High Prepregnant Body Mass Index Is Associated With Poor Lactation Outcomes Among White, Rural Women Independent of Psychosocial and Demographic Correlates

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Abstract

To determine whether high prepregnant body mass index (BMI) is associated with later onset of lactogenesis II (LGII) and shorter duration of breastfeeding, we questioned 151 women about their demographic and psychosocial characteristics during pregnancy and about the onset of LGII during days 1 to 5 postpartum. Compared to women with earlier (< 72 hours) onset of LGII, those with later onset had a higher BMI ($P < .05$), a higher proportion of primiparity ($P < .01$), and a lower infant score on the Mother-Baby Assessment ($P < .05$). Prepregnant BMI ($P < .04$) and primiparity ($P < .005$) were each associated with later onset of LGII, but only primiparity remained significant when both factors were considered simultaneously. These results suggest that, in addition to those who have just delivered their first infant, those with higher prepregnant BMI values also warrant extra support to decrease their risk of early discontinuation of breastfeeding. *J Hum Lact*. 20(1):18-29.

Keywords: breastfeeding, obesity, lactogenesis, psychosocial, body mass index

Results of studies in both experimental animals and women suggest that maternal obesity is associated with poor lactational performance. Studies in rats have shown that rat dams made obese by the feeding of high-fat diets produce less milk[1-3] and that their milk has a higher concentration of fat[2,4] but lower concentrations of protein and lactose[4] than that of controls. The pups of these dams have higher mortality rates and poorer growth than the pups of their nonobese counterparts.[3,5]

Two epidemiological studies have revealed that maternal obesity is associated with poor breastfeeding success in women. Australian investigators found that among women who breastfed for at least 14 days, those with a body mass index (BMI) > 26 kg/m^2 were 1.5-fold less likely to continue breastfeeding until their infants were 3 months old than were women with a lower BMI value.[6] We replicated these findings in a population of women in rural upstate New York. In addition, we found that obese women (BMI > 29 kg/m^2) were 3.65-fold less likely to initiate breastfeeding successfully.[7] In our study, initiation of breastfeeding was defined as breastfeeding through hospital discharge, which was 2 to 3 days after delivery.

The mechanism for the higher rate of breastfeeding failure in obese women has not been determined. One possibility is that these women experience a delayed onset of lactogenesis II and thus quit breastfeeding. In studies in Mexico, Honduras, and the United States, investigators have found that a delayed onset of lactogenesis II (the onset of copious milk secretion ≥ 72 hours postpartum) predicted a shorter duration of subsequent breastfeeding.[8] In this article, we examine both

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biological and nonbiological factors that may predict later onset of lactogenesis II: maternal prepregnant BMI, breastfeeding behavior, and psychosocial factors.

The biological initiation of lactation depends primarily on prolactin secretion and the fall in progesterone after delivery of the placenta.[9] This process may be impaired in obese women, as they may experience a delay in the fall of progesterone resulting from an elevated amount of this hormone produced by excess adipose tissue. The process of galactopoiesis relies heavily on adequate suckling by the newborn after 3 to 4 days postpartum,[10,11] which is largely determined by proper latching on of the infant to the breast.[11,12] Flat nipples often make latching on more difficult for the infant,[12] and improper latch on almost invariably leads to painful, cracked nipples and, in many women, cessation of breastfeeding.[12] Anecdotal reports from nurses at the site of our earlier work[7] indicated that obese women are likely to have large breasts, large areolas, and flat nipples, which may lead to difficulty latching on. Thus, poor breastfeeding technique or unsuccessful breastfeeding behavior is one explanation for the lower breastfeeding success in these women. In the work reported here, we measured breastfeeding technique and behavior using the Mother-Baby Assessment (MBA) tool[13] and related this behavior to maternal BMI and onset of lactogenesis II.

Psychosocial factors are also related to breastfeeding success. Several research groups have used social science theories to understand how psychosocial factors influence the initiation and duration of breastfeeding in American women.[14-17] Their research has shown that the personal or attitudinal factors, the behavioral beliefs about breastfeeding and bottle-feeding, are strongly related to the choice to breastfeed and the duration of breastfeeding. Exposure to breastfeeding role models influenced mothers' decisions to breastfeed,[16] and maternal confidence about breastfeeding predicted breastfeeding duration.[17] In addition, women who intended to breastfeed reported more social support from sources such as the baby's father and their own mothers.[18] To understand whether psychosocial constructs are associated with prepregnant BMI among breastfeeding women and whether lactation performance was modified by these psychosocial factors, we used the theory of reasoned action[19,20] and social learning theory[21,22] as described in other studies of breastfeeding behavior.

The following hypotheses were tested in this study: (1) prepregnant BMI predicts the onset of lactogenesis II, (2) the relationship between prepregnant BMI and lactogenesis II is mediated by breastfeeding behavior as indicated by MBA scores, (3) the relationship between prepregnant BMI and lactogenesis II is modified by psychosocial constructs, and (4) high prepregnant BMI is associated with a higher risk of discontinuing breastfeeding, independent of potentially confounding sociodemographic and psychosocial factors.

Subjects and Methods

The Cornell University Committee on Human Subjects and the Bassett Institutional Review Board approved these procedures.

