

**Biological and Social Factors Associated with Reduced Lactation Duration in
Overweight Women**

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

Laura Eileen Hauff

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

Co-advisors: Michael Wilson, Ph.D. and Gregory Laden, Ph.D.

June 2011

© Laura Eileen Hauff, 2011

Acknowledgements

My gratitude begins with my grandmothers, Marie Hauff and Doris Bower, who wisely instilled the importance of education into my familial heritage. With this legacy, it is maybe not surprising that I earned a Ph.D., but perhaps it is surprising that I chose the “exotic” field of anthropology, which today is more fascinating to me than when I began graduate school. I owe both my interest and my success to many.

Sincere thanks to the biological anthropology faculty at the University of Minnesota: Drs. Gilbert Tostevin, Kieran McNulty, Gilliane Monnier, John Soderberg and especially my committee members, Michael Wilson and Martha Tappen. They have provided me years of mentorship and a supportive intellectual home. Their generosity as individuals and their collective passion for human evolution never cease to amaze and inspire me.

A special thank you to Dr. Jonathan Wheaton for providing lab space and hours of instruction, simply because I had an interest and wanted to learn. To Dr. Gregory Laden, my first teacher of anthropology. If I am a good teacher today, much of it comes from his inspiration. To Dr. Hoon Song, who was the first to convince me that I truly am an anthropologist. I am a better one today because of his astute contributions to our rich discussions. Finally, crossing paths with Dr. Ellen Demerath may be the best stroke of good luck during my several years as a graduate student. This project may never have come to fruition if not for her endless encouragement, support, and insightful critique.

It was an absolute pleasure working alongside my fellow graduate students and staff members in the Department of Anthropology. Many of these individuals provided

support that was often unseen, but quite simply, made all the difference in my tenure as a graduate student. Aaron Armstrong, Heather Flowers, Jennifer Immich, and Teresa Valois deserve special recognition because their friendship made the experience of coming to campus each day so enjoyable.

Thank you to various institutions for financial support. A National Science Foundation Doctoral Dissertation Improvement Grant funded this project. The General Clinical Research Center at the University of Minnesota provided space and services to carry out my research. Several grants from the Graduate School and the Department of Anthropology, University of Minnesota, kept me and the project afloat over the course of several years. The contributions of my undergraduate assistants, Laura Egdorf and Lynn Schema, greatly exceeded my expectations and benefitted me tremendously. Many thanks are also due the participants in my study for giving generously during a busy and special time in their lives.

Finally, my heartfelt thanks go to my family. I am grateful to my siblings, Matthew, Jonathan, and Kathryn Hauff, my good friend Jessica Monson, and my godmother, Patricia Bower-Jernigan. Their friendship and unwavering faith in my ability helped sustain me. Last, but far from least, there truly are no words to express the gratitude I have for my parents, David and Eileen Hauff. I am the recipient of much good fortune, but I will never again experience luck like I did when I was born to them. Anything and everything good in my life has been touched in some way by their self-sacrificing nature, gentle pushing, boundless encouragement, and never-ending support. This dissertation is no exception. Thank you.

Dedication

For Eileen and David Hauff

Table of Contents

List of Tables.....	v
List of Figures.....	vi
Chapter I. Introduction.....	1
Chapter II: Body image concerns and reduced breastfeeding duration in primiparous overweight women.....	9
Chapter III: Perception of insufficient milk supply is associated with shorter lactation duration in primiparous overweight women.....	38
Chapter IV: Low milk output, decreased prolactin levels and poor positioning associated with early cessation of exclusive breastfeeding in obese women.....	60
Chapter V: Conclusion.....	81
References.....	87

List of Tables

Table 2.1 Participant characteristics by pre-pregnant BMI group.....	20
Table 2.2 Association of pre-pregnant maternal overweight and exclusive breastfeeding duration from general linear regression models.....	27
Table 2.3 Association of pre-pregnant maternal overweight and total breastfeeding duration from proportional hazards regression models.....	29
Table 3.1 Breastfeeding problems reported at two weeks postpartum by pre-pregnant maternal BMI group.....	48
Table 3.2 Association of pre-pregnant maternal overweight and exclusive breastfeeding duration from general linear regression models.....	51
Table 3.3 Association of pre-pregnant maternal overweight and total breastfeeding duration from proportional hazards regression models.....	53
Table 4.1 Characteristics of women and their infants by prepregnant BMI category (subset of the larger sample).....	67
Table 4.2 Outcome variables by prepregnant maternal BMI category (unadjusted).....	68
Table 4.3 Adjusted general linear regression of outcome variables by BMI category...	70
Table 4.4 Multivariate model for milk output at 7 days postpartum.....	72
Table 4.5 Logistic regression analysis of risk factors for cessation of exclusive breastfeeding at 2 weeks postpartum.....	73

List of Figures

Figure 1.1 Conceptual model of mediating factors between high maternal body mass index and reduced lactation duration.....	8
Figure 2.1 Kaplan-Meier estimates of probability of exclusive breastfeeding duration by postpartum week and pre-pregnancy maternal BMI.....	22
Figure 2.2 Kaplan-Meier estimates of probability of total breastfeeding duration by postpartum week and pre-pregnancy maternal BMI.....	23
Figure 4.1 Plot of Mother Baby Assessment score by maternal body mass index (kg/m ²).....	71
Figure 4.2 Plot of milk output by maternal body mass index (kg/m ²).....	72
Figure 4.3 Possible causal pathways for the factors associated with early cessation of exclusive breastfeeding.....	80

CHAPTER I

INTRODUCTION

International health organizations (WHO, 2003) and the American Academy of Pediatrics (Gartner et al., 2005) unanimously recommend to breastfeed infants exclusively (no other liquid or solid besides breastmilk) through the first six months of life and to some extent through at least the first year because breastfeeding is the best option for ensuring healthy infant growth and development. In infants, breastfeeding decreases the incidence and severity of a wide-range of infectious diseases (Heinig, 2001), enhances neurodevelopment (Anderson et al., 1999), and decreases rates of childhood obesity (Arenz, 2004; Metzger and McDade, 2010). Maternal benefits include decreased risk of postpartum hemorrhaging and an earlier return of the uterus to a pre-pregnancy state (Chua et al., 1994), decreased risk of breast and ovarian cancers (Collaborative Group on Hormonal Factors in Breast Cancer, 2002; Jernstrom et al., 2004; Newcomb et al., 1994; Rosenblatt and Thomas, 1993) and a more rapid and sustained maternal weight loss pattern (Dewey et al., 1993).

Encouragingly, breastfeeding initiation rates in the United States are currently higher than they have been for decades. The most recent data released from the Centers for Disease Control and Prevention indicate that 75% of infants were breastfed to some extent in 2007. Unfortunately, rates for continuation of breastfeeding are dramatically lower. Only 13% of infants were breastfed exclusively at six months and only 22% were breastfed any amount at twelve months (CDC, 2007). These numbers are especially troubling because many of the benefits of breastfeeding are realized in a dose-response

pattern so that the longer the duration of lactation, the greater the amount of benefits received (Gartner et al., 2005).

One subgroup of women that has particular difficulty meeting these recommendations, and thus appears to be at higher risk for losing the many benefits of breastfeeding, are those with high pre-pregnant body mass index (BMI). As obesity increases worldwide, this pattern is a potentially significant global public health problem. In many countries, including both urban and rural developing, the prevalence of overweight young women now exceeds that of underweight (Mendez et al., 2005). The association between overweight women and reduced lactation duration is of particular concern in the United States, as prevalence rates of obesity among reproductive age females are currently at 34% and have been increasing for years (Flegal et al., 2010). For this reason, it is especially important to identify factors that lead to early cessation of both exclusive and any breastfeeding in overweight women.

The relationship between high maternal body mass index and reduced lactation duration was first demonstrated in 1992 by Rutishauser and Carlin, yet the association has only been intensely investigated over the past decade. It is now well established that overweight and obese women experience a variety of poor breastfeeding outcomes, independent of various socio-demographic characteristics. These include: lower breastfeeding initiation rates (Donath and Amir, 2000; Hilson et al., 1997; Kitsantas and Pawlowski, 2010; Krause and Lovelady, 2011; Li et al., 2003; Manios et al., 2009; Scott et al., 2006), delay in onset of lactogenesis II (Chapman and Pérez-Escamilla, 1999; Dewey et al., 2003; Hilson et al., 2004; Nommsen-Rivers et al., 2010), and both shorter

exclusive and any breastfeeding duration (Baker et al., 2007; Donath and Amir, 2000; Forster et al., 2006; Hilson et al., 1997; Hilson et al., 2004; Kehler et al., 2009; Kugyelka et al., 2004; Li et al., 2003; Liu et al., 2009; Mok et al. 2008; Oddy et al., 2006; Riva et al. 1999). Moreover, some of these studies demonstrate that the heavier the woman, the greater the risk. One study found increasingly higher risks of breastfeeding cessation as BMI class increased (Baker et al. 2007). Additionally, others find negative associations only with obese, but not merely overweight, women (Kugyelka et al. 2004; Li et al. 2003; Mok et al. 2008). The effect of gestational weight gain on the consequence of high pre-pregnant BMI is inconclusive. In some studies, high weight gain during pregnancy appears to increase the risk of short duration among overweight women (Hilson et al., 2006; Li et al., 2003), but in others, gestational weight gain had no effect (Baker et al., 2007).

The aforementioned associations were mainly observed in women categorized as Caucasian from the United States, Canada, Australia and Western European countries. Within the United States, obese Hispanic women also were found to have lower initiation rates (Kugyelka et al., 2004), but obese African Americans did not have lower initiation or duration rates compared to African American women of normal body mass index (Kugyelka et al. 2004; Liu et al. 2009). Only two other studies included sizable populations of women in ethnic categories other than Caucasian, although the effect of ethnicity was not explored (Kitsantas and Pawlowski, 2010; Li et al., 2003).

Although studies consistently report an association between maternal obesity and poor lactation outcomes, the cause(s) of this relationship is still not clear. Many of these

studies sample large medical record databases, which make it difficult to explore particular explanations for the association between maternal overweight and reduced breastfeeding initiation and duration. Additionally, some of these studies have had difficulty disentangling confounding factors, especially parity and maternal intention and commitment to breastfeeding. Because breastfeeding is contingent upon a delicate set of physiological, behavioral and social conditions, the explanation is likely to be made up of multiple and interacting causes. For this reason, I explored potential mediating effects on the relationship between high pre-pregnant maternal BMI and reduced lactation duration using a holistic approach, by examining a variety of explanations in a primiparous sample that was committed to breastfeeding and well-supported in their endeavor.

If uninterrupted, the lactation process in humans begins with mammary gland development and differentiation at puberty. This process continues during pregnancy as the gland becomes capable of milk secretion, but is hormonally blocked from doing so until parturition. This stage is referred to as lactogenesis I. Milk, referred to as colostrum immediately postpartum, is initially limited in quantity, but increases rapidly in response to hormonal changes. Lactogenesis stage II is marked by this onset of copious milk secretion that follows parturition, usually within 48-72 hours postpartum. This rapid increase in milk volume is commonly referred to as the “coming in” of milk. At this time, milk removal from the breast, whether from infant suckling or maternal expression, is necessary for increased milk synthesis and secretion (Neville, 2001a; Neville, 2001b; Riordan, 2005). Inefficient transfer of milk from mother to infant leads to delays in breastfeeding establishment. If milk production does not reach appropriate levels,

supplementation may be necessary, which often results in reduced duration of exclusive breastfeeding. Transfer of milk may not take place for many reasons, from the maternal decision not to breastfeed her infant to a variety of physiological, psychological and behavioral factors that interrupt the process among those who do intend to breastfeed.

There are various ways in which high maternal BMI could affect factors that reduce lactation directly or via the pathway of low milk volume (due possibly to delayed onset of lactogenesis II) (see Figure 1.1). The conceptual model demonstrates that high maternal BMI could disrupt development of the mammary gland either during puberty or pre-pregnancy. This may compromise one's ability to breastfeed, resulting in reduced duration or no breastfeeding at all. High maternal BMI could also lead to hormone abnormalities, complications during pregnancy, labor, or delivery, as well as inefficient positioning while breastfeeding. These factors may affect milk production to some extent, even if only initially after parturition. Finally, high maternal BMI could reduce women's intention to initially breastfeed by interacting with a variety of socio-demographic and/or psycho-social factors. In those that do initiate breastfeeding, the decision to continue could be impacted by socio-demographic and psychosocial factors, or a variety of problems that arise while breastfeeding. Breastfeeding problems include maternal factors such as sore nipples, as well as infant factors such as difficulty latching-on to the breast.

The aim of this thesis research is to investigate potential mediating effects between high pre-pregnant maternal BMI and reduced lactation duration in an effort to provide new understanding of this association. This thesis is partitioned into chapters that include discussion of various components of the conceptual model: Chapter II explores

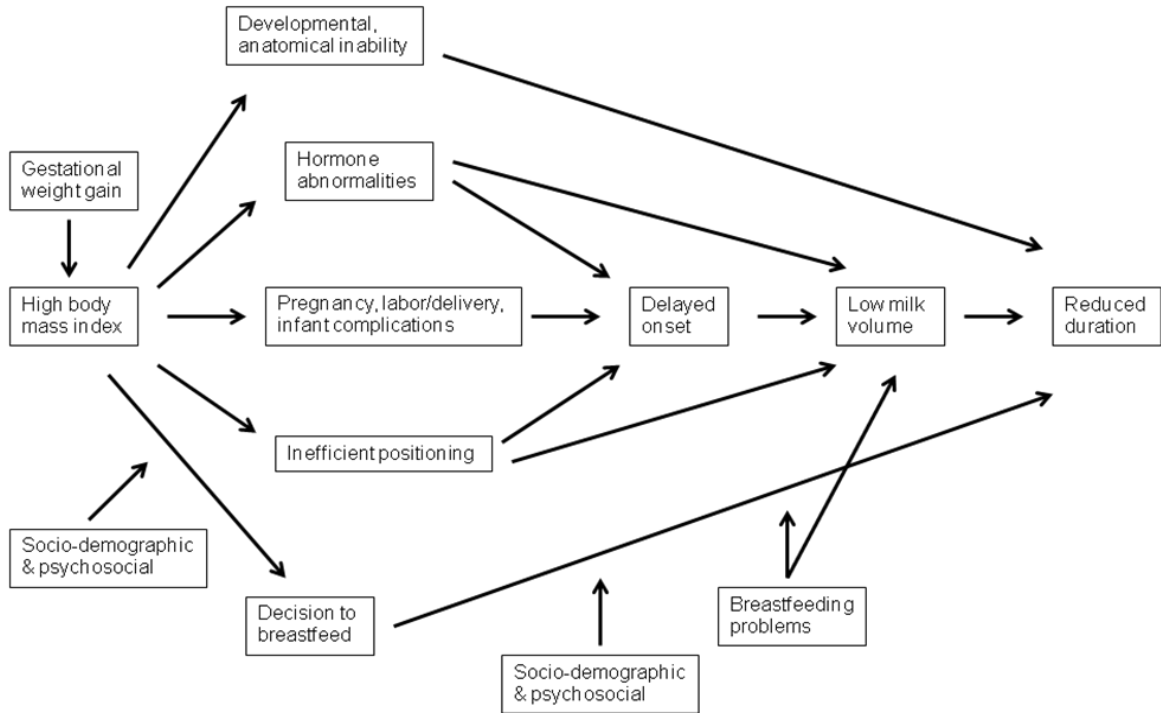
the impact of psychosocial factors on women's decisions to continue breastfeeding, Chapter III investigates how breastfeeding problems influence women's decisions to continue breastfeeding, and Chapter IV examines how the factors of hormone abnormalities and mother-infant positioning relate to short breastfeeding duration via low milk output. In particular, this dissertation takes a holistic approach and examines the following research questions: 1) Do psychosocial factors of concerns with one's body shape/weight and comfort/confidence with one's body impact the relationship between high pre-pregnant maternal BMI and reduced lactation duration?; 2) Are breastfeeding problems in the early postpartum period, such as maternal perception of insufficient milk, more prevalent among overweight women and if so, do these problems mediate the association with reduced duration?; and 3) Do obese women have difficulty obtaining efficient positioning or experience hormonal abnormalities that result in initial low milk supply and, ultimately, early cessation of exclusive breastfeeding?

The present study follows a prospective, longitudinal design to achieve this aim. I collected data from a variety of sources: questionnaire responses, hormone analyses, observations of breastfeeding behavior and measures of milk output. This sample is unique in that all participants were primiparous with a strong intention and commitment to breastfeed and they were well supported by family and health professionals. This study design is important because these participants should be among the most successful at breastfeeding. Results from this thesis contribute a better understanding of the effect of maternal overweight on reduced breastfeeding duration while avoiding the challenges that past studies have encountered with regard to issues of parity and maternal intention

to breastfeed. Although it was not a specific aim of this paper to investigate how socio-demographic characteristics, gestational weight gain patterns or labor and delivery complications affect obese women differentially, I considered many of these variables either by exclusion criteria before recruitment into the study or by controlling for them in adjusted analyses. It is not within the scope of this dissertation to explore how development of the mammary gland during puberty or pregnancy may be affected by maternal obesity and impact lactation duration. Otherwise, I explored all other components of the conceptual model.

This thesis is composed of five chapters, including this Introduction. Chapter II presents the findings from survey responses that explore the relationship between body image, maternal overweight and reduced lactation duration. Chapter III focuses on breastfeeding problems during the first two weeks postpartum, paying particular attention to maternal perception of insufficient milk supply. Due to the importance of the early postpartum period for establishing milk supply, Chapter IV analyzes the effects of mother-infant positioning while breastfeeding and hormone levels on milk output within one-week after birth. Finally, the Conclusion gives a brief summary, including the strengths and limitations of the project, as well as identifying practical implications of the study and areas for further research.

Figure 1.1 Conceptual model of mediating factors between high maternal body mass index and reduced lactation duration.



CHAPTER II

BODY IMAGE CONCERNS AND REDUCED BREASTFEEDING DURATION IN PRIMIPAROUS OVERWEIGHT WOMEN

Although the association between high maternal body mass index (BMI) and poor lactation outcomes has been known for almost two decades, few published studies have investigated the cause. Those seeking an explanation have tended to focus on physiological reasons such as altered hormone levels, delay in onset of lactogenesis II or the interaction of pre-pregnant maternal overweight with gestational weight gain. While these studies produce important findings, a more complete exploration would also include psychosocial factors that influence women's decision to initiate and, subsequently, continue breastfeeding. These include support from family and friends, maternal self-efficacy, and knowledge of breastfeeding, among others.

