjusted) = 0.08
- Model c: P (adjusted) = 0.33
- Model d: P (adjusted) = 0.49

1 n in parentheses; interquartile range in brackets. Model a: binary logistic regression model, adjusted for maternal age, education, postpartum work status, and parity; household income as a percentage of the Poverty Income Ratio; and an interaction between BMI and intended duration of breastfeeding in women who intended to breastfeed for <12 mo; overweight or obese women were more likely to express or try to express milk in the past 3 mo than were normal-weight women. Model b: binary logistic regression model, adjusted for maternal education. Model c: Cox proportional hazards regression model, adjusted for maternal postpartum work status and infant birth weight. Model d: ordinal logistic regression model, adjusted for maternal education, postpartum work status, and intended duration of breastfeeding. There is no interquartile range for this model because of the categorical nature of the outcome variable.
women, such as latching on and positioning of the infant, may be ameliorated by breast-milk expression.

Women did not differ between BMI categories in whether, when, or why they expressed milk, except in one reason for milk expression. In other studies, investigators found that women did not differ by BMI in their knowledge of the benefits of FBM, intention to FBM, or attempting to FBM (10, 11), which may explain why we found that, overall, milk expression behavior was similar between women in different BMI categories. This interpretation is supported by the similarities in reasons given for milk expression between women in different BMI categories in the IFPS II. However, these overall results hide important findings that were visible only in our cross-sectional analyses. Women differed by BMI group in several milk expression behaviors before 2 mo but not at 5 or 7 mo postpartum. At 2 mo, obese women were more likely than overweight or normal-weight women to have tried milk expression and were less likely to have obtained milk when they did so. Obese women who expressed before 2 mo were also less likely than were normal-weight women to indicate that they were expressing their milk so someone else could feed the infant and were more likely to report that they expressed their milk to keep up their supply when the infant could not breastfeed.

### TABLE 4

<table>
<thead>
<tr>
<th>BMI category</th>
<th>Ever expressed (n)</th>
<th>Median duration of PM</th>
<th>Median duration of FAB</th>
<th>Median duration of FBM</th>
<th>Median duration of FBM-ex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal weight (n = 506)</td>
<td>59.3 (300)</td>
<td>30.1 [39.6]</td>
<td>30.1 [39.6]</td>
<td>5.9 [27.7]</td>
<td></td>
</tr>
<tr>
<td>Overweight (n = 245)</td>
<td>66.5 (163)</td>
<td>8.0 [20.8]</td>
<td>8.0 [20.8]</td>
<td>0 [5.3]</td>
<td></td>
</tr>
<tr>
<td>Obese (n = 202)</td>
<td>55.9 (113)</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>0.0024</td>
</tr>
</tbody>
</table>

### TABLE 5

<table>
<thead>
<tr>
<th>BMI and milk-expression category and model</th>
<th>Median duration of PM</th>
<th>Median duration of FAB</th>
<th>Median duration of FBM</th>
<th>Median duration of FBM-ex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overweight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never expressed (n = 120)</td>
<td>8.0 [20.8]</td>
<td>8.0 [20.8]</td>
<td>8.0 [20.8]</td>
<td>0 [5.3]</td>
</tr>
<tr>
<td>P value of model adjusted for covariates</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>0.0024</td>
</tr>
<tr>
<td>Obese</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ever expressed (n = 421)</td>
<td>25.8 [39.1]</td>
<td>25.8 [39.2]</td>
<td>25.8 [40.6]</td>
<td>3.4 [31.1]</td>
</tr>
<tr>
<td>P value of model adjusted for covariates</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>0.0005</td>
</tr>
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</table>

1 Interquartile range in brackets. PM, duration mother produced breast milk (fed at the breast or expressed); FAB, duration infant was fed at the breast; FBM, duration infant was fed any breast milk (at the breast or expressed); FBM-ex, duration infant was fed any breast milk exclusively. All analyses were performed with Cox proportional hazards regression and adjusted for intended duration of breastfeeding.

2 Also adjusted for maternal education, race, and parity. There were interactions between milk expression and education and between expression and parity.

3 Also adjusted for maternal education and parity. There was also an interaction between expression and parity.

4 Also adjusted for maternal age and parity. There were interactions between expression and postpartum work status, between expression and education, and between expression and parity.

5 Also adjusted for intended duration of breastfeeding for time due to nonproportionality. There were interactions between expression and parity and between expression and infant birth weight.