Subject Selection and Data Collection

We used the obstetric database at Mary Imogene Bassett Hospital to identify all pregnant women in the 10-county service area who were between 19 and 45 years old. At a routine prenatal visit in the outpatient clinic during the period from August to November 1998, potential subjects were informed of the study and asked if they planned to breastfeed. If they confirmed that they met the eligibility criteria (intention to breastfeed, carrying a singleton fetus), they were invited to participate in the study, and their written informed consent was obtained. Of the 223 women who were approached, 72 women refused to participate or did not meet the eligibility criteria; thus, 151 women enrolled in the study.

A brief questionnaire was administered orally to collect information on their age; education; participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), which gives aid to women meeting nutritional risk criteria and who fall below 185% of the poverty line; and the Prenatal Care Assistance Program (PCAP), which gives aid to women falling below 185% of the poverty line; type of insurance; marital status; prior breastfeeding experience; parity; smoking habits; and reproductive history. Women were asked to recall their prepregnant weight and height. Prepregnant weight was defined as the weight at or immediately prior to conception. Recalled prepregnant weight is within 1 pound of measured weight early in the first trimester in this population (C. Olson, personal communication, November 2001).

Prepregnant BMI was calculated as the prepregnant weight in kilograms divided by the height in meters squared. Women were categorized using Institute of

Medicine criteria[19] as being of underweight/normal weight, overweight, or obese if their prepregnant BMI was < 26.1 kg/m^2, between 26.1 and 29.0 kg/m^2, or ≥ 29.0 kg/m^2, respectively.

A psychosocial questionnaire was also administered at this time, and women were asked to complete it during or after their checkup. If it was not feasible for the subject to complete the questionnaire at this contact, she was contacted again at a later prenatal visit and asked to complete it then. Two subjects completed the questionnaire at home and returned it by mail.

Subjects were contacted daily by telephone on days 1 to 5 postpartum at a time of day that corresponded with the time they delivered their infants (or early in the morning if they had delivered at night). A brief questionnaire, developed by Chapman and Perez-Escamilla from the University of Connecticut,[24] was administered at each contact. The questionnaire included 3 questions about infant feeding method, the number of breastfeeding episodes in the past 24 hours, and the quantity of formula and water given. It also included 11 questions relating to breast symptoms commonly associated with the onset of lactogenesis II: the presence of a "tingling" feeling in the breast, fullness, swelling, and so on. Women were also asked if they thought their milk had "come in" as well as the time and day that they felt this had occurred. This provided the time (in hours) postpartum used in the analyses involving the onset of lactogenesis. Women were contacted for 5 days or until their milk had "come in," whichever came first. This technique for assessing onset of lactogenesis II has been used to detect when a low milk transfer occurred (< 9.2 g/feeding at 60 days postpartum) in other studies and may be used as a useful public health marker of onset of lactogenesis II.[8] Women were considered to have a timely onset of lactogenesis II if they reported their milk coming in < 72 hours postpartum and a late onset of lactogenesis II if they reported their milk coming in ≥ 72 hours postpartum.

Of the 151 women who agreed to participate, 14 were excluded because they had an infant with a congenital problem (n = 1), had a miscarriage after recruitment (n = 2), had postpartum hemorrhaging or surgery (n = 2), had their infant taken by child services (n = 1), had an infant born < 37 weeks gestation (n = 3), had used illegal substances at the time of their delivery (n = 1), were missing the information necessary to calculate BMI (n = 1), or did not attempt to breastfeed (n = 3). Thus, 137 women were eligible for study. Among the eligible women, 21 failed to complete the questionnaire and 21 did not complete the postpartum interview. These groups did not overlap completely, so data on 114 women were available for analyses that involved information from both of these sources.

At approximately 8 to 12 months postpartum, subjects were contacted by telephone and asked questions pertaining to the duration of exclusive and any breastfeeding. Specifically, they were asked, "Are you still breastfeeding?" "When did you stop breastfeeding altogether?" and "When did you first start introducing things other than breast milk (eg, formula, solid foods, etc)?" The first 2 questions were used to ascertain the duration of any breastfeeding, and the variable was considered "censored" if the subject was still breastfeeding at the time of the interview. The third question was used to ascertain the duration of exclusive breastfeeding. This variable was not censored in any of the cases included in this study.

Information about the subjects was also obtained from their medical records. This included the last weight before delivery, the type of delivery, birth weight and gestational age of the infant, MBA scores for each 8-hour shift they were in the hospital, and whether the subject was still breastfeeding at the time of discharge.

Questionnaire Development and Pretesting

The psychosocial questionnaire that was administered during pregnancy measured 6 psychosocial constructs that have been reported to predict breastfeeding:[14-18] behavioral beliefs for breastfeeding and bottlefeeding, breastfeeding knowledge, social learning, maternal confidence, and 3 types of social support (tangible, emotional, and informational). It was pretested among women from the study site who were awaiting prenatal care. These women were not participants in the investigation reported here. Of 26 women who agreed to participate, 24 completed all items of the questionnaire. Twenty women intended to breastfeed, 3 intended to use formula, and 1 woman was undecided about her infant feeding choice. These women were representative of the entire population in their level of education and participation in government assistance programs.