One cause that has not been adequately examined is how attitudes relating to body image may play a role in shorter breastfeeding duration lengths among overweight women. Body image is defined as a multi-dimensional assemblage of one's internal representation of his/her outward appearance (Pruzinsky and Cash, 2002; Thompson et al., 1999). Body dissatisfaction is one component of body image relating to dissatisfaction with the body (or parts of the body) (Thompson et al., 1999), sometimes in relation to an ideal (Heinberg, 1996). Pregnancy and childbirth result in considerable changes to a woman's body size and shape. Not surprisingly, it is well established that women develop negative feelings towards their body image or dissatisfaction with their bodies at various times throughout pregnancy (Skouteris et al., 2005; Strang and Sullivan,

1985) and the postpartum period (Drake et al., 1998; Gjerdingen et al., 2009; Jenkin and Tiggemann, 1997; Strang and Sullivan, 1985; Rallis et al., 2007).

Additionally, greater maternal weight, pre-pregnancy (Fox and Yamaguchi, 1997; Gjerdingen et al., 2009; Hilson et al., 2004; Huang et al., 2004; Walker, 1998), during pregnancy (Huang et al., 2004; Wiles, 1993) and during the postpartum period (Jenkin and Tiggemann, 1997; Walker, 1998), is a factor that exacerbates dissatisfaction. Poor body image or dissatisfaction with one's body has a negative implication for infant health as those with greater body image concerns tend to bottle-feed with formula rather than breastfeed (Barnes et al., 1997; Foster et al., 1996; Gjerdingen, et al. 2009). While it is known that those with body image concerns tend not to initiate breastfeeding, data are scarce relating body dissatisfaction with breastfeeding success among those who have already initiated breastfeeding. One study found no difference in body satisfaction between those who were successful at breastfeeding versus those who were not, although maternal weight was not taken into account (Hughes, 1984). A second study reported that "less satisfaction with appearance" was one factor among many that related to both maternal obesity and shorter total lactation duration (Hilson et al., 2004).

In this chapter, I aim to better explain the largely unexamined relationship between maternal overweight and body image, as it relates to breastfeeding success, by prospectively examining the following hypotheses: a) Pre-pregnant overweight BMI is associated with both shorter exclusive and shorter total duration of breastfeeding; b) Greater body image concerns are associated with both high maternal BMI and shorter lactation duration; and c) The relationship between high pre-pregnant BMI and reduced

lactation duration is mediated by body image concerns. This study is unique because it is the first to critically examine all three variables of breastfeeding duration, body image and high maternal pre-pregnancy body mass in primiparous women who are well-supported and committed to breastfeeding. This research is important because once the causes of short lactation duration among overweight women are understood, interventions may be better targeted to help these women reach their breastfeeding goals.

METHODS

Study participants

Two hundred and fifty-seven pregnant women from Minneapolis-St. Paul were recruited via advertisements in six clinics, pre-natal birth classes at four hospitals, and around the University of Minnesota campus during the time period from September 2008 to October 2009. The study ran through June 2010. Women giving birth for the first time and planning to breastfeed their infants were included. Women were excluded from the study if they were cigarette smokers, less than 18-years-of-age, planned to use estrogen-based birth control within six months postpartum, delivered their infant earlier than 37 gestational weeks, gave birth to an infant whose birth weight was less than 2500 g or had an APGAR score (used to assess the health of newborns) of less than 7 after five minutes. Participants were characterized as normal weight when their BMI was 18.5 - 24.9 kg/m² and overweight when their BMI was ≥ 25 kg/m². Seven women had a BMI of < 18.5 kg/m², but were included in the normal BMI group because they did not differ from others in this category. Body mass index was calculated as the weight in kilograms divided by the height in meters squared. Participants' pre-pregnancy height and weight

were self-reported. Informed consent was obtained from each subject after study explanation. The protocol was approved by the Institutional Review Board and the General Clinical Research Center Scientific Advisory Committee of the University of Minnesota (2008).

Eight women decided not to participate after consenting to the study and thus there is no information on the characteristics of these individuals. Ten individuals stopped participation after taking the first survey: three were excluded because their babies were born < 37 weeks gestation and seven because they could not be reached for follow-up after taking the first survey. These ten women did not differ from the remaining participants in demographic characteristics, nor in frequency of overweight status or intention of breastfeeding duration. Two participants could not be reached for follow-up after taking the second survey at two-weeks postpartum. Four participants completed all study components but failed to report a date when they stopped breastfeeding or to communicate that they were still breastfeeding when the study ended. These six women were included in analyses in which their information was provided. Thus the final sample consisted of 239, except for analyses involving total duration time in which case N=233. In summary, a total of 9.3% (24/257) of participants were lost to follow-up over the course of the entire 22-month study period.

Measures

The two outcome variables in this study were exclusive breastfeeding duration (weeks) and total breastfeeding duration (weeks). Participants were considered to be exclusively breastfeeding if they were providing only breastmilk to their infant and no

other liquids or solids for nutritional value. Exclusive breastfeeding duration was measured from the time of infant birth until the infant received non-breastmilk liquids or solids and continued to do so without going back to a breastmilk only diet. Participants were considered to be breastfeeding if they were nursing or pumping/expressing milk to any extent for their infant. Total breastfeeding duration was measured from the time of infant birth until the time when participants completely ceased all nursing and pumping, unless they were still breastfeeding at the end of the study, in which case they were right censored.

All women submitted a pre-natal survey (during their third trimester of pregnancy), another at two-weeks postpartum and a third at four-months postpartum (or time of weaning, whichever came first). These responses provided information relating to demographic characteristics, hospital delivery experience, intended and actual breastfeeding patterns, and questions on a variety of psychosocial issues related to breastfeeding. Responses to each question in the surveys were voluntary and as such, some participants did not answer some questions despite completing the rest of the survey. Sample size for a particular analysis may fluctuate in accordance with these types of missing data. Survey measures included the following questions.

Demographic/support variables: maternal age; education level (4-year college graduate, *yes/no*); income level (household income qualifies for the Federal assistance program, Women, Infants and Children (WIC), *yes/no*); working for pay at four months postpartum (*yes/no*); and marital status (*married/single*). Mothers' perceptions of personal and institutional support were assessed as follows: in the prenatal survey,

“Describe the level of agreement the baby’s father (or other person you will raise the child with) has with your plan to feed your infant.” Answers were provided using a 5-point Likert scale from *strongly agree* to *strongly disagree*. “Were you ever breastfed as a baby?” (*yes/no*). “Will you have attended a class on breastfeeding by the time your baby is born?” (*yes/no*); in the two-week postpartum survey, “While you were in the hospital or birth center for delivery of this baby, did anyone help you with breastfeeding by showing you how or talking to you about breastfeeding?” (*yes/no*). “Since your baby was born, have you attended a breastfeeding support group or visited with a lactation consultant?” (*yes/no*). Mothers’ intended exclusive and total breastfeeding durations were assessed by questions on the prenatal survey of “How long do you think you will breastfeed exclusively (in months)?” and “How old do you think your baby will be when you completely stop breastfeeding (in months)?”

Perinatal variables: Maternal and infant variables that relate to the time period of late pregnancy through childbirth and the early postpartum period include gestational diabetes mellitus (GDM) (diagnosed, *yes/no*); gestational weight gain (GWG) (classified as *Below*, *Within*, and *Above* in relation to recommendations from the Institute of Medicine for appropriate weight category (IOM 2009); mode of delivery (cesarean section, *yes/no*); postpartum depression (diagnosed or treated for, *yes/no*); hours until full milk production postpartum (time period in hours until milk “came in”); infant sex (*male/female*); and infant weight at birth, at two weeks postpartum and four months postpartum.

Psychosocial variables: Maternal concern with body image was assessed with questions asked in the pre-natal survey: “Do you think you will avoid breastfeeding in

public because others might see your breasts?” (*yes/no*). “Were you ever concerned about your body shape or weight before you became pregnant?” Answers were *No; Yes, but rarely concerned; Yes, I was sometimes concerned; Yes, I was often concerned*. “Are you comfortable with and self-confident in your body?” (*yes/no*). And in the four-month postpartum survey: “Are you concerned about your body shape or weight?” Answers were: *No; Yes, but rarely concerned; Yes, I am sometimes concerned; Yes, I am often concerned*. “Are you comfortable with and self-confident in your body?” (*yes/no*).

Statistical analysis

In order to retain as many participant responses as possible in statistical analyses, missing values for two variables were computed by using a simple imputation strategy of assigning the sample means for each variable. This was done for 4.1% of observations for infant weight at four months and 2.1% of observations for hours postpartum until full milk production. This adjustment did not affect results.

Chi-square (χ^2) and *t*-test (2-tailed) analyses were conducted to compare the characteristics of women with normal BMI pre-pregnancy to those with overweight BMI pre-pregnancy. All participants had stopped breastfeeding exclusively when the study ended. Accordingly, complete exclusive duration lengths are reported and general linear models were used to examine associations between the outcome variable, exclusive duration, with the independent variables. Thirty-four percent of participants were still breastfeeding to some extent when the study ended, thus, total duration lengths are only observed partially. These participants were classified as not having the event of interest (i.e. cessation of breastfeeding) and were, therefore, right-censored for analyses that

involve total duration. The Kaplan-Meier life table method and Cox proportional hazards regression were employed to account for these censored data (Cox, 1972; Hosmer and Lemeshow, 1999). The Kaplan-Meier life table method was used to determine whether exclusive duration and total duration of any breastfeeding, also an outcome variable, differed by maternal pre-pregnant BMI categories, as well as by other independent variables. Wilcoxon's test was used to compare the survival curves.

After examining the unadjusted bivariate associations, multiple general linear models were used to assess the independent effects of maternal overweight on exclusive breastfeeding duration. Following a hierarchical regression modeling technique (Newton and Rudestam, 1999), models were built in steps on the basis of significance in the bivariate analyses. Variables that were associated ($P < 0.10$) with exclusive duration and/or maternal overweight were added to the model. Variables that remained independent significant predictors of duration ($P < 0.05$) were carried over to the next model. Body image variables were added to this adjusted model one at a time to determine whether the magnitude of the relationship with prepregnant BMI and exclusive duration decreased with their addition. Potential interactions among the resulting main effect variables and maternal BMI were investigated by adding their cross-product terms to the equation for the final model-building step. No significant interactions were found. The final explanatory variables were checked for multicollinearity by examining the Variance Inflation Factor (VIF) and the values were not high enough to indicate collinearity (Cody and Smith, 2006). Model fit was assessed and the final model was

chosen based on both the highest R^2 value and the lowest Akaike Information Criterion (AIC) score (Akaike, 1974).

Cox proportional hazards regression analyses were conducted to determine the hazard risk (HR) of discontinuing any breastfeeding among overweight women compared to those with normal pre-pregnancy BMI. Proportional hazards regression models the effects of independent variables on the “hazard” (or risk) of breastfeeding cessation over time. The hazard can be thought of as the instantaneous risk of breastfeeding cessation at a given time point.

Models were built in steps on the basis of significance in the bivariate analyses. Variables that were significantly associated ($P < 0.10$) with total duration and/or maternal overweight were added to the model. Variables that remained independent significant predictors of duration ($P < 0.05$) were carried over to the next model. Body image variables were added to this adjusted model one at a time to determine whether the magnitude of the relationship with prepregnant BMI and total duration decreased with their addition. Potential interactions among the resulting main effect variables and maternal BMI were investigated by adding their cross-product terms to the equation for the final model-building step. No significant interactions were found. Cox regression is semi-parametric and allows for a continually changing “risk” (or hazard) over time. The major assumption of this type of analysis is that although the hazard may change over time for two individuals/groups, the hazard ratio for the change in exposure between them remains constant. To test this assumption, time-dependant covariates were included in the model. Time-dependent covariates are interactions of the predictors with time, in

this analysis, log(time) (UCLA, 2011). They were not significant individually or collectively so the assumption of proportionality was met. The final explanatory variables were checked for multicollinearity by examining the Variance Inflation Factor (VIF) and the values were not high enough to indicate colinearity (Cody and Smith, 2006). The final model was selected based on the lowest Akaike Information Criterion (AIC) score. All analyses were conducted with SAS (version 9.2; SAS Institute, Inc, Cary, NC).

RESULTS

Characteristics of the total sample and of the participants by prepregnant BMI category are shown in Table 2.1. Mean maternal age was 29.7 years and most were married (88.7%), college-educated (90.8%) and of high socioeconomic status (only 13.4% had a household income that qualified for WIC). Over 71% of participants were working for pay at four-months postpartum. Self-identified ethnicity of participants was as follows: 202 participants (84.5% of the total sample) identified as Caucasian, 6 as African American, 20 as Asian, 3 as Hispanic, 1 as Native American, 1 as Pacific Islander and 6 as other or no response. Because the number of women who identified as an ethnicity other than Caucasian is small and too heterogeneous as a group to analyze in a statistically meaningful way, the role of ethnicity on lactation duration was not tested. Fewer than 4% of participants were diagnosed with gestational diabetes and 5.6% with postpartum depression. Many women (N=119) experienced delayed onset of full milk production (defined as > 72 hours) as the mean number of hours reported until milk “came in” was 75.3 ± 23.0 . Overweight participants were less likely to have a 4-year college degree ($P < 0.0001$) and be married ($P = 0.003$) and they were more likely to

have an income that qualifies for WIC ($P = 0.033$) compared to those with normal BMI. There were no significant differences ($P < 0.05$) by BMI group in any other demographic or perinatal characteristics.

Participants reported being committed to breastfeeding and receiving familial and institutional support: 75.5% of participants were breastfed themselves as babies, 63.2% took a prenatal breastfeeding class, 96.6% of participants received breastfeeding assistance from hospital staff following delivery, and 100% of those who were raising the baby with another adult had support from that individual to breastfeed the baby. The two BMI groups did not differ in any of these measures of breastfeeding support.

Table 2.1 Participant characteristics by pre-pregnant BMI group.

	Total Sample (N=239)*	Normal BMI (N=159)*	Overweight BMI (N=80)*	P value¹
Demographic				
Maternal age (years)	29.7 ± 4.5	30.0 ± 3.9	29.1 ± 5.1	0.136
Prepregnant BMI (kg/m ²)	24.3 ± 4.8	21.7 ± 1.9	29.6 ± 4.6	<.0001
4-year college grad (% yes)	90.8%	96.2%	80.0%	<.0001
Married (yes)	88.7% (N=238)	93.0% (N=158)	80.0%	0.003
Work, 4 month PP (% yes)	71.6% (N=236)	74.7% (N=158)	65.4% (N=78)	0.136
Self-identified ethnicity ²				---
Caucasian	84.5% (N=202)	83.7% (N=133)	86.3% (N=69)	
African American	2.5% (N=6)	0.6% (N=1)	6.3% (N=5)	
Asian	8.4% (N=20)	10.7% (N=17)	3.8% (N=3)	
Hispanic	1.3% (N=3)	1.3% (N=2)	1.3% (N=1)	
Native American	0.4% (N=1)	0%	1.3% (N=1)	
Pacific Islander	0.4% (N=1)	0.6% (N=1)	0%	
Other or No Response	2.5% (N=6)	3.1% (N=5)	1.3% (N=1)	
Income (% WIC eligible)	13.4%	10.1%	20.0%	0.033
Duration				
Planned exclusive (wks)	22.0 ± 9.5 (N=232)	21.8 ± 9.6 (N=153)	22.5 ± 9.2 (N=79)	0.627
Planned total (wks)	43.8 ± 17.7	44.0 ± 16.2	43.6 ± 20.4	0.857
Exclusive (wks)	16.5 ± 9.9 (N=235)	17.5 ± 9.2 (N=157)	14.3 ± 10.9 (N=78)	0.019
Total (wks) ³	40.9 (27.3) (N=233)	48.9 (42.9-52.6) (N=156)	38.6 (27.7-46.0) (N=77)	0.009⁴
Perinatal/support				
Gestational weight gain (kg)			(N=78)	<.0001
Above recommendation	53.2%	43.4%	73.1%	
Within recommendation	38.8%	47.8%	20.5%	
Below recommendation	8.0%	8.8%	6.4%	
C-section delivery (% yes)	25.3% (N=237)	21.5% (N=158)	32.9% (N=79)	0.057
GDM (% yes)	3.8%	2.5%	6.3%	0.150
PP depression (% yes)	5.6% (N=233)	6.3% (N=158)	4.0% (N=75)	0.469
Time PP till milk onset (hrs)	75.3 ± 23.0	73.5 ± 21.8	78.9 ± 25.1	0.086
Attend prenatal BF class	63.2% (N=238)	62.0% (N=158)	66.3%	0.418
BF help in hospital (% yes)	96.6% (N=238)	96.9%	96.2% (N=79)	0.792
BF help after discharge (yes)	65.8% (N=237)	68.6%	60.3% (N=78)	0.206
Mother BF as baby (% yes)	75.5% (N=233)	77.9% (N=154)	70.9% (N=79)	0.237
Infant sex (% male)	54.2% (N=238)	57.0% (N=158)	48.8%	0.230
Infant weight (kg)				
Birth	3.5 ± 0.4 (N=233)	3.5 ± 0.4 (N=158)	3.5 ± 0.5 (N=79)	0.443
2 weeks	3.7 ± 0.5 (N=235)	3.7 ± 0.5 (N=157)	3.7 ± 0.5 (N=78)	0.926
4 months	6.8 ± 0.8	6.8 ± 0.8	6.7 ± 0.8	0.808

	Total Sample (N=239)*	Normal BMI (N=159)*	Overweight BMI (N=80)*	P value¹
Psychosocial				
Avoid BF in public (% yes)	41.4%	41.5%	41.3%	0.969
Body confidence, pre-pregnancy (% no)	28.5%	17.0%	51.3%	<.0001
Body confidence, 4 month PP (% no)	35.5%	28.5% (N=158)	50.0% (N=76)	0.001
Body concerns, pre-preg				0.081
Yes, often concerned	18.8%	15.7%	25.0%	
Yes, sometimes concerned	45.2%	43.4%	48.8%	
Yes, rarely concerned	24.3%	26.4%	20.0%	
No	11.7%	14.5%	6.3%	
Body concerns, 4 month PP				0.002
Yes, often concerned	19.2%	14.6%	29.0%	
Yes, sometimes concerned	39.3%	36.1%	46.1%	
Yes, rarely concerned	22.7%	27.9%	11.8%	
No	18.8%	21.5%	13.2%	

Values presented are frequencies or means \pm standard deviations.

*Sample size provided was used for all statistical tests unless otherwise noted.