6 Also adjusted for maternal education, postpartum work, and parity.

7 Also adjusted for parity. There was an interaction between expression and intended duration of breastfeeding.

8 Also adjusted for maternal age. There was an interaction between expression and intended duration of breastfeeding.
These results support our hypotheses that obese women would have more difficulties producing milk, would be more likely to try expressing their milk, and would be less successful at obtaining milk, but these hypotheses were true only in the first several weeks after birth. It is possible that once women overcome breastfeeding difficulties soon after delivery, differences between BMI groups become less pronounced. Our results support those of Mok et al. (14), who found that obese women were more likely to experience breastfeeding difficulties but were not more likely to stop breastfeeding than were normal-weight women. They proposed that obese women who maintained any breastfeeding may represent a strongly motivated group who develop greater self-efficacy as they overcome breastfeeding challenges early postpartum. Our results are also in accord with our prior observations that most of the differences in breastfeeding behavior between the BMI groups is established in the first weeks postpartum (10).

Although >94% of women in each BMI category who ever tried to express milk were able to obtain milk successfully, obese women were about twice as likely to fail to obtain milk as were nonobese women. The increased risk of failing to express milk successfully experienced by obese women is not surprising given our findings (10, 15, 16) and those of others (9, 11–14, 17) that overweight and obese women had shorter durations of feeding breast milk.

The reasons why obese women have less success with breast-milk expression may be related to the reasons why they have less success FAB. Obese women are more likely than normal-weight women to have a cesarean delivery (28, 29), which is associated with delayed onset of lactogenesis II (the onset of copious milk production) (17, 30). Independent of delivery method, maternal obesity is also a risk factor for delayed onset of lactogenesis II (15, 18). Women with delayed onset of lactogenesis II are more likely to fail to initiate feeding at the breast and have shorter durations of feeding human milk (31).

Obese women may also have less success with breast-milk expression because they try this in the early postpartum period. It is possible that obese women who experienced delayed lactogenesis II and attempted to express milk early postpartum were unable to obtain milk by expression. They may have been able to overcome this barrier if they had first established their milk supply. Another possibility is that obese women may have experienced more difficulty obtaining a proper fit with and positioning of their pump’s breast shield, which could have interfered with successful expression (32).

Although breastfeeding intention was a significant confounder in the associations between BMI and ever expressing milk and cessation of expressing milk as well as between milk expression and the durations of milk production and feeding among overweight and obese women, it did not fully explain any of these associations. The results therefore suggest that a longer intended duration of breastfeeding predicts a higher likelihood of expressing milk and expressing milk to an older infant age, but does not explain any differences found among BMI groups in breast-milk expression or breastfeeding outcomes.

The IFPS II is the first national study to provide information on breast-milk expression. Thus, it provides the first opportunity to explore the relations between maternal prepregnancy BMI and milk expression. Its strengths include its longitudinal design, extensive survey questions, and large and widely distributed sample. These attributes permit the evaluation of temporal associations and also increase the power and external validity of the analyses.

Several limitations also must be considered when interpreting the results. Clear definitions of breastfeeding terms were not always provided to subjects, which may have caused them to misinterpret some questions about how they fed their infants. In addition, the questions about cessation of breastfeeding did not distinguish between PM, FAB, FBM, and FBM-ex, which made it difficult to create duration variables for these behaviors. The durations of PM, FAB, and FBM did not completely overlap, and their associations with covariates were not identical. These findings indicate the need for unambiguous terms to describe various breastfeeding behaviors (SR Geraghty and KM Rasmussen, unpublished manuscript, 2010). Although there are internationally recognized breastfeeding terms that may include feeding expressed milk (33), these terms do not separate women who are feeding breast milk but not feeding at the breast, expressing predominantly or exclusively, or engaging in other behaviors involving the feeding of breast milk that have only recently become more common. Finally, the generalizability of this study to the American population is limited by the low proportion of minority women in the IFPS II (34).

This was the first study to provide insight into how maternal prepregnancy overweight and obesity are associated with breast-milk expression outcomes as well as how expression is associated with breast-milk production and feeding outcomes. Although it may be inferred from our overall results that it might be reasonable to advise overweight and obese women to express milk to improve the durations of producing and feeding breast milk, caution is warranted. Our findings at 2 mo suggest that this advice is only helpful to obese women who have been able to establish a good milk supply. Moreover, when we provided obese mothers with breast pumps immediately after delivery in a preliminary experiment (35), it did not improve breastfeeding duration. As a result, further experimental studies are required to establish whether expression is indeed beneficial for heavier women and, if so, when this might be true.

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REFERENCES