Scoring of the Psychosocial Questionnaire

The behavioral breastfeeding beliefs scores were calculated by assigning a scale score to each item, ranging from 1 to 5. Answers in favor of breastfeeding (eg, answering "strongly agree" to the question "breastfeed-

Table 1. Results of the Psychosocial Questionnaire for Women Participating in the Study (n = 116)

Construct	*Range*	*Cronbach α**
Behavioral beliefs, breastfeeding	10-23	.65
Behavioral beliefs, bottle-feeding	3-25	.69
Breastfeeding knowledge	1-9	
Social learning	–3-9	
Maternal confidence	2-5	.90
Social support		
Tangible support	0-27	
Emotional support	1-16	
Informational support	0-19	

*Cronbach's α is a test of reliability.

ing is more natural than bottle-feeding") were given a higher score (5 points), while answers not in favor of breastfeeding were given a low score (1 point). The score (1-5) for each item was multiplied by the score (1-5) for the accompanying evaluation item (eg, "choosing a feeding method that is natural is important to me"). Conversely, to calculate the behavioral bottle-feeding beliefs score, answers that were in favor of bottle-feeding (ie, answering "strongly agree" to the question "bottle-feeding allows others to feed the baby") were given a higher score (5 points), while those not in favor of bottle-feeding were given a low score (1 point). As with the breastfeeding beliefs score, the score (1-5) for these items was multiplied by the score of an accompanying evaluation item ("finding a feeding method that allows others to feed the baby is important to me"). The overall behavioral beliefs score was calculated as the difference between the breastfeeding beliefs score and the bottle-feeding beliefs score. A higher overall behavioral beliefs score indicated a stronger belief that breastfeeding was a better infant feeding method than bottle-feeding, whereas a low score indicated a relative indifference to breastfeeding versus bottle-feeding.

The breastfeeding knowledge score was calculated as the number of true-or-false questions out of 9 the woman answered correctly (1 = lowest score, 9 = highest score). All questions pertained to breastfeeding behavior (eg, "you should nurse from only one breast at a time") or lactation physiology (eg, "the more your baby sucks at your breast, the more milk you will make") (Table 1). No points were deducted if the woman either answered incorrectly or failed to answer the question.

Questions included in the breastfeeding knowledge score were as follows:

1. You should nurse from only one breast at each feeding.
2. You should use a bottle at the same time you breastfeed while your milk supply is forming.
3. Let-down is an important part of breastfeeding.
4. To start your baby nursing, you should push her head toward your nipple.
5. The more your baby sucks at your breast, the more milk you will make.
6. You should not nurse very often at the beginning.
7. Breastfeeding can help you lose weight after the baby is born.
8. Some women can't breastfeed because their breasts don't produce enough milk.
9. Formula is as good as breast milk for a baby.

The social learning measure was calculated by assigning points based on the relative amount of exposure women had to breastfeeding. When asked, "How many of the following people (eg, nieces and nephews) were breastfed?" answering "all" counted as 3 points, "most" counted as 2 points, "some" counted as 1 point, and "none" counted as –1 point. For each of 3 categories (nieces and nephews, children of close friends, and younger brothers and sisters), the social learning measures were added together. A higher score indicated more exposure to breastfeeding, while a lower (or negative) score indicated a limited or nonexistent exposure to breastfeeding.

To calculate the maternal confidence score, women were asked how sure they were that they could breastfeed in 10 different situations (eg, "during the hospital stay"). Answers could range from *very sure* (most confident = 5 points) to *very unsure* (least confident = 1 point). The scores for each of the 10 items were summed to give the overall maternal confidence score, where the higher score indicated a greater confidence to breastfeed in a variety of situations and a lower score indicated a lower confidence to breastfeed in those situations.

Three types of social support were measured: tangible, emotional, and informational. Seven items pertained to tangible support, while 4 and 5 items pertained to emotional and informational support, respectively. For each item (eg, "who loans you small amounts of money?"), respondents can list any of the following that apply: baby's father, her mother, her best friend, or other. The number of supportive individuals for each type of social support was tabulated. A higher number

of supportive individuals indicated greater support, while a lower number indicated less support.

Reliability analysis was conducted on the items that would generate scale scores for the 3 constructs: behavioral beliefs for breastfeeding and bottle-feeding and maternal confidence. The Cronbach α (a measure of reliability) on the pretested questionnaire was greater than .75 for all constructs analyzed, which indicates high reliability and internal consistency of the measurement scales. When reliability was measured on the items among all women participating in the study, the Cronbach α was greater than .65 for all constructs analyzed (Table 1). The instrument also produced a desired range and distribution in the scores for all constructs.

MBA Tool

To determine the adequacy of breastfeeding behaviors for each mother-infant dyad, breastfeeding episodes are routinely observed once per 8-hour shift for the duration of the mother's and infant's hospital stay after delivery. A scale score is assigned for this breastfeeding episode using an MBA tool.[13] The MBA tool is a validated instrument that is used by specially trained registered nurses on the hospital staff, and it is part of the usual hospital protocol at Bassett Hospital. Nurses evaluated the mother-infant dyads on 5 progressive breastfeeding steps that encompass behaviors of the mother and baby: cues/signaling, positioning of the infant at the breast, latching/fixing of the infant's mouth at the breast, milk transfer to the infant, and satiation of the infant, and for each step, the nurses assigned a score from 1-10. For every step, both mother and infant were required to meet certain criteria before either one could be evaluated on the following step.

Data Analysis

Data from the questionnaires, demographic data, and information from the medical record were coded and entered into EpiInfo version 6 (Centers for Disease Control, Atlanta, GA). All data preparation, cleaning, and analysis were done using the Statistical Analysis System (SAS version 8.2, Cary, NC).