¹P-values determined by *t*-test for continuous variables and chi-square test for categorical variables.

²Sample sizes given are actual counts for each level of this variable.

³For this variable, the median (inter-quartile range) is given for the total sample and the median (95% confidence intervals) is given for the total duration values of the BMI groups. Due to censored data points, the distribution cannot be assumed to be normal and, thus, the median is more appropriate.

⁴P-value determined by Kaplan-Meier life table method, Wilcoxon test.

BMI, body mass index; WIC, Women Infant Children; C-section, delivery via cesarean section; GDM, gestational diabetes mellitus; BF, breastfeeding; PP, postpartum

Duration differences by body mass index

All but 1.7% of participants stated that they were fairly or quite certain of their plans and were determined to follow through with them. Intended duration of both exclusive and any breastfeeding did not differ by maternal BMI group. Those who planned on feeding their infant exclusively for some period of time (97.1%, N=232) intended to do so for an average of 22 ± 9.5 weeks (mean \pm standard deviation) (Table 2.1). While actual mean exclusive breastfeeding length (16.9 ± 9.9 weeks) was shorter than planned for the entire sample, those in the overweight group had significantly lower

exclusive duration (14.3 ± 10.9 weeks) compared to those in the normal BMI group (17.5 ± 9.2 weeks) ($P = 0.019$). The estimated probability of breastfeeding exclusively was less for overweight women compared to the normal BMI group during the entire first six months postpartum (Figure 2.1). The largest difference between the groups is at three months: the estimated probability that an overweight woman will breastfeed exclusively for at least 12 weeks is 57.7% (confidence interval (CI) 46.0%, 67.7%), compared to 75.8% (CI 68.3%, 81.8%) for normal BMI women.

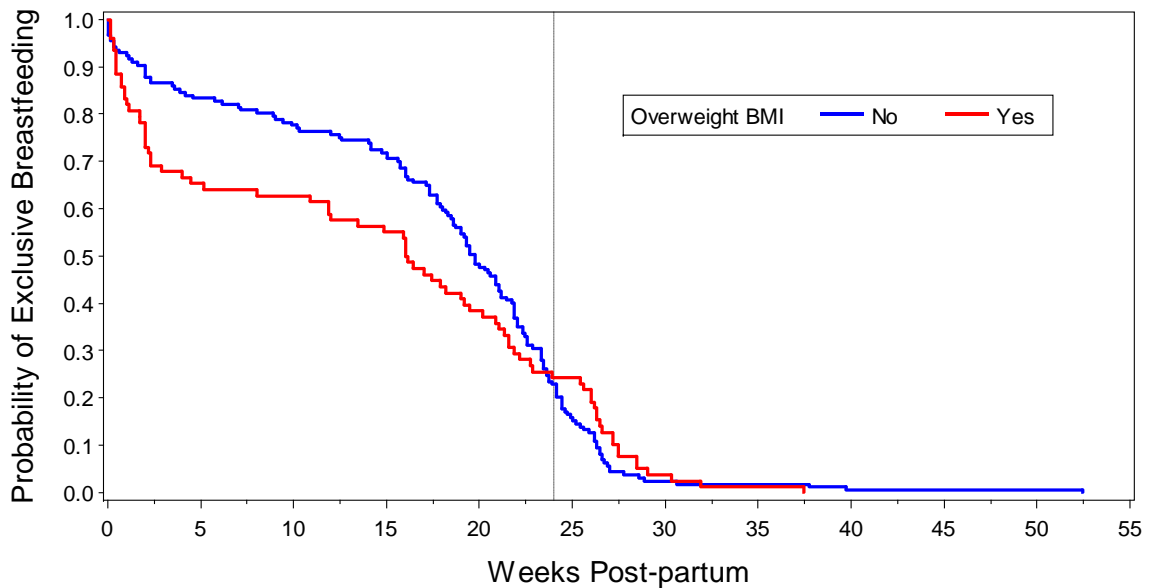


Figure 2.1 Kaplan-Meier estimates of probability of exclusive breastfeeding duration by postpartum week and pre-pregnancy maternal BMI.

Note: Dotted vertical line represents the health professional recommended time of exclusive breastfeeding until 6 months postpartum.

The pattern was similar for total duration. Mean planned duration of any breastfeeding for the entire sample was 43.8 ± 17.7 weeks (N=239), while the actual median duration was 40.9 weeks (inter-quartile range 27.3) (N=233). Because of

censored data, the distribution of total duration values cannot be assumed to be normal and thus, the median values are presented for this variable. Overweight women had a significantly lower median total duration (38.6 weeks) compared to normal weight women (48.9 weeks) ($P = 0.009$). The estimated probability for those in the overweight group to be breastfeeding any amount at six months was 66.2% (CI 54.5%, 75.6%) compared to 80.1% (CI 73.0%, 85.6%) for those in the normal BMI group. The magnitude of this difference continued as the estimated probability of any breastfeeding was less for overweight women compared to the normal BMI group during the entire first year postpartum (Figure 2.2).

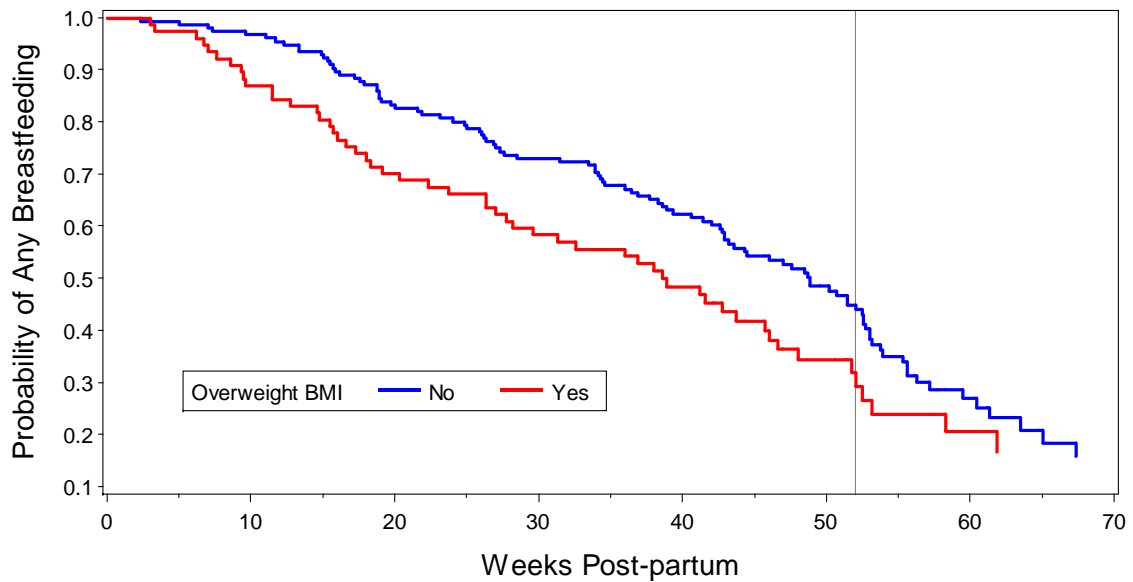


Figure 2.2 Kaplan-Meier estimates of probability of total breastfeeding duration by postpartum week and pre-pregnancy maternal BMI.

Note: Dotted vertical line represents the health professional recommended time of breastfeeding to some extent until at least 1 year postpartum.

Maternal intended duration was positively related to both actual exclusive and total lengths of lactation ($P = 0.0004$ and $P < 0.0001$, respectively). Gestational diabetes

was negatively associated with both exclusive and total duration ($P = 0.007$ and $P = 0.0003$, respectively). Number of hours until full milk production postpartum was negatively associated with exclusive duration only ($P = 0.010$). None of the other demographic or perinatal characteristics were individually associated with length of exclusive or total breastfeeding duration at the $P < 0.05$ level. (Data not shown).

Relationship of body image to body mass index and breastfeeding duration

There were a number of significant associations between body image concerns, overweight status, and lactation duration. (Associations by BMI category displayed in Table 2.1. Associations with duration not shown.) A positive response to the question asked in the prenatal survey “Do you think you will avoid breastfeeding in public because others might see your breasts?” was a significant negative predictor for both exclusive ($P = 0.002$) and total duration ($P = 0.002$), but it was not related to overweight status.

A negative response to the question asked during pregnancy, “Are you comfortable with and self-confident in your body?” was strongly associated with overweight status ($P < 0.0001$). Over 50% of overweight and obese women responded that they were not comfortable with or self-confident in their bodies pre-pregnancy and they were more than three times as likely as those of normal BMI to report this feeling. This variable was not associated with exclusive ($P = 0.314$) or total duration ($P = 0.082$), however. The frequency of overweight women that reported feeling not comfortable/self-confident at four months postpartum did not change from pre-pregnancy, while the prevalence of normal weight women who felt this way increased, yet there was still a significant difference between the BMI groups ($P = 0.001$). Feeling

comfortable/confident in one's body at this postpartum time was also a significant predictor of both exclusive ($P < 0.0001$) and total duration ($P < 0.0001$).

Finally, being concerned about one's body shape/weight pre-pregnancy was negatively associated with both exclusive ($P = 0.025$) and total duration ($P = 0.0006$), but was not related to overweight status ($P = 0.081$). At four months postpartum, however, there was a relationship to overweight status ($P = 0.002$). Women of normal weight were equally likely to be either *often* or *sometimes* concerned as they were to be *rarely* or *not* concerned, but among overweight women, three times as many were *often* or *sometimes* concerned. Therefore, normal weight women were twice as likely as overweight women to be either *rarely* or *not* concerned about their body shape/weight. Being concerned with one's body shape/weight was also significantly associated with total duration ($P = 0.0002$), but not with exclusive duration ($P = 0.064$).

Multivariate analysis of body image and exclusive duration

After adjustment for potential confounders, several variables, including pre-pregnant BMI, were significant predictors of exclusive duration. When all covariates were present in the model, BMI remained an independent predictor and its association with exclusive duration was not modified by these factors (Table 2.2). The column in Table 2.2 labeled "Coefficient" provides the beta coefficient of the maternal overweight variable in each model, as well as the beta coefficients of each variable in the final model. The beta coefficient is a mathematical weighting of each explanatory variable in the equation, holding all others constant. Here, the beta coefficient of maternal overweight is -2.81, which is interpreted to mean that overweight women had 2.81 fewer weeks of

exclusive breastfeeding compared to normal weight women, holding all other variables in the model constant.

To examine whether body image explains the association between maternal overweight and exclusive duration, each body image variable was added to the previous best-fit model. If the beta coefficient of maternal overweight becomes non-significant with the addition of another variable in the model, the interpretation is that the additional variable mediated the association between maternal overweight and duration. Concerns about one's body shape/weight and not being comfortable/confident with one's body, pre-pregnancy, were not significant predictors, nor did they mediate the relationship between pre-pregnant BMI and exclusive duration because the beta coefficients of BMI remained unchanged with inclusion of these variables (overweight $\beta = -2.75$, $P = 0.039$; $\beta = -2.68$, $P = 0.045$, respectively). Concerns about one's body shape/weight at four months postpartum attenuated the effect of BMI on exclusive duration, indicating that this variable partially explained the relationship between overweight and exclusive duration (overweight $\beta = -2.50$, $P = 0.067$). This variable was not a significant predictor in the model, however, and was not included in the final model because it did not explain additional variance. In contrast, not being comfortable/confident with one's body at four months postpartum was a significant negative predictor of exclusive duration. It clearly mediated the effect of BMI; with its inclusion in the model, BMI was no longer a significant predictor. In addition, it greatly improved the model fit. In this final model, lack of comfort/confidence with one's body mediated the effect of BMI on exclusive duration (Table 2.2).

Lack of comfort/confidence with one's body postpartum, along with avoidance of breastfeeding in public, gestational diabetes and postpartum depression, each had large effects on exclusive duration in the final model. Those with lack of comfort/confidence, avoidance of breastfeeding in public, gestational diabetes and postpartum depression had a shorter length of exclusive duration by 4.91, 3.45, 6.91, and 7.89 weeks, respectively, compared to those without these circumstances. Finally, every additional hour postpartum until full milk production began decreased the length of exclusive duration by 0.08 weeks and every additional week of intended duration increased actual exclusive duration by 0.20 weeks.

Table 2.2 Association of pre-pregnant maternal overweight and exclusive breastfeeding duration from general linear regression models.

	Variable	Coefficient	Standard Error	P value	R²	N
Model 1	Overweight (<i>yes</i>) ¹ , unadjusted	-3.20	1.36	0.019	0.02	235
Model 2	Overweight (<i>yes</i>), adjusted ²	-2.81	1.31	0.033	0.19	224
Final Model	Overweight (<i>yes</i>)	-1.70	1.30	0.194	0.24	224
	GDM (<i>yes</i>)	-6.91	3.05	0.024		
	Post-partum depression (<i>yes</i>)	-7.89	2.64	0.004		
	Avoid BF in public (<i>yes</i>)	-3.45	1.23	0.005		
	Hours until lactogenesis II	-0.08	0.03	0.004		
	Intended exclusive duration	0.21	0.06	0.002		
	Body confidence, 4 mon (<i>no</i>)	-4.91	1.28	.0002		

¹Terms in italics are the participant response and were the predicted value in analyses.

²Adjusted for other significant covariates: GDM, postpartum depression, avoidance of breastfeeding in public, hours postpartum until lactogenesis II, intended exclusive duration. GDM, gestational diabetes mellitus; BF, breastfeeding

Multivariate analysis of body image and total duration

When the hazard ratio (HR) of discontinuing any breastfeeding was examined for overweight women, they were at a significantly higher risk of discontinuation of breastfeeding than normal weight women (unadjusted HR = 1.40; CI, 1.001-1.95; $P = 0.049$) (Table 2.3). Several variables known to be related to either maternal overweight or breastfeeding duration were explored as potential confounders. Three variables were added to the model as covariates because of their significant association: gestational diabetes and avoiding breastfeeding in public were negative predictors and a longer planned duration of breastfeeding was a positive predictor of total duration. When they were entered into the proportional hazards regression model, the association between maternal overweight and duration of breastfeeding was not attenuated and remained significant (adjusted HR = 1.43; CI, 1.02- 2.01; $P = 0.041$). Each body image variable was then entered in turn. When having concerns about one's body shape/weight pre-pregnancy was added to the adjusted model, the HR for overweight was 1.48 (CI, 1.05-2.10; $P = 0.027$) (data not shown) suggesting that discontinuation of breastfeeding was not explained by pre-pregnancy body concerns. When concerns about one's body at four months postpartum was added to the model, maternal overweight was no longer significant (HR = 1.22; CI, 0.85-1.77; $P = 0.280$). Similarly, when not being comfortable/confident with one's body pre-pregnancy was added to the model, maternal overweight was no longer significant (HR = 1.35; CI, 0.95-1.91; $P = 0.093$). Finally, not being comfortable/confident with one's body at four months postpartum also reduced the effect of maternal overweight on total duration (HR = 1.31; CI, 0.93-1.86; $P = 0.126$).

Table 2.3 Association of pre-pregnant maternal overweight and total breastfeeding duration from proportional hazards regression models.

	Variable	HR	95% CI	P value¹	N
Model 1	Overweight (<i>yes</i>) ² , unadjusted	1.40	1.001-1.95	0.049	233
Model 2	Overweight (<i>yes</i>), adjusted ³	1.43	1.02-2.01	0.041	233
Final Model	Overweight (<i>yes</i>)	1.31	0.93-1.86	0.126	230
	Gestational diabetes (<i>yes</i>)	2.01	0.98-4.13	0.056	
	Avoidance of BF in public (<i>yes</i>)	1.53	1.11-2.12	0.009	
	Intended total duration	0.96	0.95-0.98	<0.0001	
	Body confidence, 4 mon (<i>no</i>)	1.56	1.11-2.19	0.011	

¹P-values are based on the Wald test for significance of Cox regression coefficients.

²Terms in italics are the participant response and were the predicted value in analyses.

³Adjusted for other significant covariates: gestational diabetes, avoidance of breastfeeding in public, intended exclusive duration.

HR, hazard ratio; CI, confidence interval; BF, breastfeeding

These results indicate that comfort/confidence with one's body pre-pregnancy and postpartum, as well as concerns about one's body during the postpartum period, mediated the relationship between maternal overweight and total duration. Of these three body image variables that were added to the adjusted model, only lack of comfort/confidence with one's body postpartum remained significant in the best-fit model and it increased the hazard of ceasing breastfeeding by 55% compared to those who were comfortable/confident (Table 2.3). Finally, those who would avoid breastfeeding in public had a 1.5-fold greater risk of ceasing compared to those who would not avoid breastfeeding in public and the hazard of ceasing breastfeeding decreased by 4% for every additional week of intended duration.

DISCUSSION

This chapter aimed to explain how pre-pregnant maternal overweight negatively impacts breastfeeding duration by testing whether body image concerns were associated with exclusive and total lactation duration. The results indicate that overweight women in this study, although uniformly and highly committed to breastfeeding and well supported, more often fell short of their own breastfeeding goals and had significantly shorter durations compared to those of normal BMI. The overweight women expressed significantly more concerns with their body shape and weight and were less confident in and comfortable with their bodies. In addition to their association with BMI, greater body image concerns, especially postpartum, also played a role in predicting shorter lactation duration.

Duration and body mass index

Intended duration of exclusive breastfeeding and intended duration of total breastfeeding remained significant factors in the final models of exclusive and total duration respectively. Although planned duration did not have a large effect in this study, each additional week that women intended to breastfeed, predicted a small increase in both exclusive and total duration length. Breastfeeding is a planned behavior and it is not surprising that the longer women planned to breastfeed, the longer the actual duration. Several researchers have used the theory of reasoned action (Ajzen and Fishbein, 1980) to explore breastfeeding behavior. This theory asserts that the most important determinant of one's behavior is one's own behavioral intention. The results of the present study echo the findings that women who intend to breastfeed for a shorter time are less likely to

continue breastfeeding (DiGirolamo et al., 2005; Lawson and Tulloch, 1995; Manstead et al., 1983; O'Campo et al., 1992; Quarles et al., 1994).

On average, those in both the normal and overweight BMI groups intended to breastfeed exclusively for just under the recommended six months and to some extent through eleven months postpartum. While women of normal BMI were about a month shy of their exclusive duration goals, on average they exceeded their goal for total duration of breastfeeding. In contrast, those in the overweight BMI category were several weeks short of both their exclusive and total duration goals. Overweight women had a higher probability of ceasing exclusive and total breastfeeding compared to normal BMI women at all times postpartum, until almost exactly the health professional recommended time period of six months and one year for exclusive and total duration, respectively.

These results are consistent with what is demonstrated in the literature regarding shorter lactation duration among overweight women. Many studies also show that obese women have shorter planned durations (Hilson et al., 2004) and even initiate breastfeeding less frequently than do women of normal weight (Li et al. 2003, Oddy et al. 2006, Scott et al. 2006), which may affect the shorter duration lengths reported. This study is unique, however, in that all participants were committed to breastfeeding and intentions did not differ between participants in the two BMI groups. In addition, participants were extremely well supported by their families and health professionals: every participant raising her baby with another adult had that individual's support to breastfeed and almost all received breastfeeding instruction in the hospital following the birth. In addition, a majority attended a prenatal breastfeeding instruction class and

received support from a health professional after hospital discharge. There were no significant differences between overweight and normal weight women in any of these measures, which make the difference in duration between the groups even more striking.

Effect of body image concerns on duration in overweight women

Although overweight women did not differ in measures of intention or support, they did vary considerably from normal weight women in other psychosocial measures, namely concerns surrounding body image. Overweight women reported being concerned about their body shape/weight more frequently than the normal BMI group both pre-pregnancy and postpartum. In addition, they were three times as likely to report a lack of comfort/confidence with their body pre-pregnancy and twice as likely to report lack of confidence postpartum. That women who were overweight before pregnancy have greater body image concerns both pre-pregnancy and postpartum is expected and has been demonstrated before (Fox and Yamaguchi, 1997; Gjerdingen et al., 2009; Hilson et al., 2004; Huang et al., 2004; Walker, 1998), but this is the first study to demonstrate a relationship between greater body image concerns and shorter exclusive breastfeeding duration.

Results of the present study confirm previous research that identified a relationship between poor body image and shorter total duration, and add to that a novel finding, by demonstrating that concerns about one's body shape/weight and comfort/confidence with one's body are associated with shorter exclusive duration in overweight women. Most research shows that those intending to breastfeed their infants have a more positive body image or fewer body shape concerns than those intending to

bottle-feed formula (Barnes et al., 1997; Foster et al., 1996; Gjerdingen et al., 2009), although one study showed no difference in body image between the two groups (Walker and Freeland Graves, 1998). While these studies explore intentions for infant feeding, only two studies have examined the relationship between body image and breastfeeding success among those who already intend to breastfeed. In contrast to the current study, Hughes (1984) found no difference in body satisfaction between those who were successful (defined as breastmilk constituting all but up to eight ounces of an infant's daily intake at four weeks postpartum) versus not. In addition, her study did not investigate the influence of maternal weight on either body image or breastfeeding success. Hilson et al. (2004) examined short breastfeeding duration among obese women and found that "less satisfaction with appearance" was one of several factors that was significantly associated with both maternal obesity and shorter total (but not exclusive duration) lactation duration, however, it did not mediate the effect of obesity. In Hilson et al.'s study, it is important to note that obese women planned to breastfeed for three fewer months than normal BMI women, which may play a role in the relationship.

While the bivariate analyses clearly confirmed the previously known association between BMI and duration, (as well as demonstrated significant associations of body image with both BMI and lactation duration), a final aim of this study was to assess if body image was a possible explanation for how high BMI might result in shorter exclusive and total duration. In the adjusted model of exclusive duration, maternal overweight remained a significant predictor when pre-pregnant body image variables were added to the model. Concerns about one's body and comfort/confidence in one's

body postpartum attenuated its effect, however, suggesting that negative body image during the postpartum time period mediated the effect of BMI on exclusive duration. Similarly, in the adjusted model of total duration, lack of body comfort/confidence both pre-pregnancy and postpartum, as well as concerns about one's shape/weight postpartum all mediated the effect of maternal overweight on duration of any breastfeeding. This is the first study to affirm the mediating effect of body image on the relationship between high maternal BMI and duration.

It is interesting to note that of the two body image measures, lack of comfort in and confidence with one's body had a stronger effect than concerns about one's body shape/weight. Breastfeeding requires women to use their body in new ways and has even been named a "confidence trick" (Jelliffe and Jelliffe, 1978). Establishing and maintaining a breastfeeding pattern often requires persistence in the face of a variety of physiological, anatomical, and social obstacles. These obstacles could be exacerbated for overweight individuals who may have large breasts or extra body tissue. For a first-time mother, not being comfortable and confident in one's body could make combating breastfeeding obstacles a continual struggle. This could eventually lead to lower confidence in one's ability to breastfeed, a factor which is known to result in shorter exclusive duration (Noel-Weiss et al., 2006).

Avoidance of breastfeeding in public, another psychosocial variable, also remained a strong negative predictor of both exclusive and total duration in the final models. Frequent and regular nursing episodes are necessary in order to produce a milk supply strong enough to support exclusive breastfeeding. As women are away from home

for longer periods as the time since delivery increases, it will be necessary to nurse away from the home in order to keep up one's milk supply. If one avoids breastfeeding in public, it could lengthen the time between feedings, which decreases the milk supply and necessitates supplementation of the infant's diet, thereby decreasing duration. I thought avoidance of breastfeeding in public might be a link between body image concerns and maternal overweight but no significant differences were found in avoidance between the BMI groups. It is possible that this measure only captured participants' level of modesty, which may not differ by BMI, and not the degree of hassle associated with breastfeeding in public, which was thought to perhaps be greater for overweight women.

Additional predictors of duration

Postpartum depression, although affecting a small percentage of this sample, was a significant negative predictor in the final exclusive duration model. It is possible that those with poor body image cease breastfeeding earlier because of the connection with poor mental health. Previous studies have documented an association between perinatal depressive symptoms and body image concerns (Abraham et al., 2001; Dipietro et al., 2003; Gjerdengin et al., 2009; Walker et al., 2002). Poor mental health is also known to result in lower breastfeeding rates and shorter breastfeeding duration (Dennis and McQueen, 2009). The order of causation between poor mental health and poor body image is unknown. The present study did not specifically examine measures of mental health in this population, but results do show that those who were diagnosed with postpartum depression stopped exclusively breastfeeding almost eight weeks earlier than those without the illness.

Gestational diabetes, like postpartum depression, had a strong negative effect on both exclusive and total duration and was a significant predictor in the final exclusive duration model. Among those with gestational diabetes (a small percentage in this sample), there was a decrease of almost seven weeks of exclusive breastfeeding compared to those without gestational diabetes. The evidence for the effect of gestational diabetes on lactation outcomes is sparse. One study showed no delay in onset of milk production (Hartmann and Cregan, 2001) and another found no difference in total duration (Gunderson et al., 2010) in women with gestational diabetes compared to women without gestational diabetes. However, results from the present study indicate gestational diabetes is a strong predictor of shorter lactation duration. The relationship of gestational diabetes to lactation success is an important avenue of future investigation.

Finally, many studies have found a strong relationship between high maternal BMI and delayed onset until full milk production (lactogenesis II) (Chapman and Perez-Escamilla, 2000; Dewey et al., 2003). Although the average time until lactogenesis II was longer among overweight women compared to the normal BMI group in this study, the relationship was only significant at the $P < 0.10$ level. Hours until lactogenesis II did remain a significant negative predictor in the final exclusive duration model.

The results presented here show that overweight/obese women, who are well supported and intend to breastfeed for as long as women of normal weight, have shorter exclusive breastfeeding duration that is mediated by lack of confidence in one's body. Given the relationship between body image, weight status in the perinatal period and breastfeeding outcomes, along with current trends toward increasing obesity in

reproductive age women, further research in this interplay is important in order to find ways to enhance mothers' body image and confidence levels during the perinatal period.

CHAPTER III

PERCEPTION OF INSUFFICIENT MILK SUPPLY IS ASSOCIATED WITH SHORTER LACTATION DURATION IN PRIMIPAROUS OVERWEIGHT WOMEN

As discussed in Chapter I, many potential reasons for early cessation of lactation operate through the pathway of low milk production (especially initially after parturition). Yet, except for establishing the relationship between high pre-pregnant maternal BMI and delayed onset of lactogenesis II, researchers have not given much direct attention to issues of milk production in overweight women. This chapter will explore breastfeeding problems occurring within the first two weeks postpartum, focusing particularly on maternal perception of low milk supply.

Several factors are necessary for efficient milk production and subsequent transfer. Milk, referred to as colostrum immediately postpartum, is limited in quantity during the first couple days postpartum. Colostrum has lower concentrations of lactose, but higher levels of antibodies and immunoglobins than mature milk, which meet the unique needs of newborns. Production of mature milk, with increased concentrations of lactose and proteins, increases rapidly around 48-72 hours after birth (Neville, 2001b; Riordan, 2005). This marks the transition to lactogenesis II, more commonly referred to as the “coming in” of milk. Inefficient milk transfer leads to delays in breastfeeding establishment, which can lead to problems with long-term milk supply. If milk is not removed from the breast, milk production may not reach appropriate levels. Establishing a sufficient milk supply can be interrupted by several factors because they suspend

breastfeeding, even temporarily, including infant factors such as disinterest or problems latching-on to the breast or maternal factors such as sore nipples or breast infections.

While less than 5% of women may have an actual physiological or anatomical inability to produce sufficient milk (Neifert, 2001), perceived insufficient milk (PIM) is often the most commonly cited reason by mothers (living in a variety of different countries and socioeconomic settings) for early supplementation or discontinuation of breastfeeding (Gatti, 2008). PIM has been defined as a state in which a mother has or perceives that she has an inadequate supply of breast milk to meet her infant's needs (Hill and Humenick, 1989). Actual milk supply, however, is rarely measured and most reports refer only to maternal perception. Women experiencing PIM have been found to be most at risk for ceasing breastfeeding during the early postpartum period (Ahluwalia et al., 2005; Heath et al., 2002; Lewallen et al., 2006; McCarter-Spaulding and Kearney, 2001; Punthmatharith and Singh, 2005; Sheehan et al., 2001; Wojnar, 2004), yet some studies report that PIM continues to be a major risk factor for several months postpartum (Blyth et al., 2002; Cooke et al., 2003; Kirland and Fein, 2003). Women most commonly report PIM in response to infant crying, which they believe to be a sign that the infant is not receiving enough milk (Tully and Dewey, 1985; Segura-Millan et al., 1994; Dettwyler and Fishman, 1992). Formula supplementation, when available, is then the universal response used to combat PIM (Blyth et al., 2002; Lewallen et al., 2006; Sacco et al., 2006; Alikassifoglu et al., 2001; Cooke et al., 2003; Heath et al., 2002; Schluter et al., 2006), which subsequently leads to early discontinuation of breastfeeding.

PIM is associated with a variety of factors, many of which are known to affect milk production: delay of lactogenesis II (Perez-Escamilla et al., 1992; Segura-Millan et al., 1994), inadequate breastfeeding knowledge or technique (Hill and Aldag, 1991; Perez-Escamilla et al., 1993; Segura-Millan et al., 1994), lack of maternal confidence in breastfeeding ability (Otsuka et al., 2008; McCarter-Spaulding and Kearney, 2001; Dykes and Williams, 1999; Blyth et al., 2002; Segura-Millan et al., 1994) mismanagement due to formula supplementation or inappropriate feeding schedule (Wright, 2001), and loss of mother/baby contact (Gussler and Briesemeister, 1980).

It is known that overweight women have shorter breastfeeding duration and that PIM is the most common reason cited for discontinuing breastfeeding, yet only three studies have explored the relationship between PIM and maternal obesity with conflicting results (Mok et al., 2008; Rutishauser and Carlin, 1992; Segura-Millan et al., 1994). The present study investigates whether this common reason for early cessation affects overweight women differentially and impacts the relationship between maternal overweight and duration. I explore a variety of common breastfeeding problems in the early postpartum period and focus on those that relate to milk production by testing the following hypotheses: a) Overweight women report PIM in greater frequencies than women of normal BMI; b) PIM is a predictor of shorter exclusive and total duration of lactation; and c) The relationship between maternal overweight and shorter lactation duration is mediated by PIM. In addition, I explore how other problems reported at this early postpartum time, may speak to the accuracy of maternal perception of insufficient milk.

METHODS

Study participants

Details of participant recruitment, including exclusion criteria, as well as the final number of participants are described in Chapter II.

Measures

The two outcome variables in this study are exclusive breastfeeding duration (weeks) and total breastfeeding duration (weeks). Participants were considered to be exclusively breastfeeding if they were providing only breastmilk to their infant and no other liquids or solids for nutritional value. Exclusive breastfeeding duration was measured from the time of infant birth until the infant received non-breastmilk liquids or solids and continued to do so without going back to a breastmilk only diet. Participants were considered to be breastfeeding if they were nursing or pumping/expressing milk to any extent for their infant. Total breastfeeding duration was measured from the time of infant birth until the time when participants completely ceased all nursing and pumping, unless they were still breastfeeding at the end of the study, in which case they were right censored.

All women submitted a pre-natal survey (during their third trimester of pregnancy), another at two-weeks postpartum and a third at four-months postpartum (or time of weaning, whichever came first). These responses provided information relating to demographic characteristics, hospital delivery experience, intended and actual breastfeeding patterns, and breastfeeding problems experienced within the early postpartum period. Responses to each question in the surveys were voluntary and as such,

some participants did not answer some questions despite completing the rest of the survey. Sample size for a particular analysis may fluctuate in accordance with these types of missing data. Survey measures included the following:

Demographic/support variables: maternal age; education level (4-year college graduate, *yes/no*); income level (household income qualifies for the Federal assistance program, *Women, Infants and Children, yes/no*); working for pay at four months postpartum (*yes/no*); and marital status (*married/single*). Mothers' perceptions of personal and institutional support were assessed as follows: in the prenatal survey, "Describe the level of agreement the baby's father (or other person you will raise the child with) has with your plan to feed your infant." Answers were provided using a 5-point Likert scale from *strongly agree* to *strongly disagree*. "Were you ever breastfed as a baby?" (*yes/no*). "Will you have attended a class on breastfeeding by the time your baby is born?" (*yes/no*); in the two weeks postpartum survey, "While you were in the hospital or birth center for delivery of this baby, did anyone help you with breastfeeding by showing you how or talking to you about breastfeeding?" (*yes/no*). "Since your baby was born, have you attended a breastfeeding support group or visited with a lactation consultant?" (*yes/no*). Mothers' intended exclusive and total breastfeeding durations were assessed by questions on the prenatal survey of "How long do you think you will breastfeed exclusively (in months)?" and "How old do you think your baby will be when you completely stop breastfeeding (in months)?"

Perinatal variables: Maternal and infant variables that relate to the time period of late pregnancy through childbirth and the early postpartum period include gestational diabetes

mellitus (GDM) (diagnosed, *yes/no*); gestational weight gain (GWG) (classified as *Below*, *Within*, and *Above* in relation to recommendations from the Institute of Medicine for appropriate weight category (IOM 2009); mode of delivery (cesarean section, *yes/no*); postpartum depression (diagnosed or treated for, *yes/no*); hours until full milk production postpartum (time period in hours until milk “came in”); infant sex (*male/female*); and infant weight at birth, at two weeks postpartum and four months postpartum.

Breastfeeding problems (yes/no): Problems that were reported to have occurred within the first two weeks postpartum include pain while breastfeeding (pain experienced while breastfeeding so great at any time that it prevented participant from breastfeeding); infant concerns (poor latch, baby choked while feeding, baby was too sleepy to nurse, baby was too distracted or not interested in nursing), milk production concerns (it took too long for the milk to come in, there was trouble getting the milk flow to start, infant was losing too much or not gaining enough weight, mother didn’t have enough milk (i.e. PIM)), breast concerns (sore, bleeding or cracked nipples, engorged breasts, clogged duct, infected or abscessed breast).

Statistical analysis

In order to retain as many participant responses as possible in statistical analyses, missing values for two variables were computed by using a simple imputation strategy of assigning the sample means for each variable. This was done for 4.1% of observations for infant weight at four months and 2.1% of observations for hours postpartum until full milk production. This adjustment did not affect results.

Chi-square (χ^2) and *t*-test (2-tailed) analyses were conducted to compare the characteristics of women with normal BMI pre-pregnancy to those with overweight BMI pre-pregnancy. All participants had stopped breastfeeding exclusively when the study ended. Accordingly, complete exclusive duration lengths are reported and general linear models were used to examine associations between the outcome variable, exclusive duration, with the independent variables. Thirty-four percent of participants were still breastfeeding to some extent when the study ended, thus, total duration lengths may only be partially observed. These participants were classified as not having the event of interest (i.e. cessation of breastfeeding) and were, therefore, right-censored for analyses that involve total duration. The Kaplan-Meier life table method and Cox proportional hazards regression were employed to account for these censored data (Cox, 1972; Hosmer and Lemeshow, 1999). The Kaplan-Meier life table method was used to determine whether exclusive duration and total duration of any breastfeeding, also an outcome variable, differed by maternal pre-pregnant BMI categories, as well as by other independent variables. Wilcoxon's test was used to compare the survival curves.

After examining the unadjusted bivariate associations, multiple general linear models were used to assess the independent effects of maternal overweight on exclusive breastfeeding duration. Following a hierarchical regression modeling technique (Newton and Rudestam, 1999), models were built in steps on the basis of significance in the bivariate analyses. Variables that were associated ($P < 0.10$) with exclusive duration and/or maternal overweight were added to the model. Variables that remained independently associated with duration ($P < 0.05$) were carried over to the next model.

Breastfeeding problem variables were then added to this adjusted model in three different groups – infant concerns, breast concerns and milk production concerns – to determine whether the magnitude of the relationship with prepregnant BMI and exclusive duration decreased with the addition of variables in each group. Potential interactions among the resulting main effect variables and maternal BMI were investigated by adding their cross-product terms to the equation for the final model-building step. No significant interactions were found. The final explanatory variables were checked for multicollinearity by examining the Variance Inflation Factor (VIF) and the values were not high enough to indicate colinearity (Cody and Smith, 2006). Final model fit was assessed based on both the R^2 value and Akaike Information Criterion (AIC) score (Akaike 1974).

Cox proportional hazards regression analyses were conducted to determine the hazard risk (HR) of discontinuing any breastfeeding among overweight women compared to those with normal pre-pregnancy BMI. Proportional hazards regression models the effects of independent variables on the “hazard” (or risk) of breastfeeding cessation over time. The hazard can be thought of as the instantaneous risk of breastfeeding cessation at a given time point.