ANOVAs with post hoc contrasts were performed to compare the characteristics between underweight/normal weight (prepregnant BMI < 26.0 kg/m^2), overweight (BMI between 26.0 and 29.0 kg/m^2), and obese (BMI ≥ 29.0 kg/m^2) women. Student's *t* tests were conducted to examine whether women who (1) experienced later or timely onset of lactogenesis II or (2) were primiparous or multiparous differed in any of the demographic characteristics, psychosocial constructs, and MBA scores at discharge from the hospital.

To investigate hypothesis 1, logistic regression analysis was performed to test whether later onset of lactogenesis II was associated with prepregnant BMI. Variables that were significantly associated with onset of lactogenesis and/or obesity were also added to the logistic regression model. To investigate hypothesis 2, logistic regression analysis was also performed to determine whether the magnitude of the relationship between prepregnant BMI and lactogenesis decreased with the addition of MBA scores to the model. In each set of logistic regression models, the most parsimonious model with minimum deviance was retained. To test hypothesis 3, logistic regression analysis also was conducted to determine whether any of the psychosocial constructs modified the relationship between BMI category and onset of lactogenesis II. Specifically, interactions between BMI and the relevant psychosocial scores were tested for statistical significance. All analyses were controlled for relevant covariates that may have been potential confounding factors. Results were considered significant at $P < .05$.

Finally, to test hypothesis 4, Cox proportional hazards regression analyses were conducted to determine the relative risk (RR) of discontinuing exclusive and any breastfeeding among overweight and obese women compared to underweight/normal-weight women. The timing of the onset of lactogenesis was examined as a mediating variable in this relationship and the model adjusted for potential confounding variables.

Results

Subject Characteristics

Obese women had a significantly lower proportion of vaginal deliveries than did underweight/normal weight women (Table 2). Interestingly, an increasingly greater proportion of women experienced later onset of lactogenesis as prepregnant BMI increased, but this did not reach significance (Table 2). Twenty-one women were underweight (prepregnant BMI < 19.8 kg/m^2), but they were included in the underweight/normal weight group, as their sociodemographic characteristics, such as education and participation in WIC/PCAP, did not differ substantially from women with a BMI between 19.8 and 26 kg/m^2.

There was a significant decline in the satisfaction with appearance as BMI increased (Table 3). Obese women also planned to breastfeed for 3 fewer months

Table 2. Characteristics of Underweight/Normal (BMI < 26.0 kg/m^2), Overweight (BMI between 26.0 and 29.0 kg/m^2), and Obese (BMI ≥ 29 kg/m^2) Women and Also Primiparous and Multiparous Women*

	BMI												*Parity*							
	Normal Weight				*Overweight*				*Obese*				*Primiparous*				*Multiparous*			
Variable	$\bar{x}$	±	*SD*	*n*	$\bar{x}$	±	*SD*	*n*	$\bar{x}$	±	*SD*	*n*	$\bar{x}$	±	*SD*	*n*	$\bar{x}$	±	*SD*	*n*
Weight at delivery (kg)	75.6	±	9.8	72	89.5	±	10.3**	11	107	±	12.4**,†	34	87.8	±	19	50	84.8	±	16.7	67
Weight gain (kg)	17.0	±	6.1	72	16.4	±	4.5	11	14.5	±	7.7	34	17.3	±	6.1	50	15.5	±	6.7	67
Age (y)	28.9	±	5.9	83	26.4	±	5.5	14	27.4	±	4.7	40	26	±	5.2	59	28.8	±	5.2‡	78
Education (y)	14.3	±	2.3	83	14.1	±	1.9	14	13.5	±	2.1	40	14.4	±	2.3	59	13.8	±	2.1	78
Married (%)	73.7			76	92.9			14	75.0			36	62.3			53	86.3§			73
WIC/PCAP (%)	38.1			83	42.9			14	48.7			40	42.4			59	40.3			77
Previous breastfeeding (%)	52.9			83	50.0			14	45.0			40	0			59	89.8‡			78
Smoking at conception (%)	12.9			83	7.1			14	7.5			40	8.5			59	12.8			78
Vaginal delivery (%)	89.2			74	100.0			14	75.7†			37	81.5			54	90.1			71
Length of hospital stay (d)	2.1	±	1.0	75	2.1	±	0.4	14	2.4	±	0.8	37	2.4	±	1.0	54	2.0	±	0.7§	72
MBA at discharge (infant's)	4.1	±	0.5	68	4.1	±	0.3	12	4.1	±	0.5	36	4	±	0.4	51	4.2	±	0.4§	65
Birth weight of infant (g)	3574	±	489	75	3618	±	464	14	3772	±	515	37	3538	±	495	54	3712	±	491	72
Onset of leaking (d)‖	2.3	±	1.2	19	2.5	±	1.5	6	1.7	±	0.9	9	2.13	±	1.2	15	2.16	±	1.2	19
Onset of tingling (d)‖	2.1	±	1.1	12	1.3	±	0.5	4	2.1	±	1.7	8	2.4	±	1.8	8	1.75	±	0.9	16
Duration of EBF (wk)	3.6	±	3.9	68	2.6	±	3.2	14	2.7	±	2.3	33	3.0	±	2.7	47	3.3	±	3.8	68
Duration of any BF (wk)	7.3	±	8.9	68	5.6	±	5.4	14	4.6	±	4.6	33	6.8	±	9.5	68	6.0	±	5.9	68
Later onset lactogenesis II (%)	18.5			65	30.8			13	33.3			36	41.7			48	12.1‡			66
Primiparous (%)	39.8			83	42.9			14	50.0			40	—		—					
Prepregnant body mass index	—		—	—									26.4	±	6.2	59	25.2	±	5.6	78

*Abbreviations: BMI = body mass index; BF = breastfeeding; WIC/PCAP = Supplemental Nutrition Program for Women, Infants, and Children/Prenatal Care Assistance Program; MBA = Mother-Baby Assessment score; EBF = exclusive breastfeeding.
**Significantly different from underweight/normal-weight women (ANOVA), $P < .01$.
†Significantly different from overweight women (ANOVA), $P < .01$.
‡Significantly different from the primiparous group by *t* test, $P < .001$.
§Significantly different from the primiparous group by *t* test, $P < .01$.
‖Women completing the postpartum interviews (n = 116).