Models were built in steps on the basis of significance in the bivariate analyses. Variables that were significantly associated ($P < 0.10$) with total duration and/or maternal overweight were added to the model. Variables that remained independently associated with duration ($P < 0.05$) were carried over to the next model. Variables associated with breastfeeding problems were then added to this adjusted model in three different groups –

infant concerns, breast concerns and milk production concerns – to determine whether the magnitude of the relationship with prepregnant BMI and exclusive duration decreased with the addition of variables in each group. Potential interactions among the resulting main effect variables and maternal BMI were investigated by adding their cross-product terms to the equation for the final model-building step. No significant interactions were found. Cox regression is semi-parametric and allows for a continually changing “risk” (or hazard) over time. The major assumption of this type of analysis is that although the hazard may change over time between two individuals/groups, the hazard ratio for the change in exposure between them remains constant. To test this assumption, time-dependant covariates were included in the model. Time-dependent covariates are interactions of the predictors with time, in this analysis, $\log(\text{time})$ (UCLA, 2011). They were not significant individually or collectively so the assumption of proportionality was met. The final explanatory variables were checked for multicollinearity by examining the Variance Inflation Factor (VIF) and the values were not high enough to indicate colinearity (Cody and Smith, 2006). The final model was selected based on the lowest Akaike Information Criterion (AIC) score. All analyses were conducted with SAS (version 9.2; SAS Institute, Inc, Cary, NC).

RESULTS

Characteristics of the total sample, as well as frequencies of each study variable by prepregnant maternal BMI are shown in Table 2.1. Participants tended to be relatively older for giving birth for the first time, be married, college-educated, of high socioeconomic status and self-identify as Caucasian. For comparison, average age of first

birth in Minnesota is 25.8 years, 35.2% of women giving birth in Minnesota have a four-year college degree, 85.2% identify as Caucasian and 70.2% are married (CDC 2009; PRAMS 2006).

Participants were well supported by both family and health professionals in their decision to breastfeed. Although intended duration of both exclusive and any breastfeeding did not differ by maternal BMI group, average actual duration lengths were significantly shorter for those in the overweight BMI group. Complete details of the demographic and support characteristics, as well as lengths of exclusive and total duration by BMI can be found in Chapter II.

Association of breastfeeding problems and body mass index

Fewer than 7% of participants reported no problems related to breastfeeding within the first two weeks postpartum. The vast majority experienced different problems to varying degrees (Table 3.1). Under *Infant Concerns*, 47.9% reported that their infant had trouble latching on, 13.5% of infants choked while feeding, 34% said their babies would not wake up regularly enough to nurse, and 17.6% thought their baby was too distracted or not interested in nursing. In the category of *Milk Production Concerns*: 13% thought that their milk took too long to come in, 8.4% reported trouble getting the milk flow to start, 24.4% said that their infant had trouble gaining or was losing too much weight, and 11.8% responded that they did not have enough milk. Under *Breast Concerns*: 60.1% had sore or cracked nipples, 44.1% experienced engorgement, 6.3% had a clogged duct and 5% had an infected or abscessed breast. A large majority (84.9%)

experienced pain while breastfeeding during the first two weeks postpartum but only 9.7% reported that its severity prevented them from breastfeeding to some extent.

Table 3.1 Breastfeeding problems reported at two weeks postpartum by pre-pregnant maternal BMI group.

Problem	Total Sample (N=239)*	Normal BMI (N=159)*	Overweight BMI (N=80)*	P value¹
Pain that prevented BF	9.7% (N=158)	8.8%	11.4% (N=79)	0.525
Infant concerns	(N=238)		(N=79)	
Latch	47.9%	46.5%	50.6%	0.552
Choking	13.5%	13.8%	12.7%	0.802
Not wake up	34.0%	31.5%	39.2%	0.232
Distracted	17.6%	18.2%	16.3%	0.703
Milk production	(N=238)		(N=79)	
Too long	13.0%	12.0%	15.2%	0.484
Flow trouble	8.4%	6.3%	12.7%	0.095
Lost weight	24.4%	20.8%	31.7%	0.065
No milk	11.8%	7.6%	21.5%	0.002
Breast concerns			(N=79)	
Sore nipples	60.1%	58.5%	63.3%	0.476
Engorgement	44.1%	49.7%	32.9%	0.014
Clogged duct	6.3%	6.3%	6.3%	0.991
Infection	5.0%	5.7%	3.8%	0.536

Values presented are frequencies.

*Sample size provided was used for all statistical tests unless otherwise noted.

¹P-values determined by chi-square test.

BMI, body mass index; WIC, Women Infant Children; C-section, delivery via cesarean section; GDM, gestational diabetes mellitus; BF breastfeeding

There were two statistically significant differences between the BMI groups related to problems of milk production at two weeks postpartum. Overweight women reported that they did not have enough milk (i.e. PIM) almost three times more frequently than women of normal BMI ($P = 0.002$). In addition, while half of women with normal body weight reported engorgement, overweight women did so only 33% of the time ($P = 0.01$). Finally, almost a third of overweight women reported that their babies were not

gaining enough/losing too much weight, compared to only 20% in the normal BMI group ($P = 0.065$), yet there was no actual infant weight difference between the groups at two weeks postpartum ($P = 0.926$). There were no other significant differences between the BMI groups in frequency of breastfeeding problems.

Association of breastfeeding problems and duration

Several reported factors of milk production were also associated with shorter exclusive and total duration: engorgement was associated with increased exclusive ($P < 0.0001$) and total ($P = 0.0002$) duration; baby losing too much/not gaining enough weight and not having enough milk were both associated with decreased exclusive ($P = 0.002$ and $P < 0.0001$, respectively) and total duration (both $P < 0.0001$); and trouble getting the milk to flow was associated with decreased exclusive ($P = 0.032$) and total duration ($P = 0.011$). Maternal perception that her milk took too long to come in was also related to shorter total duration length ($P = 0.0002$). In addition, infant choking while feeding was associated with both increased exclusive and total duration ($P = 0.030$, $P = 0.038$, respectively), while pain that was great enough to suspend breastfeeding to some extent was related to shorter exclusive duration ($P = 0.025$). No other early breastfeeding problems were associated with lactation duration. (Data not shown).

Multivariate analysis of breastfeeding problems and exclusive duration

After adjustment for potential confounders, several variables, including prepregnant BMI, were significant predictors of exclusive duration. When all covariates were present in the model, BMI remained an independent predictor but its association with exclusive duration was slightly attenuated by these factors (Table 3.2). The column

in Table 3.2 labeled “Coefficient” provides the beta coefficient of the maternal overweight variable in each model, as well as the beta coefficients of each variable in the final model. The beta coefficient is a mathematical weighting of each explanatory variable in the equation, holding all others constant. Here, the beta coefficient of maternal overweight is -2.73, which is interpreted to mean that overweight women had 2.73 fewer weeks of total breastfeeding compared to normal weight women, holding all other variables in the model constant.

To examine whether breastfeeding problems explained the association between maternal overweight and exclusive duration, each group of problems (infant concerns, milk production concerns and breast concerns) was added to the previous best-fit model. If the beta coefficient of maternal overweight becomes non-significant with the addition of another variable in the model, the interpretation is that the additional variable mediated the association between maternal overweight and duration. Within these categories, two variables, infant choking during breastfeeding and engorgement, were positive independent predictors and maternal perception of not enough milk (PIM) was a significant negative predictor of exclusive duration. Infant choking did not attenuate the effect of maternal overweight on exclusive duration (overweight $\beta = -2.77$, $P = 0.046$) and it did not remain significant when entered with all covariates in the final model (data not shown). When engorgement and maternal PIM were included separately, however, maternal overweight became non-significant indicating each of these two variables clearly mediated the effect of BMI.

Engorgement, PIM, gestational diabetes and postpartum depression each had large effects on exclusive duration in the final model (Table 3.2). As demonstrated by the beta coefficient of -3.72, those not experiencing engorgement were predicted to exclusively breastfeed for almost a month less (i.e. 3.72 weeks) than those with engorgement. Exclusive duration was over two months less among those who perceived that they did not have enough milk, relative to those who did not report this problem. As average exclusive breastfeeding duration in this study was approximately four months, this translates into an exclusive duration length less than half as long as the average length. Gestational diabetes and postpartum depression each predicted a loss of six weeks of exclusive breastfeeding. Finally, longer intended duration of exclusive breastfeeding had a significant protective effect in the final model (Table 3.2).

Table 3.2 Association of pre-pregnant maternal overweight and exclusive breastfeeding duration from general linear regression models.

	Variable	Coefficient	SE	P value	R²	N
Model 1	Overweight (<i>yes</i>) ¹ , unadjusted	-3.20	1.36	0.019	0.02	235
Model 2	Overweight (<i>yes</i>), adjusted ²	-2.73	1.33	0.042	0.15	224
Final model	Overweight (<i>yes</i>)	-1.08	1.27	0.394	0.28	224
	GDM (<i>yes</i>)	-6.76	2.97	0.024		
	Post-partum depression (<i>yes</i>)	-6.16	2.59	0.018		
	Hours until lactogenesis II	-0.04	0.03	0.101		
	Intended exclusive duration	0.20	0.06	0.001		
	Engorgement (<i>no</i>)	-3.72	1.20	0.002		
	No milk (<i>yes</i>)	-8.25	1.86	<.0001		
	Infant choking (<i>no</i>)	-2.78	1.66	0.096		

¹Terms in italics are the participant response and were the predicted value in analyses.

²Adjusted for other significant covariates: GDM, post-partum depression, hours postpartum until lactogenesis II, intended exclusive duration

SE, standard error; GDM, gestational diabetes mellitus; BF, breastfeeding

Multivariate analysis of breastfeeding problems and total duration

Overweight women experienced a 1.4-fold greater risk of discontinuation of breastfeeding than normal weight women (unadjusted HR = 1.40; CI, 1.001-1.95; $P = 0.049$) (Table 3.3). Several variables known to be related to either maternal overweight or breastfeeding duration were explored as potential confounders. Two variables were added to the model as covariates because of their significant association: gestational diabetes was a negative predictor and a longer planned duration of breastfeeding had a protective effect on total duration. When they were entered into the proportional hazards regression model, the association between maternal overweight and duration of breastfeeding was not attenuated and remained significant (adjusted HR = 1.41; CI, 1.001-1.98; $P = 0.049$) (Table 3.3).

Each group of breastfeeding problems was then added to this adjusted model. When infant concerns (trouble latching on, infant choking while feeding, infant not waking up enough or distracted) were included, the HR for overweight was 1.48 (CI, 1.05-2.10; $P = 0.027$) suggesting that discontinuation of breastfeeding was not explained by infant-related breastfeeding problems. When breast concerns (sore nipples, engorgement, clogged duct or infection) were added to the model, overweight was no longer significant (HR = 1.35; CI, 0.96-1.90; $P = 0.089$). Engorgement appears to be the variable that results in this mediation. None of these variables, including engorgement, however, were statistically significant independent predictors and, thus, were not included in the final model. Similarly, when concerns related to milk production (milk took too long to come in, trouble getting the milk to flow, baby did not gain enough/lost

too much weight, maternal PIM) were tested, the significance of overweight was eliminated (HR = 1.34; CI, 0.94-1.91; $P = 0.103$). Although both PIM and maternal perception that the milk took too long to come in remained independent predictors in the final model, only PIM had a mediating effect on the relationship between maternal overweight and duration of any breastfeeding.

In the final model, women who reported PIM had a 1.7-fold increased risk of ceasing any breastfeeding relative to those who did not report PIM. Similarly, those who believed their milk took too long to come in had an 89% increased risk of ceasing breastfeeding over those who did not report this problem. Those with gestational diabetes were greater than two times more likely to stop breastfeeding compared to those without gestational diabetes. Finally, the risk of ceasing breastfeeding decreased by almost 4% for every additional week of intended duration (Table 3.3).

Table 3.3 Association of pre-pregnant maternal overweight and total breastfeeding duration from proportional hazards regression models.

	Variable	HR	95% CI	P value¹	N
Model 1	Overweight (<i>yes</i>) ² , unadjusted	1.40	1.001-1.95	0.049	233
Model 2	Overweight (<i>yes</i>), adjusted ³	1.41	1.001-1.98	0.049	233
Final model	Overweight (<i>yes</i>)	1.35	0.95-1.92	0.094	230
	GDM (<i>yes</i>)	2.16	1.07-4.38	0.033	
	Intended total duration	0.96	0.95-0.98	<.0001	
	Milk too long to come in (<i>yes</i>)	1.89	1.19-2.99	0.007	
	No milk (PIM) (<i>yes</i>)	1.69	1.06-2.70	0.028	

¹P-values are based on the Wald test for significance of Cox regression coefficients.

²Terms in italics are the participant response and were the predicted value in analyses.

³Adjusted for other significant covariates: GDM and intended total duration

HR, hazard ratio; CI, confidence interval, GDM, gestational diabetes mellitus

DISCUSSION

Overweight women in this study reported perceived insufficient milk (PIM) in significantly higher frequencies than women with normal BMI. PIM was also an independent negative predictor for both exclusive and total lactation duration. Finally, a novel finding from this study is that breastfeeding problems related specifically to milk production in the early postpartum period appear to partly explain the relationship between maternal overweight and lactation duration.

Association between body mass index, perceived insufficient milk and duration

Three studies previously explored a relationship between PIM and maternal obesity, but produced conflicting results. Rutishauser and Carlin (1992) first presented a relationship between maternal obesity (assessed at one-month postpartum) and shorter breastfeeding duration. Women were asked their reason for weaning and results show that the obese women in their sample cited “inadequate lactation” less frequently than women with normal BMI as a reason for early cessation. In contrast, Segura-Millan and colleagues (1994) found that high maternal BMI (measured at one-week postpartum) was one of several variables that was significantly associated with an earlier onset of PIM (assessed at one-week postpartum), yet BMI did not remain a significant predictor of PIM in their multivariate model. In both of these cases, maternal BMI was assessed postpartum and not pre-pregnancy as in the present study.

The present research adds support to the finding that high maternal BMI is associated with greater frequency of PIM. Overweight women reported that they did not have enough milk at two weeks postpartum almost three times more frequently than did

women of normal BMI. Only one other study investigated an association between pre-pregnancy BMI and PIM. Mok and colleagues (2008) explored maternal perceptions and infant weight changes in obese versus normal-weight mothers and report that fewer obese women believed they had sufficient milk for their infants at both one and three months postpartum than did women of normal BMI. Furthermore, obese women in their sample also gave PIM as the reason they chose to stop exclusive breastfeeding more frequently than did those of normal weight, however, this relationship was not supported when exploring reasons for cessation of any breastfeeding.

The present study is the first to find an association between PIM and shorter duration of any breastfeeding in overweight women. PIM had a negative effect not only on exclusive duration (similar to the finding by Mok et al. 2008), but additionally on total breastfeeding duration. Those who reported PIM were at greater risk of ceasing breastfeeding completely at any time compared to those who did not report PIM, which falls in line with previous knowledge that PIM is a common predictor of short lactation duration in all women, regardless of BMI status (Gatti et al. 2008). Additionally, however, perceived insufficient milk mediated the effect of maternal overweight on duration, which suggests it is a potential explanation for why overweight women experience reduced exclusive and total lactation duration.

Maternal overweight and accuracy of maternal perception of insufficient milk

Although it is well documented that there is a strong relationship between PIM and reduced duration, this association raises the question: Do women who report insufficient milk actually produce less or simply believe that they do? It is important to

note that actual milk supply is rarely measured, and that reports of PIM in the literature are often based on maternal perception alone (Gatti et al., 2008). Although it is not possible to answer this question with the present sample either, a subset of participants from this study (N=41) participated in more intensive data collection and milk output was measured once at seven days postpartum. Overweight women produced significantly less milk at this time period compared to those of normal weight (1.42 oz vs. 1.98 oz, respectively) ($P = 0.049$), which suggests a true lower milk supply among overweight women (full details are discussed in Chapter IV). The results of one other study may indirectly examine the accuracy of maternal perception in relation to actual milk supply. Hill & Aldag (2007) found that inadequate milk supply (< 500 mL/day) at six weeks postpartum (using 24-hour test-weights) was a significant predictor of formula supplementation by twelve weeks postpartum and that mothers who reported PIM at eight weeks were more likely to provide formula at twelve weeks relative to those who did not report PIM. Unfortunately, they did not include maternal BMI measures in their study.

Additional results from the present study also indirectly support the claim that overweight women have a true lower milk supply. Engorgement at two weeks postpartum was an independent positive predictor of length of exclusive breastfeeding and significantly fewer overweight women reported this condition compared to normal weight women. Engorgement has been defined as “the swelling and distension of the breasts, usually in the early days of initiation of lactation, caused by vascular dilation as well as the arrival of the early milk” (Lawrence and Lawrence, 2005). There is no standard tool for assessing engorgement, which varies on a continuous scale. While

engorgement is often referred to as a breastfeeding problem (and can be in severe cases that do not clear), breast “fullness” is actually an indication that milk is accumulating (ABM, 2009). In addition, engorgement is associated with maternal perception of efficient milk production. Cooke and colleagues (2003) explored the relationship between a variety of breastfeeding problems and maternal perception of infants’ satisfaction with breastfeeding. They found that infant satisfaction score was negatively associated with PIM, yet it was positively associated with engorgement. At both two and six weeks postpartum, women who experienced engorgement had a significantly higher mean infant satisfaction score than those who did not.

On the other hand, a true insufficient milk supply may be reflected in smaller infant weight gains. Results of the present study, however, show no difference in infant weight at any time postpartum between the BMI groups. One reason for this lack of association may be because the causal chain between PIM, actual low milk supply and timing of supplementation (i.e. cessation of exclusive breastfeeding) is unknown. Once one believes her infant is not receiving enough milk, whether or not that belief is accurate, formula supplementation is more likely to take place, which could obscure any weight differences that may otherwise be seen in women who are exclusively feeding only their own milk supply. One study has, in fact, demonstrated that PIM in exclusively breastfeeding obese women is associated with slower growth of their infants. Mok et al. (2008) found that in addition to more frequent reports of insufficient milk by obese women, infants of obese breastfeeding mothers lost more weight before hospital

discharge and gained less weight at one month compared with infants of normal BMI breastfeeding mothers and obese mothers who were formula-feeding.

Finally, a delay in milk “coming-in” (lactogenesis II) is also known to affect milk supply and has been associated with both PIM (Perez-Escamilla et al., 1992; Segura-Millan et al., 1994) and maternal obesity (Chapman and Pérez-Escamilla, 1999; Dewey et al., 2003; Hilson et al., 2004; Nommsen-Rivers et al., 2010). In the present study, overweight women did have a higher mean time until lactogenesis II, relative to normal BMI women, although this difference was not as large as that reported by other studies. Because a delay in onset often results in initial low production and subsequently, earlier supplementation, the presence of this association also provides indirect evidence of a true lower milk supply among overweight women.

It cannot be ruled out, however, that PIM actually induces a lower milk supply. Mothers who may have an adequate milk supply, but perceive that they do not, may respond by supplementing, which then does result in a lower supply. Perhaps overweight mothers have different perceptions about what constitutes an adequate milk supply compared to mothers that are not overweight. Future research on maternal decision-making in the early postpartum period is needed to assess the accuracy of PIM and disentangle how this affects lactation duration in overweight women. Findings from this study highlight the importance of addressing milk supply issues immediately postpartum and better management of the mother-infant pair until a sufficient milk supply is built. Interventions that decrease the incidence of breastfeeding problems affecting supply and/or increase maternal confidence that her milk supply is sufficient, may play an

important role in reducing the prevalence of early lactation cessation, especially in overweight women.

CHAPTER IV

LOW MILK OUTPUT, DECREASED PROLACTIN LEVELS AND POOR POSITIONING ASSOCIATED WITH EARLY CESSATION OF EXCLUSIVE BREASTFEEDING IN OBESE WOMEN

As previously discussed, establishing lactation during the early postpartum period is of critical importance to continued breastfeeding success. Due to the significance of this time period and the variety of factors that can affect it, this chapter will focus on how maternal obesity negatively impacts lactation establishment by exploring several key aspects related to breastfeeding during the first-week postpartum. Mother-infant pairs that transfer milk from mother to infant shortly after parturition experience greater long-term breastfeeding success than those who experience a delay in breastfeeding establishment (Chapman and Perez-Escamilla, 2000).

Several steps are necessary for efficient milk production and subsequent transfer. Milk secretion is under hormonal control and initially begins at birth. Most influential are decreases in progesterone and estrogen with a simultaneous steep increase in prolactin. After parturition, women have high baseline prolactin concentrations and prolactin responds to nursing episodes with sharp peaks (Neville, 2001a; Riordan, 2005). Women may experience difficulty establishing lactation if these hormone patterns are altered. Differences in hormone concentrations have been reported in non-pregnant, non-lactating obese women and men compared to normal weight controls. Adipose tissue is an extra source of and storage tissue for estradiol. In addition, elevated estrogen values have been found in regularly menstruating obese women (Azziz, 1989; Birkenfeld and Kase, 1994; Ellison, 2001). Pijl et al. (1993) found lower basal prolactin levels among obese subjects

compared to those of normal weight. In addition, the release of prolactin, in daily pulses and in response to other hormones, has been shown to be reduced in obese men and women (Cavagnini et al., 1981; Kopelman, 2000).

After initial secretion, milk needs to be removed from the breast for continued production and supply is largely influenced by infant demand (i.e. the frequency of feedings). In humans, breastfeeding is a learned behavior in which mother and baby must successfully execute a variety of steps to ensure proper latching on by the infant. Inefficient transfer due to improper positioning leads to delays in breastfeeding establishment. If milk is not removed from the breast, milk production may not reach appropriate levels and severe infant weight loss may result (Manganaro et al., 2001).

After previously investigating the impact of various psychosocial factors on the relationship between maternal overweight and reduced lactation duration, in this chapter I explore whether maternal pre-pregnant obesity impacts hormone levels and breastfeeding behavior. The following hypotheses are tested: 1) Obese women have altered hormone levels, specifically a) estradiol levels are increased and, b) prolactin levels are decreased relative to normal weight women; 2) Obese mothers have more difficulty obtaining correct positioning as indicated by lower mother-infant positioning scores; and 3) Obese women produce lower milk volume, resulting in early cessation of exclusive breastfeeding. This approach is unique in the holistic way it explores hormonal and behavioral factors in a group of women who were highly motivated and should be among the most successful at breastfeeding. This approach contributes a better understanding of how the interaction among various factors influences the relationship between maternal

obesity and early cessation of exclusive breastfeeding, while avoiding confounding due to lack of maternal commitment to breastfeeding.

METHODS

Study participants

A subset of 54 women from the larger sample (described in Chapter II) participated in data collection procedures for this more intensive component of the study. Two participants could not be contacted for follow-up and one participant delivered earlier than 37 weeks gestation and was therefore ineligible for participation. Thus, the final sample consisted of 51 participants. All participants intended to breastfeed their infants exclusively (no other solids or liquids) for at least 1-2 months postpartum. Exclusion criteria did not differ from the larger study. Participants' pre-pregnancy height and weight were self-reported and confirmed with medical records. Body mass index was calculated as the weight in kilograms divided by the height in meters squared. Following *World Health Organization* classification, participants were characterized as normal weight when their BMI was 18.5-24.9 kg/m², overweight when their BMI was 25-29.9 kg/m² and obese when their BMI was ≥ 30 kg/m² (WHO, 2003). Informed consent was obtained from each subject after study explanation. The protocol was approved by the Institutional Review Board and the General Clinical Research Center Scientific Advisory Committee of the University of Minnesota (2008).

Serum samples

Blood samples of 12 mL were collected by venipuncture within 48 hours after birth and again at approximately 7 days postpartum in a private hospital room and private

clinic setting, respectively. Samples collected within 48 hours were drawn at least 60 minutes after the last breastfeeding episode. Samples collected at 7 days postpartum were drawn from participants fasting overnight for at least 8 hours and were taken between 07:30-10:30. At 7 days postpartum, participants had blood drawn shortly before their infant latched on to breastfeed, and an additional 3 mL sample was drawn approximately 30 minutes after the start of the nursing episode in order to capture the expected prolactin peak in response to nursing (Battin et al., 1985). The duration of the nursing episode was recorded, as was the time the infant was last fed. Within 48 hours postpartum, 51 participants were available to provide a blood sample, but only 48 samples were collected due to hospital errors in collection and storage. Ten participants chose not to provide further blood samples, resulting in a total of 41 participants who provided samples at 7 days postpartum. These ten participants were not significantly different from the remaining 41 participants in any of the characteristics listed in Table 4.1, nor did they differ in status of exclusively breastfeeding at 2 weeks postpartum. Samples were allowed to clot for approximately 30-45 minutes at room temperature and were then centrifuged at 3200 rpm for 10 minutes. Sera were separated and frozen at -20° C.

Hormone assays

Serum samples were assayed for estradiol and cortisol using non-extraction, solid-phase ¹²⁵I radioimmunoassay kits and following manufacturer's instructions (Coat-A-Count kits; Siemens Healthcare Diagnostics, Deerfield, IL). For estradiol, the intra and interassay coefficients of variation were 9.3% and 12.3% respectively. Assay sensitivity was 8 pg/mL. For cortisol, the intra and interassay coefficients of variation were 6.9%

and 15.4% respectively. Assay sensitivity was 0.2 µg/dL. Prolactin levels were assessed using a sandwich-type immunoradiometric assay (IRMA), with intra and interassay CV of 5.2% and 13.9% respectively. Assay sensitivity was 0.1 ng/mL (Coat-A-Count kit; Siemens Healthcare Diagnostics, Deerfield, IL). All serum samples were assayed in duplicate using standards supplied by the manufacturer. The three hormonal assays also included human serum-based tri-level controls, the values of which fell within expected ranges (CON6 Multivalent Control Module; Siemens Healthcare Diagnostics, Deerfield, IL).

Behavioral assessment (Mother-Baby Assessment score)

The adequacy of breastfeeding behavior in each mother-infant dyad was assessed once at 7-days postpartum. A scale score was assigned at each feeding episode based on the Mother-Baby Assessment tool (MBA). The MBA observational tool is a validated instrument designed to assess the success of a single nursing episode by rating both mothers and infants for a possible combined score of ten (Mulford, 1992). Breastfeeding is a learned behavior that relies on a constant stimulus-response feedback pattern between mothers and their infants. Therefore, this scale assigns value to both a mother and infant behavior in five sequential categories: mother-infant signaling, infant positioning, latching of infant's mouth to breast, milk transfer, and infant satiation. The behavior in each category must be successfully executed before value is given to a behavior in the following category. Dyads that do not achieve a score greater than seven out of ten require additional assistance because little to no milk transfer took place.

Milk output

A one-time measure of milk output was determined by intake volume using infant test weights with a BabyWeigh scale (Medela, Inc., McHenry, IL) at 7 days postpartum. The infant was weighed before and after a breastfeeding episode, the pre-feed weight was subtracted from the post-feed weight and the difference represents the volume of milk consumed. Insensible water loss was not estimated. The manufacturer's stated accuracy for the scale is $\pm 0.034\%$ of the reading with a resolution of 2 g (0.1 oz).

Statistical analysis

General linear regression or chi-square (χ^2) tests were performed to compare the maternal and infant characteristics of women classified as normal weight, overweight or obese according to pre-pregnancy BMI. Multiple linear regression models were used to test whether maternal BMI category (normal, overweight, obese) was associated with the outcome variables of prolactin, estradiol and cortisol levels at 48 hours and 7 days postpartum, milk output at 1-week postpartum, MBA score at 1-week postpartum and status of exclusive breastfeeding at 2-weeks postpartum. Unadjusted relationships between maternal BMI category and these outcome variables were first explored using χ^2 or general linear regression models. Those that had a significant association with BMI – prolactin level at 48 hours postpartum, milk output at 1-week postpartum, MBA score at 1-week postpartum and status of exclusive breastfeeding at 2 weeks postpartum – were examined further. To explore the impact of potentially confounding factors, additional independent variables were tested against the outcome variables by general linear regression. Possible covariates were considered based on whether there was a theoretical

basis for an association and if the independent variable occurred earlier in time than the outcome variable. Those covariates that were not significant ($P > 0.05$) were dropped, and the least-squares means from the final models, by maternal BMI category, are presented for each outcome variable.

Multivariate logistic regression models were used to test maternal BMI category on the status of exclusive breastfeeding at 2-weeks postpartum (*yes/no*). For this analysis, variables were standardized with a mean of zero and standard deviation of one. Covariates were considered in this model using the same procedure as above and only those with $P < 0.10$ were retained and entered the model using forward stepwise selection. Adjusted odds ratios and 95% confidence intervals from this final model are presented. All analyses were conducted with SAS (version 9.2; SAS Institute, Inc, Cary, NC). Differences between groups are considered statistically significant at $P < 0.05$.

RESULTS

Characteristics of the participants by prepregnant BMI category are shown in Table 4.1. Mean maternal age was 29 ± 5.8 years, 80.4% of participants had a four-year college degree and 15.7% had a household income that qualified them for the Federal assistance program, *Women, Infants and Children* (WIC). Self-identified ethnicity of participants was as follows: 45 participants (88.2% of the total sample) identified as Caucasian, 3 as African American, 2 as Asian, and 1 as Native American. Participants reported being committed to breastfeeding and receiving familial and institutional support: 76.5% of participants were breastfed themselves as babies, 70.6% took a prenatal breastfeeding class, 96% of participants reported receiving breastfeeding

assistance from hospital staff following delivery, 100% of those who were raising the baby with another adult had full support from that individual to breastfeed the baby, and all participants had an intention to exclusively breastfeed their infants for at least 1-2 months postpartum. The c-section rate was 32%, which matches the national average of 31.8% (Martin et al. 2010). There was not a significant difference in c-section rate by BMI category. The only significant difference in maternal or infant characteristics among the maternal BMI groups was the prevalence of gestational diabetes ($P = 0.01$); the two women who presented with gestational diabetes were both obese.

Table 4.1 Characteristics of women and their infants by prepregnant BMI category (N=51)

Variable	Normal BMI (N=24)	Overweight BMI (N=17)	Obese BMI (N=10)	P value ¹
Maternal age (years)	30.1 ± 1.2	28.9 ± 1.4	27.8 ± 1.8	0.55
Prepregnant BMI (kg/m ²)	22.1 ± 0.6	27.4 ± 0.7	36.5 ± 0.9	<.0001
GWG (kg) (n=50)	16.6 ± 1.1	16.0 ± 1.3	13.6 ± 1.8	0.35
College graduate (% yes)	87.5% (N=21)	82.4% (N=14)	60.0% (N=6)	0.18
Self-identified ethnicity				
(Caucasian)	87.5% (N=21)	94.1% (N=16)	80.0% (N=8)	0.54
(African American)	4.2% (N=1)	5.9% (N=1)	10.0% (N=1)	0.80
(Asian)	8.3% (N=2)	0% (N=0)	0% (N=0)	0.31
(Native American)	0% (N=0)	0% (N=0)	10.0% (N=1)	0.12
Income (% WIC eligible)	12.5% (N=3)	17.6% (N=3)	20.0% (N=2)	0.83
C-section delivery (% yes)	20.8% (N=5)	52.9% (N=9)	20.0% (N=2)	0.07
Gestational diabetes (% yes)	0% (N=0)	0% (N=0)	20.0% (N=2)	0.01
Time PP till milk onset (hrs)	71.8 ± 5.6	83.2 ± 6.9	82.9 ± 9.2 (N=9)	0.36
Attend prenatal BF class	62.5% (N=15)	82.4% (N=14)	60.0% (N=6)	0.44
BF help in hospital (% yes)	91.7% (N=22)	100% (N=17)	100% (N=17)	0.31
Mother BF as baby (% yes)	83.3% (N=20)	82.4% (N=14)	50.0% (N=5)	0.09
Infant weight (kg)	3.56 ± 0.1	3.58 ± 0.1	3.50 ± 0.2	0.93
Infant sex (% male)	50.0% (N=12)	58.8% (N=10)	30.0% (N=3)	0.35

Values presented are percentages or means ± standard deviations.

¹P-values determined by general linear regression for continuous variables and chi-square test for categorical variables.

BMI, body mass index; WIC, Women Infant Children; C-section, delivery via cesarean section; PP, post-partum depression; BF, breastfeeding; GWG, gestational weight gain

Early cessation of exclusive breastfeeding and maternal obesity

Four breastfeeding outcome variables were found to have an association with maternal BMI category and were further explored (prolactin at 48 hours, MBA score, milk output and status of exclusive breastfeeding at two weeks) (Table 4.2). There was a significant difference in the frequency of women who reported early cessation of exclusive breastfeeding (cessation by two weeks postpartum). Only one woman in the normal BMI category stopped breastfeeding exclusively by 2 weeks so that 96% of women in this category were still doing so at this time. In contrast, 35% (9 of 26) of overweight and obese women had stopped breastfeeding exclusively by 2 weeks ($\chi^2 = 7.24, P = 0.027, N=50$). Due to small sample sizes in some cells, the overweight and obese categories were combined for a 2x2 analysis which revealed a stronger statistically significant association between maternal overweight and early cessation (Fisher's exact test $P = 0.011, N=50$).

Table 4.2 Outcome variables by prepregnant maternal BMI category (unadjusted).

	Normal BMI	Overweight BMI	Obese BMI	P value¹
MBA score 7 d*	9.6 ± 0.4 (N=19)	8.9 ± 0.5 (N=14)	7.5 ± 0.6 (N=8)	0.02
Milk output (oz) 7 d*	1.98 ± 0.2 (N=19)	1.6 ± 0.2 (N=14)	1.1 ± 0.3 (N=8)	0.06
Exclusive BF 2 wks*	95.8% (N=24)	64.7% (N=17)	66.7% (N=9)	0.02²
Estradiol (pg/mL) 48 hr	787.6 ± 109.8 (N=24)	834.8 ± 143.8 (N=14)	790.4 ± 170.1 (N=10)	0.96
Estradiol (pg/mL) 7d	133.5 ± 11.6 (N=19)	159.2 ± 13.5 (N=11)	116.2 ± 17.9 (N=8)	0.14
Cortisol (µg/dL) 48 hr	22.6 ± 1.9 (N=24)	18.9 ± 2.6 (N=14)	21.5 ± 3.0 (N=10)	0.51
Cortisol (µg/dL) 7 d	23.3 ± 1.4 (N=18)	24.7 ± 1.6 (N=11)	22.0 ± 2.1 (N=8)	0.58
Prolactin (ng/mL) 48 hr*	186.1 ± 10.9 (N=24)	165.5 ± 14.8 (N=14)	132.8 ± 16.9 (N=10)	0.03

Prolactin (ng/mL) 7 d baseline	129.8 ± 10.4 (N=18)	121.6 ± 12.1 (N=11)	102.7 ± 16.0 (N=8)	0.38
Prolactin 7 d response to 30 min BF episode	52.0 ± 16 (N=18)	68.4 ± 18.6 (N=11)	23.9 ± 26.4 (N=7)	0.39

Values presented are percentages or unadjusted LSmeans ± standard errors.

¹P-values determined by general linear regression

²P-value determined by chi-square test

*Tested for associations with the following potential confounders: gestational weight gain, mode of delivery, infant birth weight and infant sex, gestational diabetes mellitus (GDM) status, and maternal age. Only GDM showed significance with both prolactin level at 48 hours postpartum and milk output. Additional confounders were tested as follows. None were significant.

Prolactin at 48 hrs: time of blood draw postpartum and breastfeeding attempt within 2 hours postpartum.

Milk output, 7 days: breastfeeding attempt within 2 hours postpartum and time postpartum until onset of milk production.

MBA score, 7 days: attendance at pre-natal breastfeeding class and breastfeeding assistance provided in the hospital following delivery.

Exclusively breastfeeding, 2 weeks: amount of education, income level, pre-natal intention of exclusive breastfeeding duration, attendance at pre-natal breastfeeding class, mother breastfed as a baby herself, and lactation assistance received from health professional after leaving the hospital.

Prolactin at 48 hours and maternal obesity

In general, the BMI categories presented similar hormone profiles but with one significant difference: prolactin levels within 48 hours postpartum (for unadjusted means see Table 4.2). Prolactin concentration within 48 hours postpartum was significantly associated with both BMI category and gestational diabetes status separately ($P = 0.037$, $P = 0.022$ respectively). The overall linear regression model including these two variables was statistically significant ($P = 0.031$), however, neither BMI category nor gestational diabetes status themselves retained significance ($P = 0.153$, $P = 0.127$ respectively) (for adjusted means see Table 4.3).

Table 4.3 Adjusted general linear regression of outcome variables by BMI category.

	Normal BMI	Overweight BMI	Obese BMI	P value	R²
Prolactin, 48 hours (N=47) ¹	153.8 ± 23.3	133.2 ± 25.3	113.4 ± 20.7	0.031	0.19
MBA score, 7 days (N=41)	9.6 ± 0.4	8.9 ± 0.4	7.5 ± 0.6	0.025	0.18
Milk output, 7 days (N=41) ¹	1.98 ± 0.2	1.6 ± 0.2	1.1 ± 0.3	0.065	0.13

Values presented are adjusted LSmeans ± standard errors.