Table 3. Scores of Psychosocial Characteristics of Underweight/Normal (Prepregnant BMI < 26.0 kg/m^2), Overweight (BMI between 26.0 and 29.0 kg/m^2), and Obese (BMI ≥ 29 kg/m^2) Women and Also Primiparous and Multiparous Women*

	BMI												*Parity*							
	Normal Weight				*Overweight*				*Obese*				*Primiparous*				*Multiparous*			
Variable	$\bar{x}$	±	*SD*	*n*	$\bar{x}$	±	*SD*	*n*	$\bar{x}$	±	*SD*	*n*	$\bar{x}$	±	*SD*	*n*	$\bar{x}$	±	*SD*	*n*
Planned duration of BF* (mo)	9.3	±	5.7	54	9.8	±	3.0	13	6.9	±	4.6**	28	7.4	±	3.15	40	9.7	±	6.2†	55
Plan to return to work/ school (%)	60.3			62	61.5			13	71.9			32	76.1			46	55.7†			61
Satisfied with appearance	3.7	±	1.0	68	3.6	±	0.8	14	3.0	±	1.1‡,§	35	3.7	±	1	52	3.3	±	1.1	64
Breasts feel different (%)	85.3			67	92.9			14	85.7			35	90.4			52	82.8			66
Behavioral beliefs (BF)	16.5	±	2.9	69	16.3	±	2.5	14	15.8	±	2.6	34	16	±	2.4	51	16.5	±	3	65
Behavioral beliefs (bottle)	12.0	±	3.8	67	12.6	±	4.5	14	13.2	±	3.6	34	12.5	±	3.5	50	12.3	±	4.1	63
Exposure to BF role models	2.9	±	2.9	66	2.9	±	3.3	13	1.8	±	2.8	34	2.5	±	2.7	50	2.7	±	3	64
Maternal confidence	4.3	±	0.7	66	4.1	±	0.6	14	4.2	±	0.5	15	4.1	±	0.6	51	4.4	±	0.6†	64
Knowledge of BF	6.1	±	1.9	67	6.9	±	1.0	14	6.4	±	1.9	35	5.7	±	2	52	6.8	±	1.5‖	
Tangible support	12.4	±	5.2	67	13.6	±	5.4	14	11.9	±	3.4	35	13.8	±	4.9	52	11.3	±	4.3‖	64
Emotional support	10.6	±	4.3	67	11.1	±	4.0	14	10.2	±	3.9	35	11.5	±	4.3	52	9.9	±	3.7†	64
Informational support	7.6	±	4.3	67	6.6	±	2.4	14	7.1	±	3.4	35	8.6	±	4	52	6.4	±	3.3†	64

*Abbreviations: BMI = body mass index; BF = breastfeeding. Characteristics were assessed during pregnancy.
**Significantly different from underweight/normal-weight women (ANOVA), $P < .05$.
†Significantly different from the primiparous group by *t* test, $P < .01$.
‡Significantly different from underweight/normal-weight women (ANOVA), $P < .01$.
§Significantly different from overweight women (ANOVA), $P < .01$.
‖Significantly different from the primiparous group by *t* test, $P < .001$.

than did underweight/normal-weight and overweight women.

In this primarily Caucasian population, only 50% of the women had previous breastfeeding experience, and nearly 43% were primiparous. Although the education level was relatively high (34% have 12 years of education, compared to the national average of 66%), the population was not highly advantaged; 41% of the women in the study participated in government assistance programs.

Women with later onset of lactogenesis had higher prepregnant BMI values (28.3 ± 6.3 vs 25.4 ± 5.9 kg/m^2, $P < .05$, respectively), were more likely to be primiparous (71.4% vs 32.6%, $P < .01$), were less likely to have previously breastfed an infant (28.6% vs 59.3%, $P < .01$), and their infants had lower MBA scores at discharge (4.0 ± 0.4 vs 4.2 ± 0.5, $P < .05$) than women with earlier onset of lactogenesis. Neither the duration of breastfeeding nor any of the psychosocial characteristics differed between women with earlier versus later onset of lactogenesis II (data not shown).

In addition to having a higher proportion with delayed onset of lactogenesis II than multiparous women, primiparous women were significantly younger, less likely to be married, had a longer hospital stay, and had infants with a lower MBA score (Table 3). Of course, no primiparous women had previous experience with breastfeeding compared to 90% of the mulitparous women in this sample. Compared to multiparous women, those who were having their first babies planned to breastfeed for 2 months less, were more likely to plan to return to work or school, and had lower scores for maternal confidence about breastfeeding, knowledge of breastfeeding, and tangible, emotional, and informational support for breastfeeding (Table 4).