¹Adjusted for GDM

BMI, body mass index; MBA, Mother Baby Assessment.

Mother-Baby Assessment score and maternal obesity

Pre-pregnant maternal BMI was also associated with lower Mother Baby Assessment (MBA) score at 7 days postpartum ($P = 0.025$) (Table 4.3). Obese women had a greater frequency (38%) of low MBA scores (≤ 7) than both normal BMI (5%) and overweight BMI women (21%). Only one woman of normal BMI had a low MBA score, while two obese women had scores of 2 and 3 respectively, which are likely driving this association (Figure 4.1). Neither self-reported prenatal breastfeeding instruction, breastfeeding assistance in the hospital after delivery, nor delivery via c-section were associated with MBA score ($P > 0.5$ for all).

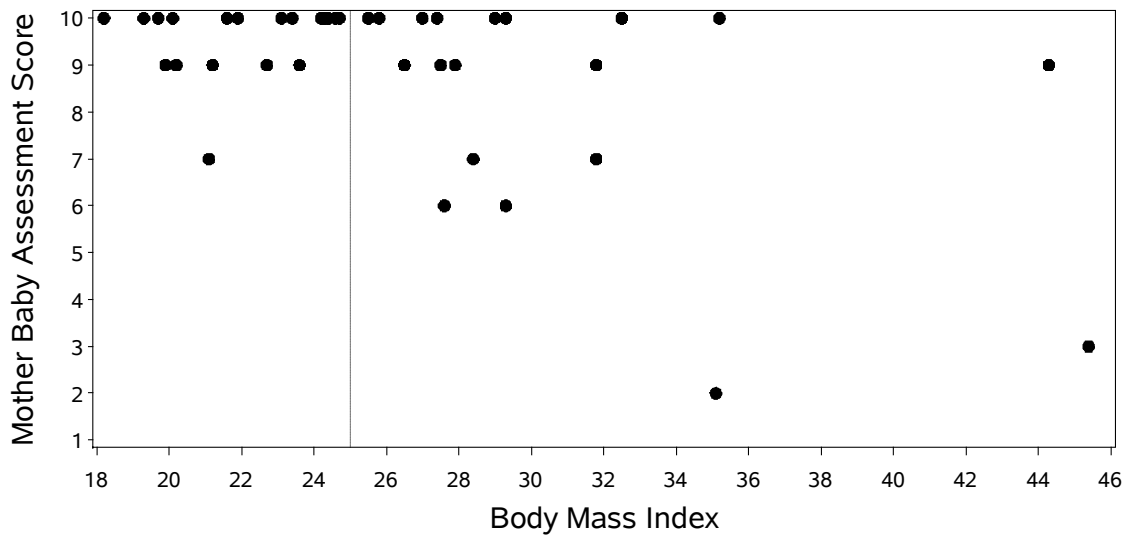


Figure 4.1 Plot of Mother Baby Assessment score by maternal body mass index (kg/m^2).

Note: The dotted vertical line represents the cut-off between normal and overweight BMI. MBA values ≤ 7 indicate inefficient positioning.

Milk output and maternal obesity

Milk output at 7 days postpartum was significantly associated with the predictor variables of prolactin concentration within 48 hrs postpartum ($P = 0.037$) and MBA score at 7 days postpartum ($P < 0.0001$). It also was significantly associated with gestational diabetes status ($P = 0.05$). Lower milk output in obese women was hypothesized and on average, their milk output was approximately half that of women with normal BMI (1.1 vs. 1.98 oz). Although the magnitude of the difference was large, it was significant only at the $P < 0.10$ level ($P = 0.065$) (Table 4.3, Figure 4.2). In the multiple regression model, MBA score was the only variable that remained significantly associated with milk output (Table 4.4).

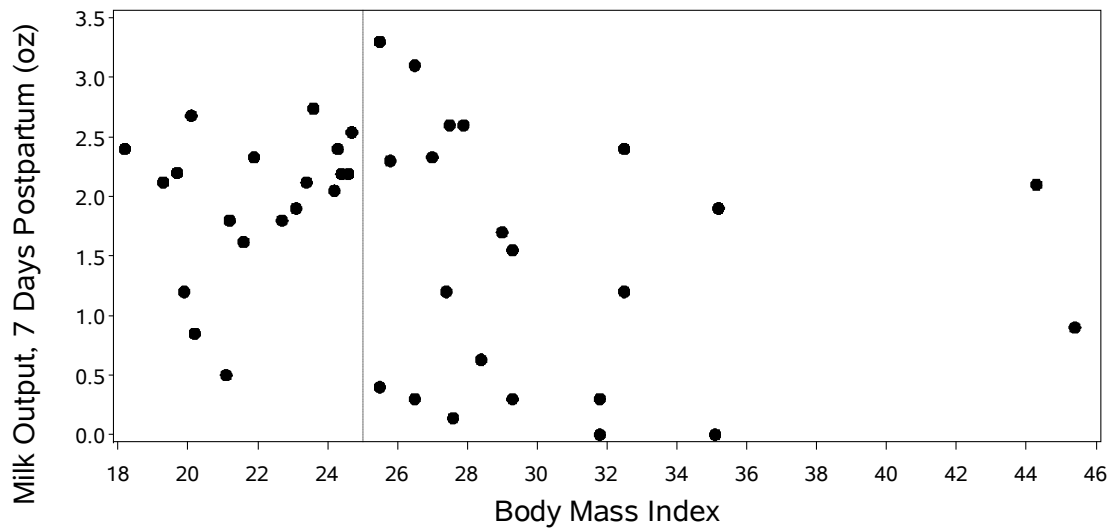


Figure 4.2 Plot of milk output by maternal body mass index (kg/m^2).
 Note: The dotted vertical line represents the cut-off between normal and overweight BMI.

Table 4.4 Multivariate model for milk output at 7 days postpartum ($N=41$)

	Coefficient	Standard Error	P value	R ²
Maternal BMI				0.45
Obese	-0.24	0.34	0.48	
Overweight	-0.12	0.28	0.66	
Normal	referent	referent	referent	
Prolactin at 48 hrs	0.002	0.002	0.37	
MBA score	0.26	0.07	0.0006*	

BMI, body mass index; MBA, Mother Baby Assessment

Risk factors for cessation of exclusive breastfeeding by two weeks postpartum

Time to onset of milk production ($P = 0.010$), milk output ($P = 0.016$) and MBA ($P = 0.014$) score were all significantly associated with early cessation of exclusive breastfeeding. In the logistic regression model that included these variables, only milk output at 7 days remained significant, while delay in the onset of milk production remained significant only at the $P < 0.10$ level. Specifically, greater milk output at 7 days reduced the risk of early cessation of exclusive breastfeeding (Odds Ratio 0.41 per

standard deviation increase in milk output, CI: 0.17-0.98, $P = 0.045$) and delay in the onset of milk production increased the risk of early cessation of exclusive breastfeeding (Odds Ratio 2.32 per standard deviation increase in hours, CI: 0.99-5.40, $P = 0.052$) (Table 4.5).

Table 4.5 Logistic regression analysis of risk factors for cessation of exclusive breastfeeding at 2 weeks postpartum (N=41)

Variable	Odds Ratio	95% CI	P value
Milk output, 7 days	0.41	0.17 – 0.98	0.045
Hours postpartum till BF established	2.32	0.99 – 5.40	0.052

CI, confidence interval

DISCUSSION

This study aimed to help explain how maternal obesity negatively impacts breastfeeding outcomes by exploring both hormonal and behavioral determinants of successful breastfeeding. The results indicate that early cessation of exclusive breastfeeding in overweight and obese women, who intend to breastfeed and are well-supported, is influenced by low milk output, which is in turn influenced by low MBA scores and low prolactin levels, factors that, in this sample, are associated with high maternal BMI.

Early cessation of exclusive breastfeeding and maternal obesity

This study yielded results that are consistent with results reported in the literature regarding the association of maternal obesity and short breastfeeding duration. The prevalence of early cessation of exclusive breastfeeding was higher among overweight and obese women compared to women of normal BMI. Both milk output and hours

postpartum until full milk production commenced were found to impact the risk of ceasing exclusive breastfeeding at 2 weeks postpartum. Previous studies have found that a delay in onset of lactation is correlated with shorter lactation duration (Chapman and Pérez Escamilla, 2000) and these results confirmed this finding. This study also found that low milk output at day 7 postpartum was associated with early cessation of exclusive breastfeeding. Both mothers and health care providers are highly sensitive to infant weight patterns at this time and if milk production is too low for adequate infant weight gain, or even perceived to be too low (as most mothers do not have regular access to an infant scale), early supplementation of liquids or solids other than breastmilk may take place, which in turn may further suppress milk production, creating a negative feedback loop.

Milk output and maternal obesity

Although BMI was not significantly associated with milk output, it did approach significance in the predicted direction and is functionally meaningful; women of normal BMI produced almost twice the amount of milk produced by obese women in this sample. No other study has explored whether low milk output plays a role in early cessation of lactation among obese women. Thus, this novel finding suggests that this may be an important area of research in future studies. On average, by days 5-7 postpartum, milk transfer to the infant is commonly 550-650 grams per day (or approximately 19-23 oz per day) (Chen et al., 1998; Neville et al., 1988). Lactation consultants recommend an average of 2 oz per breastfeeding episode (or approximately 18-24 oz per day) be transferred from mother to infant at this time period (Jane Helgesen

IBCLC, personal communication). The infants of obese women in this sample were only receiving just over half that amount on average (1.1 oz vs. 1.98 oz in the normal BMI mother). Milk output was significantly associated with both prolactin concentration at 48 hours postpartum and MBA score at 7 days postpartum, however, MBA score appears to be the main driving force for variation in milk output. Although higher prolactin levels do not necessarily lead to greater milk production, high prolactin levels are necessary for milk synthesis and it is thought that excess adiposity may lower prolactin levels and thereby reduce milk production (Lawrence and Lawrence, 2005; Neville, 2001).

Postpartum hormone profiles and maternal obesity

Postpartum women have high baseline prolactin concentrations and prolactin usually displays a sharp rise in response to nursing. Because of the importance of this hormone in breastfeeding and because the natural nocturnal increase in prolactin is delayed in both obese adult men and women (Kopelman, 2000), it was hypothesized that obese women in this sample may have lower prolactin levels, which may disrupt lactation. Obese women in this study did have significantly lower levels of prolactin at 48 hours, but not 7 days postpartum, compared to those of normal BMI. One other study (Rasmussen and Kjolhede, 2004) found a similar result showing that overweight and obese women had a significantly lower prolactin response to nursing when samples were taken before and 30 minutes after a breastfeeding episode within 48 hours postpartum. The study by Rasmussen & Kjolhede did not have data on duration of lactation among their subjects and was thus, unable to connect their finding of low prolactin response to shortened duration of lactation among obese women. Although only able to obtain a pre-

nursing blood sample at 48 hours postpartum (unlike Rasmussen & Kjolhede who obtained both a before and after nursing blood sample at this time) results of this study demonstrate for the first time a connection between low basal prolactin levels immediately postpartum and early cessation of exclusive breastfeeding among women with high BMI. This finding strengthens the potential explanation that obese women experience poor breastfeeding outcomes, in part, because of lower prolactin levels shortly after delivery.

Ethnic diversity in this sample was low and prohibited engagement in meaningful statistical analyses on how ethnicity may play a role in the effect of obesity on lactation success, yet it is interesting to note that women who self-identified as Caucasian had significantly lower prolactin levels compared to those who identified as an ethnicity other than Caucasian ($P = 0.04$). Although the number of women who identified as an ethnicity other than Caucasian is small and too heterogeneous as a group to analyze in a statistically meaningful way, there are ethnic differences in individual data points that are notable. Four of the five highest prolactin concentrations within 48 hours postpartum belonged to women who identified as African American, Asian or Native American in this study. The association between lower prolactin levels at 48 hours postpartum and obesity status is strengthened then when only data points from Caucasian women are included in the model ($N = 42, P = 0.022$). To my knowledge, there has not been research on postpartum prolactin concentrations stratified by ethnicity, however, some studies have found that prolactin levels during pregnancy are lower among Caucasian women compared to women who identify with a different ethnicity (Arslan et al., 2006; Lipworth

et al., 1999; Potischman et al., 2005). Although there has not been research on obesity and breastfeeding outcomes in Asian-American or Native American populations, two studies (Kugyelka et al., 2004; Liu et al., 2009) have found that the association between obesity and poor breastfeeding outcomes does not hold among African American women in that obese African American women have similar lengths of exclusive and any breastfeeding duration compared to African American women of normal BMI. No research has yet been done to explain why obesity status appears to play a different role among African Americans as it relates to breastfeeding success, but prolactin levels in the immediate post-partum period should be further explored.

In addition to prolactin, estradiol and cortisol levels were also examined. It was hypothesized that higher estradiol levels in obese women may be related to a delay in onset of lactation or early cessation of exclusive breastfeeding because a sharp drop in sex steroids (including estradiol) is expected following childbirth and because adipose tissue is a significant source of and storage tissue for estradiol (Birkenfeld and Kase, 1994; Ellison, 2001; Riordan, 2005). There is also evidence that maintenance of cortisol levels in the presence of high prolactin levels is also important in the onset of lactation (Ganguly et al., 1980; Neville and Morton, 2001). The results of this study, however, revealed no significant association between BMI and either estradiol or cortisol levels.

Although only two women in this study presented with gestational diabetes, both were obese, and thus, gestational diabetes played a statistical role in the significance of obesity on both prolactin levels at 48 hours postpartum and milk output at 7 days postpartum. The evidence on whether gestational diabetes has a negative effect on

lactation outcomes is unclear. Women with Type I (insulin dependent) diabetes are known to experience a delay in onset of milk production (Arthur et al., 1989), yet, this condition was found to have no effect on basal prolactin levels in pregnant women when compared to non-diabetic women (Botta et al., 1984). In addition, no significant difference was found in milk production at 7 days postpartum in women with Type I diabetes compared to control women (Neubauer et al., 1993). There is less information on women with noninsulin-dependent gestational diabetes, however, some studies show no delay in onset of milk production (Hartmann and Cregan, 2001), nor a decrease in total duration of lactation (Gunderson et al., 2010) in women with gestational diabetes compared to women without gestational diabetes. Thus, there is no consistent negative effect of gestational diabetes on lactation success. Additionally, women with diabetes are often overweight so it is difficult to tease apart whether the obesity or the diabetes is involved. Because of the small number of women with diabetes in this study, it is not possible to analyze the role gestational diabetes plays in prolactin concentration and milk output, however, the association tells us that it would be important to explore in future studies.

Mother-infant positioning and maternal obesity

Mother Baby Assessment (MBA) score, as a measure of correct positioning and technique for a successful breastfeeding episode, had a significant association with BMI in our study. Correct positioning and latching on are necessary to establish a consistent milk supply shortly after birth. Incorrect positioning during this critical window would lead to low milk transfer between mother and infant, which would ultimately result in

needing to supplement shortly after birth. A low MBA score could be the result of several problems, including poor positioning due to mechanical difficulties associated with maternal obesity and/or large breasts. Only one other study (Hilson et al., 2004) has explored MBA scores in relation to maternal BMI, but they found no difference in MBA scores among the BMI groups in their sample. In contrast to results from the present study, they found that MBA score did not mediate the relationship between delayed onset of lactogenesis II and high maternal BMI in their study population. Hilson and colleagues collected their data shortly after birth while women were still in the hospital following delivery, and thus, their average MBA score of 4.1 may reflect that most of the women, regardless of BMI status, were still learning to breastfeed their infants.

Previous research shows that difficulty establishing correct positioning shortly after birth is common, yet most mother-infant dyads succeed within a few days postpartum. A study exploring the prevalence of suboptimal infant breastfeeding behavior (SIBB), evaluated via use of the Infant Breastfeeding Assessment Tool (IBFAT), found that 49% of participants displayed SIBB on the day of delivery in the hospital, yet only 14% did so at 7 days postpartum (Dewey et al., 2003). This study also reported high maternal BMI to be a risk factor for SIBB at 7 days postpartum, but maternal BMI was determined at 14 days postpartum, rather than pre-pregnancy. In addition, although the IBFAT is similar to the MBA, it only measures infant feeding behavior and does not take into account maternal behaviors, which are especially important when exploring the effect of maternal obesity on effective positioning.

This study is unique in that MBA score data was collected at 7 days postpartum, a time by which women and their babies need to successfully establish breastfeeding in order to avoid excess infant weight loss. A novel finding was the significant association between BMI category and MBA score with obese women having a greater frequency of low scores. It might be expected that prenatal breastfeeding instruction and/or breastfeeding assistance in the hospital after delivery may be positively related to MBA scores or that delivery by c-section may negatively affect MBA scores. None of these variables, however, had a significant relationship with MBA score. In the multivariate model, MBA score is the variable that appears to be driving lower milk output and may be the mediator between obesity and milk output, ultimately leading to an increased risk of ceasing exclusive breastfeeding as early as 2 weeks postpartum.

In summary, obesity was associated with early cessation of exclusive breastfeeding. Low milk output may be impacting women’s decisions to begin supplementing with liquids or solids other than breastmilk. Low milk output may be influenced by the mediating factor of obesity on MBA score (a proxy for incorrect positioning) or on early postpartum prolactin levels, which would affect the development of a sufficient milk supply in this critical window two weeks postpartum (Figure 4.3).

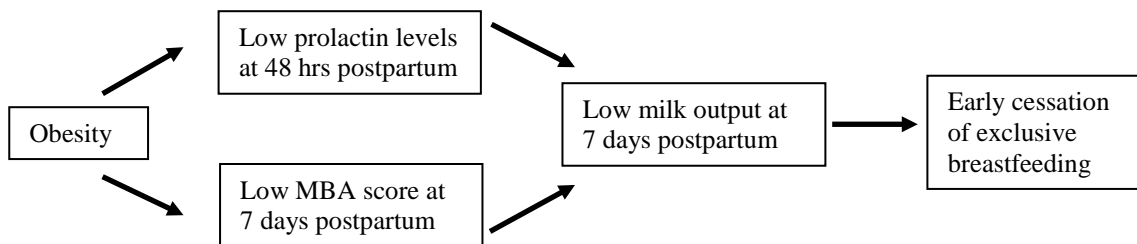


Figure 4.3 Possible causal pathways for the factors associated with early cessation of exclusive breastfeeding. Arrows denote (unadjusted) significant interactions ($P < 0.05$).