Onset of Lactogenesis II

In the test of hypothesis 1, prepregnant BMI was, by itself, a significant ($P < .04$; Table 4) predictor of delayed onset of lactogenesis II. Maternal parity, a dichotomous variable, was an even more significant ($P < .001$) independent predictor of delayed onset of lactogenesis II. When both factors were present in the model simultaneously, the significance of each was attenuated, and only maternal parity remained statistically significant (Table 4).

In the test of hypothesis 2, infants' MBA scores were added to the best-fit model from testing hypothesis 1 above. The infant's MBA score did not appear to mediate the relationship between prepregnant BMI and later onset of lactogenesis because the odds ratio for prepregnant BMI remained unchanged when adjusted for the infant's MBA score (Table 4). The deviance of the model that contained the infant's MBA score improved, but the sample size was reduced; when the models with and without the infant's MBA score were run with the same sample, there was no significant difference in deviance.

Table 4. Association Between Maternal Prepregnant Body Mass Index (BMI) and Later Onset of Lactogenesis II (n = 138)

Predictor	*Odds Ratio (95% Confidence Interval)*	*P Value*	*Model Deviance**
Prepregnant BMI (n = 114)	1.08 (1.0, 1.2)	< .04	122.5
Primiparity (n = 114)	5.27 (2.1, 13.4)	< .001	114.2
Prepregnant BMI	1.1 (1.0, 1.2)	.07	110.5
Primiparity (n = 114)	5.0 (1.9, 12.9)	< .001	
Prepregnant BMI	1.1 (1.0, 1.2)	.06	99.7
Primiparity (n = 103)	4.7 (1.7, 12.8)	.002	
Prepregnant BMI	1.1 (1.0, 1.2)	< .08	98.8
Primiparity	4.2 (1.5, 11.8)	.007	
Infant's Mother-Baby Assessment score (n = 103)	0.6 (0.2, 1.9)	*ns***	

*Deviance is a measure of explanatory power of the model (lower deviance indicates more explanatory power).
**Not significant ($P > .05$).

Investigation of hypothesis 3 revealed that only one psychosocial factor modified the relationship between prepregnant obesity and onset of lactogenesis: knowledge of breastfeeding (interaction in logistic regression analysis, $P = .04$). There were no significant interactions between overweight and any of the psychosocial variables. When prepregnant BMI was entered as a continuous variable, only breastfeeding knowledge significantly interacted with BMI ($P = .03$). In this interaction, there was no change in the likelihood of later onset of lactogenesis as knowledge of breastfeeding increased among the underweight/normal-weight women, but the likelihood of later onset increased as knowledge of breastfeeding increased among overweight/obese women. Knowledge of breastfeeding by itself was not related to onset of lactogenesis.

There was no significant relationship between either onset of tingling ($\beta = 1.43$, $P = .34$) or onset of leaking ($\beta = 1.003$, $P = .99$) and onset of lactogenesis II when adjusting for previous breastfeeding experience.

Duration of Breastfeeding

When the RR of discontinuing any breastfeeding was examined for overweight and obese women, only obese women were at a significantly higher risk of earlier dis-

continuation of breastfeeding than underweight/normal-weight women (unadjusted RR = 2.43; confidence interval [CI], 1.40-4.20; $P = 0.002$) (data not shown). Neither overweight nor obesity was significantly related to duration of exclusive breastfeeding. Duration of breastfeeding did not differ between primiparous and multiparous women (Table 3).

Further analysis to elucidate the pathway between obesity and duration of breastfeeding revealed that several variables were both associated with obesity and with breastfeeding duration, acting as potentially confounding variables in this relationship: a shorter planned duration of breastfeeding, plans to return to work or school, less satisfaction with appearance, and a greater indifference toward breastfeeding. When they were entered into the proportional hazards regression model, the association between obesity and duration of breastfeeding decreased in magnitude but remained significant (adjusted RR for obesity = 2.03; CI, 1.07-4.5; $P = .03$), indicating that they only partially explained the relationship between obesity and breastfeeding duration. When later onset was added to the adjusted model, the RR for obesity was 2.37 (CI, 1.11-5.04; $P = .03$) (data not shown), suggesting that the discontinuation of breastfeeding was not explained by a later onset of lactogenesis II. When MBA scores were added to the model (data not shown), the RR of obesity was not significant (RR = 2.17; CI, 0.85-5.56; $P = .07$), which indicates that breastfeeding behavior may have mediated the relationship between obesity and duration of breastfeeding.

For the underweight/normal weight, overweight, and obese women, there was a 30-, 34-, and 23-week discrepancy, respectively, between intended duration of breastfeeding and actual duration of breastfeeding. The strength of the association between intended and actual breastfeeding was weakest for obese women ($\beta = -.24$, $P = .25$), although they had the smallest discrepancy between planned (27.6 week) and actual (4.6 week) duration of breastfeeding. For underweight/normal-weight and overweight women, the association was much stronger (underweight/normal weight: $\beta = .51$, $P = .03$; overweight: $\beta = 1.25$, $P = .009$).

Discussion

In this study, prepregnant BMI was positively and significantly associated with an increased likelihood of later onset of lactogenesis II. Prepregnant BMI was not the only factor that was significantly associated with delayed onset of lactogenesis II: Being primiparous was even more strongly associated with this outcome than was maternal prepregnant BMI. That both factors are important predictors of later onset of lactogenesis II is indicated by the reduction in deviance with both factors in the model compared to each by itself. The infant's MBA score did not attenuate the association of prepregnant BMI and thus did not mediate the relationship between prepregnant BMI and the onset of lactogenesis II.

No psychosocial variables were related to onset of lactogenesis per se, but knowledge of breastfeeding did modify the relationship between prepregnant obesity and the onset of lactogenesis. Finally, the psychosocial variables commonly associated with breastfeeding attenuated but did not eliminate the statistically significant association of prepregnant BMI with early discontinuation of breastfeeding; however, breastfeeding behavior appeared to mediate the relationship between prepregnant BMI and duration of breastfeeding.

Study Limitations

Our subject recruitment period and the distribution of prepregnant BMI values among the women whom we were able to recruit did not permit us to enroll the number of subjects we needed to demonstrate, for instance, that obesity per se was significantly associated with a late onset of lactogenesis. Our ability to detect a significant association between obesity and lactogenesis was further limited by the unexpected distribution of primiparity among our subjects. Primiparity increased with increasing maternal prepregnant BMI instead of decreasing, as had been the case in our prior research in this population[7] and as one might expect if women had become obese as a result of prior childbearing. Inasmuch as obesity is increasing among younger women,[25] it is likely that those studying this subject in the future also will encounter an association between maternal prepregnant obesity and primiparity. Simply increasing the sample size may not be as effective a design strategy as stratifying subjects on both BMI category and parity. As discussed in more detail below, even this may not be sufficient if it is important to distinguish between the biological and behavioral correlates of parity as they affect the continuation of breastfeeding.

Breastfeeding advice from nurses and certified lactation consultants is given to all women delivering at the study site. Alternative explanations for our observed results are that a bias against obese women exists in the

delivery of this information or that obese women are less receptive to this advice. We do not believe that either alternative explanation is correct. In fact, our original work in the same population revealed that obese women were as likely to attempt breastfeeding and were therefore as interested in and committed to breastfeeding as were nonobese women.

Delayed Onset of Lactogenesis II

Despite these limitations, we have several novel findings. Increasing prepregnant BMI was associated with delayed lactogenesis, which supports the findings from our earlier work.[7] We calculated that a 1-unit (1 kg/m^2) increase in prepregnant BMI was associated with a 0.5-hour delay in onset of lactogenesis II in this sample. In a clinical setting, the difference in the onset of lactogenesis II for a woman with a BMI of 40 kg/m^2 (the maximum in this sample) and a BMI of 20 kg/m^2 (an underweight/normal-weight woman in this sample) would be 10 hours. Anecdotal reports from the study site indicate that this difference is important when mothers may no longer be in the supportive hospital environment, are anxious about their delayed milk arrival, and may succumb to the use of formula to feed their infants.

Another novel feature of this study was the evaluation of the usefulness of the MBA score—a tool for evaluating breastfeeding behavior—for predicting lactogenesis. In this study, we found that infants' MBA scores were significantly lower among women with later onset of lactogenesis. The fact that we found significant differences in MBA scores among women who experienced earlier versus later onset of lactogenesis II indicates that the MBA tool was adequate for the purposes of this study. Researchers who conduct future studies of breastfeeding behavior may wish to include further validation of the MBA scoring system if more subtle differences in breastfeeding behavior are to be detected. For the purposes of clinical counseling, our finding that lower infant MBA scores were associated with later onset of lactogenesis II indicates that this tool could be useful for alerting health care providers to potential breastfeeding problems.

Psychosocial Factors

This is also the first study to measure how specific psychosocial factors known to be related to the intention to breastfeed or to duration of breastfeeding are associated with prepregnant body fatness and whether these factors are, in turn, related to timely onset of lactation and duration of breastfeeding. As anticipated, obese women were less satisfied with their appearance and planned to breastfeed for a shorter period of time but did not differ from nonobese women in any of the other psychosocial characteristics.

Although we found that none of the psychosocial variables studied was related to lactogenesis per se, we identified one psychosocial factor, knowledge of breastfeeding, that modified the relationship between BMI and onset of lactogenesis. We explored several hypotheses to explain the interaction between obesity and breastfeeding knowledge. One hypothesis is that knowledge may be acting as a proxy for socioeconomic status. In fact, we found that neither maternal age, nor education, nor participation in WIC/PCAP, all potential indicators of socioeconomic status in this population, was significantly associated with breastfeeding knowledge. Another possibility is that knowledge was a proxy for breastfeeding frequency. This was also not the case, as knowledge was not related to overall frequency of breastfeeding and was related to frequency on only one individual day: day 4 ($\beta = .93$, $P = .03$). Interestingly, the interaction observed between obesity and breastfeeding knowledge followed a familiar pattern. Preliminary results of another study in Connecticut revealed that among nonobese women, increasing breastfeeding frequency in the early postpartum period was associated with earlier onset of lactogenesis II, whereas among obese women, there was no benefit from increasing breastfeeding frequency.[26] These converging results suggest that obesity and/or high BMI may be a robust predictor of later onset of lactogenesis and that breastfeeding education directed toward obese women may not help in changing the risk of later onset of lactogenesis.

Finally, because we were concerned that self-efficacy might be related to obesity and to our breastfeeding outcomes and because self-efficacy related to breastfeeding has not been studied in obese women, we made a strategic decision to measure self-efficacy as it related specifically to breastfeeding. We did not find that self-efficacy for breastfeeding differed between obese and nonobese individuals. This novel finding is consistent with earlier findings by Gortmaker and colleagues,[27] who observed that self-esteem, a component of self-efficacy, among overweight women (BMI > 95th percentile for age and sex, overlapping our definition of obesity) did not differ compared to underweight/normal-

weight women, though their educational attainment was much lower.

Duration of Breastfeeding

Much like the interaction between obesity and breastfeeding knowledge, the shorter duration of breastfeeding observed among obese women appears to have psychosocial roots. Obese women breastfed for a shorter time, in part because of their shorter planned duration of breastfeeding, lower satisfaction with appearance, plans to return to work or school, and their generally greater indifference toward breastfeeding as an infant feeding method. Because we assessed all of these factors, in addition to BMI, at the same time during pregnancy, it is impossible to determine the directionality and time order of these prenatal events. Although later onset of lactogenesis II was not an intervening variable between obesity and breastfeeding duration, our results show that breastfeeding duration may be determined by early breastfeeding behavior. However, because the relationships between breastfeeding duration and the covariates included in the model are not linear, the adjustments we have made in our proportional hazards regression model may be inefficient. There is a clear need to examine other statistical models to understand the relationship between obesity and breastfeeding duration better.

The Role of Parity

Although we did not intend to study parity as a separate predictor of delayed onset of lactogenesis II, as this association was well known before our research began, the distribution of parity among our subjects was both unexpected and problematic. One expects a higher BMI among multiparous women because they are older (by 3 years in this sample) and thus have had more opportunity to gain weight with age and also because they have had the opportunity to gain weight associated with their prior childbearing. This was not the case in this sample; prepregnant BMI was not higher among the multiparous women. This may reflect increasing obesity among young women[25] as well as difficulty in conceiving that has long been known to occur among women who are obese.[28] Alternatively, this distribution of parity among the BMI groups may simply have reflected the fact that pregnant women without children were more willing to enroll in a research study like this one.

Understanding the role of parity is further complicated by the fact that parity is in some ways a poorly specified variable for this research. This is because there are 2 distinct roles for parity. One is a biological role, namely, that milk volume rises faster in the first week after birth in multiparous than in primiparous women.[29] This is adequately captured by the primiparous/multiparous dichotomy used here. There is also another potential role for parity that is important for research on breastfeeding, namely, that some multiparous mothers will have had prior experience with breastfeeding (90% in this sample), while primiparous mothers have uniformly had no such experience. Others[30] have observed that prior experience with breastfeeding was more important than parity for the continuation of breastfeeding. Prior experience with breastfeeding is likely to have contributed to the higher scores on all the variables associated with confidence about and knowledge of breastfeeding as well as perceived support for breastfeeding that was characteristic of the multiparous subjects in this investigation. Prior experience with breastfeeding would help mothers to keep breastfeeding despite a later onset of lactogenesis II associated with obesity. Unfortunately, in this sample of women, so few multiparous subjects lacked prior breastfeeding experience that we could not evaluate the separate contribution of this experience to mitigating the negative association of obesity with lactogenesis II or duration of breastfeeding.

In this study, the primary outcome was biological, namely, the onset of copious milk secretion, an event unlikely to be dramatically influenced by behaviors that are typical of healthy mother-infant dyads. These analyses also support the conclusion that there may be a biological relationship between prepregnant BMI and delayed onset of lactogenesis II. The relatively high (2.0 and greater) adjusted odds ratios for the association between overweight or obesity and the later onset of lactogenesis II are consistent with this interpretation. The hormonal control of the onset of copious milk secretion is well understood.[9] In particular, the postpartum fall in progesterone concentration that occurs after the delivery of the placenta is the trigger for lactogenesis. Maintenance of prolactin and cortisol concentrations is required for this trigger to be effective.[9] What is not known is how obesity may modify this hormonal cascade. Possibilities might include a delay in the reduction of estrogen and progesterone concentrations because they are produced in adipose tissue, an inadequate metabolic transition from pregnancy to lactation[3] and a reduction in the prolactin response to suckling.[31] Research in women to investigate these possibilities is in progress in our laboratory.

Public Health Implications

In our earlier work in the same community,[7] 41% of the breastfeeding failure among women who ever attempted breastfeeding was attributable to maternal overweight and obesity. This population, in which more than 99% of the individuals are Caucasian and a high proportion are socioeconomically disadvantaged (40%-50% participate in government assistance programs), is representative of many US women. Inasmuch as 34% of white American women are overweight (BMI ≥ 27.3 kg/m^2),[32] devising strategies to alleviate some of the difficulty with breastfeeding many overweight and obese women face would have significant public health importance because such an intervention could potentially increase the duration of breastfeeding. In addition, the breastfeeding duration reported for women in this study was well below what is recommended. Our report confirmed that more lactation guidance and support is warranted for all women in the Bassett community, particularly in the postpartum period after women return home after delivery.

In conclusion, the results of this study confirm our previous observation that prepregnant BMI is a determinant of breastfeeding success.[7] Although our approach in this study was not the definitive test of the hypothesis that psychosocial variables might explain the lowered breastfeeding success among obese women, our results are consistent with the possibility that the relationship between obesity and breastfeeding is in part biological. In addition, we have reported new findings that increased breastfeeding knowledge does not decrease the likelihood of late onset of lactogenesis among obese women and that obesity is associated with myriad psychosocial variables that contribute to the prediction of a shorter duration of breastfeeding.

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