CHAPTER V

CONCLUSION

Summary

The purpose of this thesis was to investigate potential mediating effects on the relationship between high pre-pregnant maternal body mass index and reduced lactation duration in an effort to provide new understanding of this association. My holistic analysis of this relationship provides evidence that support many of the suggested links presented in the conceptual model in Chapter I. Consistent with previous studies, overweight women did have significantly reduced duration of both exclusive and any breastfeeding compared to women with normal BMI, even though their intentions for breastfeeding duration did not differ. This reduced duration appears to be influenced by high maternal BMI interacting with several factors. High maternal BMI was associated with both hormone abnormalities and inefficient positioning while breastfeeding, which was related to reduced milk output. In addition, psychosocial factors, as well as breastfeeding problems in the early postpartum period contributed to overweight women's decision to cease breastfeeding earlier than planned.

Psychosocial factors relating to body image impacted this relationship. Overweight women were less comfortable with and confident in their bodies and they had more concerns about their body shape/weight. This study is the first to report that these concerns mediated the reduced duration observed in this subgroup of women. Body image concerns during the postpartum period, and especially those relating to women's comfort and confidence in their bodies, appear to impact the association more heavily

than do pre-pregnancy concerns about one's body shape/weight. This distinction is important as postpartum confidence with one's body may be more amenable to intervention, compared to body image concerns that develop before pregnancy.

Breastfeeding problems related to milk production in the first two weeks postpartum were also found to explain reduced exclusive duration, and also for the first time, total duration, among overweight women. Although only a small percentage of the total sample reported perceived insufficient milk, overweight women were significantly more likely to do so than normal weight women. Engorgement, a measure of breast fullness that signals milk accumulation, was a positive predictor of duration and overweight women experienced engorgement in significantly lower frequencies than women of normal weight. Results indirectly suggest that maternal perception may accurately reflect a true lower milk supply.

Finally, one of the more interesting findings to emerge from this study is that obese women had lower prolactin levels shortly after birth and they had more difficulty establishing efficient positioning while nursing. Both of these factors were found to negatively influence milk output, although positioning was a stronger predictor. As low milk production is one of the main paths to reduced duration, the finding that obese women had lower milk output at one-week after birth is important in explanations of reduced duration. That obese women have less efficient positioning, which leads to lower milk output and ultimately, early cessation of exclusive breastfeeding, is a novel finding and should be a key avenue of future research on this topic.

In addition to study findings that speak to the aims of this study, two other variables are note-worthy because of their impact on duration. The length of time women intend to breastfeed matters. Longer planned duration clearly has a positive impact on the actual duration of lactation, although the effect is small. Second, there is not currently a clear understanding if, and if so, how gestational diabetes impacts lactation, although results from this study suggest it has a negative effect. While there was no difference in status of gestational diabetes between the two BMI groups in the full sample of this study, gestational diabetes is known to be more common in overweight women and is thus, an important area for future research.

Strengths and limitations

This study has several limitations. First, like all observational studies, the results of this study cannot determine what causes women with high pre-pregnant BMI to experience reduced breastfeeding duration. Rather, an attempt was made to identify potential explanations for this association. Second, while participation by women who identified as non-European/Caucasian was sought and encouraged, the final sample was not demographically diverse and thus cannot be generalized to other populations. In addition, recruitment largely took place in a university setting, which likely contributed to the older and more highly educated sample. Third, the results of this study would be strengthened with the addition of more and different types of data. The milk output, MBA score, and hormone level values were only measured at a single point in time, which may not be an accurate representation of average daily levels. Qualitative data on maternal perception of milk supply and infant needs, as well as a record of the actions taken in

response to this assessment would be beneficial in teasing out the causal pattern related to early cessation of exclusive breastfeeding. Additionally, information on how women navigate the changes their bodies experience in relation to their new role as breastfeeding mothers would increase the value of this research. Fourth, in the subset of participants from the larger sample, the sample size is small due to the type and intensity of data collected. All participants were giving birth for the first time and it can be difficult to collect data during this sensitive time period. The relatively small sample size limits the ability to precisely estimate the magnitude of effects, such as the number of hours to lactation establishment postpartum and milk output on the risk of exclusive breastfeeding cessation. It is significant, however, that even in this small sample, important differences were still found.

Despite its limitations, this study provides a novel and important contribution because of the comprehensive nature in which data were explored in order to address the complex ecology of breastfeeding in overweight women. Many studies to date have consisted of large samples drawn from medical records. Although such studies have been extremely useful in identifying the relationship between reduced lactation and obesity, these studies have not provided the information necessary to explain why the association exists. Additionally, some of these studies have had difficulty disentangling confounding factors, especially parity and maternal intention and commitment to breastfeeding. In contrast, the present study included only primiparous women, almost all of whom intended to breastfeed exclusively for some period of time. All reported that they had familial support for their decision to breastfeed and the majority received support from

health professionals. As a group, they were highly educated with relatively high income levels, living in a region with high breastfeeding rates. This group of women was highly motivated and should be among the most successful at breastfeeding. Results from this study help clarify why they experience difficulty and may be useful in developing interventions.

Implications

Taken together, none of the factors found to reduce duration in this study affect overweight women exclusively. Problems surrounding milk supply, lack of confidence with one's body, and inefficient positioning, for example, are obstacles to successful lactation that all women may experience regardless of body mass index. Recognition of the greater frequency of these problems in overweight women, however, will be important in reducing their negative effect. Unfortunately, most medical professionals and lactation consultants are not currently aware that obesity is a risk factor for difficulty with breastfeeding, and therefore, do nothing special when counseling this group of women (Rasmussen et al., 2006). The important implications of the present study – that lack of confidence in one's body and perception of insufficient milk are associated with reduced duration and that inefficient positioning is a main predictor of lower milk output – speak to the influence of these factors for breastfeeding success. Fortunately, many of them are modifiable factors and, therefore, may be amenable to intervention. Study results demonstrate that there is an opportunity for health professionals to intervene during the critical early postpartum time period when breastfeeding patterns are established.

Only one intervention study to date has focused on improving breastfeeding outcomes in obese women (Rasmussen et al., 2010). Participants in the treatment group of this randomized control trial received telephone-based support postpartum from a lactation consultant or provision of a breast pump. Unfortunately, implementation of these interventions was difficult and neither intervention increased the duration of lactation among obese women. Results from this thesis demonstrate that interventions including a more direct, in-person approach may be better targeted at solving problems of inefficient positioning and providing support to women who are not confident with their bodies or believe their milk production is not sufficient. Medical professionals could spend more time with this subgroup of women before and shortly after birth and/or provide options for mothers to arrange a visit within a few days after birth to be evaluated, as more intense assistance immediately after birth may be extremely helpful for this subgroup of women.

REFERENCES

- ABM. Academy of Breastfeeding Medicine Protocol Committee. 2009. ABM Clinical Protocol #20: Engorgement. *Breastfeeding Med* 4: 111-113.
- Ahluwalia I, Morrow B, Hsia J. 2005. Why do women stop breastfeeding? Findings from the Pregnancy Risk Assessment and Monitoring System. *Pediatrics* 116: 1408–1412.
- Abraham S, Taylor A, Conti J. 2001. Postnatal depression, eating, exercise, and vomiting before and during pregnancy. *Intl J Eating Disord* 29: 482–7.
- Ajzen I, Fishbein M. 1980. *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.
- Akaike H. 1974. A new look at the statistical model identification. *IEEE Trans Aut Control* 19: 716–723.
- Alikassifoglu M, Erginoz E, Gur E, Baltas Z, Beker B, Arvas A. 2001. Factors influencing the duration of exclusive breastfeeding in a group of Turkish women. *J Hum Lactation* 17: 220–226.
- Anderson J, Johnstone B, Remley D. 1999. Breast-feeding and cognitive development: a meta-analysis. *Am J Clin Nutr* 70: 525–535.
- Arenz S, Ruckerl R, Koletzko B, von Kries R. 2004. Breast-feeding and childhood obesity: a systematic review. *Int J Obesity* 28: 1247–1256.
- Arslan A, Zeleniuch-Jacquotte A, Lukanova A, Afanasyeva Y, Katz J, Levitz M, Del Priore G, Toniolo P. 2006. Effects of parity on pregnancy hormonal profiles across ethnic groups with a diverse incidence of breast cancer. *Cancer Epidemiol Biomarkers Prev* 15: 2123-2130.
- Arthur P, Smith M, Hartmann P. 1989. Milk lactose, citrate, glucose as markers of lactogenesis in normal and diabetic women. *J Pediatr Gastroenterol Nutr* 9: 488-496.
- Azziz R. 1989. Reproductive endocrinologic alterations in female asymptomatic obesity. *Fertil Steril* 52: 703–25.
- Baker J, Michaelsen K, Sørensen T, Rasmussen K. 2007. High prepregnant body mass index is associated with early termination of full and any breastfeeding in Danish women. *Amer J Clin Nutr* 86: 404-411.

- Barnes J, Stein A, Smith T, Pollock J. 1997. Extreme attitudes to body shape, social and psychological factors and a reluctance to breast feed. ALSPAC study team. Avon longitudinal study of pregnancy and childhood. *J Royal Soc Medi* 90: 551–9.
- Battin D, Marris R, Fleiss P, Mishell Jr. D. 1985. Effect of suckling on serum prolactin, luteinizing hormone, follicle-stimulating hormone, and estradiol during prolonged lactation. *Obstetrics and Gynecology* 65: 785-788.
- Birkenfeld A, Kase N. 1994. Functional anatomy and physiology of the female breast. *Obstet Gynecol Clin N Am* 21: 433-444.
- Blyth R, Creedy D, Dennis C, Moyle W, Pratt J, De Vries S. 2002. Effect of maternal confidence on breastfeeding duration: An application of breastfeeding self-efficacy theory. *Birth* 29: 278–284.
- Botta R, Donatelli M, Bucalo ML, Bellomonte ML, Bompiani, GD. 1984. Placental lactogen, progesterone, total estriol and prolactin plasma levels in pregnant women with insulin-dependent diabetes mellitus. *Eur J Obstet Gynecol Reprod Biol* 16: 393–401.
- Cavagnini F, Maraschini C, Pinto M, Dubini A, Polli EE. 1981. Impaired prolactin secretion in obese patients. *J. Endocrinol. Invest.* 4: 149–53.
- CDC (Centers for Disease Control and Prevention). 2009. National Center for Health Statistics Data Brief: Delayed childbearing: more women are having their first child later in life. Retrieved March 31, 2011 from <http://www.cdc.gov/nchs/data/databriefs/db21.htm>
- CDC (Centers for Disease Control and Prevention). 2007. Breastfeeding national immunization survey data: Retrieved March 31, 2011 from http://www.cdc.gov/breastfeeding/data/NIS_data/
- Chapman D, Pérez-Escamilla P. 2000. Maternal perception of the onset of lactation is a valid, public health indicator of lactogenesis stage II. *J. Nutr.* 130: 2972–2980.
- Chapman D, Pérez-Escamilla P. 1999. Identification of risk factors for delayed onset of lactation. *J Am Dietetic Assoc* 99: 450-454.
- Chen D, Nommsen-Rivers L, Dewey K, Lonnerdal B. 1998. Stress during labor and delivery and early lactation performance. *Am J Clin Nutr* 68: 335–344.
- Chua S, Arulkumaran S, Lim I, Selamat N, Ratnam S. 1994. Influence of breastfeeding and nipple stimulation on postpartum uterine activity. *Br J Obstet Gynaecol* 101: 804–805.

- Cody R, Smith J. 2006. Applied statistics and the SAS® programming language, 5th Ed. Upper Saddle River, NJ: Pearson Prentice Hall, Inc.
- Collaborative Group on Hormonal Factors in Breast Cancer. 2002. Breast cancer and breastfeeding: collaborative reanalysis of individual data from 47 epidemiological studies in 30 countries, including 50302 women with breast cancer and 96973 women without the disease. *Lancet* 360: 187–195.
- Cooke M, Sheehan A, Schmied V. 2003. A description of the relationship between breastfeeding experiences, breastfeeding satisfaction, and weaning in the first 3 months after birth. *J Hum Lactation* 19: 145–156.
- Cox D. 1972. Regression models and life tables (with discussion). *Journal of Royal Statistical Society: Series B*, 34: 187-220.
- Dennis C, McQueen K. 2009. The relationship between infant-feeding outcomes and postpartum depression: A qualitative systematic review. *Pediatrics* 123: e736-e751.
- Dettwyler K, Fishman C. 1992. Infant Feeding Practices and Growth. *Annual Review of Anthropology* 21: 171-204.
- Dewey K, Nommsen-Rivers L, Heinig MJ, Cohen R. 2003. Risk factors for suboptimal infant breastfeeding behavior, delayed onset of lactation, and excess neonatal weight loss. *Pediatrics* 112: 607-619.
- DiGirolamo A, Thompson N, Martorell R, Fein S, Grummer-Strawn L. 2005. Intention or experience? Predictors of continued breastfeeding. *Health Educ Behav* 32: 208–226.
- Dipietro J, Millet S, Costigan K, Gurewitsch E, Caulfield L. 2003. Psychosocial influences on weight gain attitudes and behaviors during pregnancy. *J Am Dietet Assoc* 103: 1314–9.
- Donath S, Amir L. 2000. Does maternal obesity adversely affect breastfeeding initiation and duration? *J Paediatr Child Health* 36: 482-486.
- Drake M, Verhulst D, Fawcett J, Barger D. 1988. Spouses' body image changes during and after pregnancy: A replication in Canada. *J Nurs Scholar* 20: 88–92.
- Dykes F, Williams C. 1999. Falling by the wayside: a phenomenological exploration of perceived breast-milk inadequacy in lactating women. *Midwifery* 15: 232-246.

- Ellison P. 2001. *On fertile ground: a natural history of human reproduction*. Cambridge, MA: Harvard University Press.
- Flegal K, Carroll M, Ogden C, Curtin L. 2010. Prevalence and trends in obesity among US adults, 1999-2008. *JAMA* 303: 235-241.
- Forster D, McLachlan H, Lumley J. 2006 Factors associated with breastfeeding at six months postpartum in a group of Australian women. *International Breastfeeding Journal* 1: 18.
- Foster S, Slade P, Wilson K. 1996. Body image, maternal fetal attachment, and breast feeding. *J Psychosom Res* 41: 181-4.
- Fox P, Yamaguchi C. 1997. Body image change in pregnancy: A comparison of normal weight and overweight primigravidas. *Birth* 24: 35-40.
- Ganguly R, Ganguly N, Mehta N, Banerjee MR. 1980. Absolute requirement of glucocorticoid for expression of the casein gene in the presence of prolactin. *Proc Natl Acad Sci USA* 77: 6003-6006.
- Gartner L, Morton J, Lawrence R, Naylor A, O'Hare D, Schanler R, Eidelman A. American Academy of Pediatrics Section on Breastfeeding. 2005. Breastfeeding and the use of human milk. *Pediatrics* 115: 496-506.
- Gatti L. 2008. Maternal perceptions of insufficient milk supply in breastfeeding. *J Nurs Scholarship* 40: 355-363.
- Gjerdingen D, Fontaine P, Crow S, McGovern P, Center B, Miner, M. 2009. Predictors of mothers' postpartum body dissatisfaction. *Women & Health* 49: 491-504.
- Gussler J, Briesemeister L. 1980. The Insufficient Milk Syndrome: a biocultural explanation. *Med Anth* 4: 145-174.
- Gunderson E, Jacobs Jr. D, Chiang V, Lewis C, Feng J, Quesenberry Jr. C, Sidney S. 2010. Duration of lactation and incidence of the metabolic syndrome in women of reproductive age according to gestational diabetes mellitus status: a 20-year prospective study in CARDIA (Coronary Artery Risk Development in Young Adults). *Diabetes* 59: 495-504.
- Hartmann P, Cregan M. 2001. Lactogenesis and the effects of insulin-dependent diabetes mellitus and prematurity. *J Nutr* 131: 3016S-3020S.

- Hass D, Howard C, Christopher M, Rowan K, Broga M, & Corey T. 2006. Assessment of breastfeeding practices and reasons for success in a military community hospital. *J Hum Lact* 22: 439-445.
- Heath A, Tuttle C, Simons M, Cleghorn C, Parnell W. 2002. A longitudinal study of breastfeeding and weaning practices during the first year of life in Dunedin, New Zealand. *J Am Dietetic Assoc* 102: 937-943.
- Heinberg L. 1996. Theories of body image disturbance: Perceptual, developmental, and sociocultural factors. In J. Thompson (Ed.), *Body image, eating disorders and obesity: An integrative guide for assessment and treatment*. Washington, DC: American Psychological Association.
- Heinig M. 2001. Host defense benefits of breastfeeding for the infant. Effect of breastfeeding duration and exclusivity. *Pediatr Clin North Am* 48: 105-123.
- Hill P, Aldag J. 2007. Predictors of term infant feeding at week 12 postpartum. *J Perinatal Neonatal Nurs* 21: 250-255.
- Hill P, Aldag J. 1991. Potential indicators of insufficient milk supply syndrome. *Res Nurs Health* 14: 1-19.
- Hill P, Humenick S. 1989. Insufficient milk supply. *J Nurs Scholarship* 21: 145-148.
- Hilson J, Rasmussen K, Kjolhede C. 2004. High prepregnant body mass index is associated with poor lactation outcomes among white, rural women independent of psychosocial and demographic correlates. *J Hum Lact* 20:18-29.
- Hilson J, Rasmussen K, Kjolhede C. 1997. Maternal obesity and breastfeeding success in a rural population of Caucasian women. *Am J Clin Nutr* 66: 1371-1378.
- Hosmer D, Lemeshow S. 1999. *Applied survival analysis: regression modeling of time to event data*. New York: John Wiley & Sons, Inc.
- Huang H, Wang S, Chen C. 2004. Body image, maternal-fetal attachment, and choice of infant feeding method: A study in Taiwan. *Birth* 31: 183-8.
- Hughes R. 1984. Satisfaction with one's body and success in breastfeeding. *Issues Compr Pediat Nurs* 7: 141-153.
- IOM (Institute of Medicine). 2009. *Weight gain during pregnancy: reexamining the guidelines*. Washington, DC: The National Academies Press.

- Jelliffe D, Jelliffe E. 1978. Human milk in the modern world: psychological, nutritional, and economic significance. Oxford: Oxford University Press.
- Jenkin W, Tiggemann, M. 1997. Psychological effects of weight retained after pregnancy. *Women Health* 25: 89–98.
- Jernström H, Lubinski J, Lynch H, Ghadirian P, Neuhausen S, Isaacs C, Weber B, Horsman D, Rosen B, Foulkes W, Friedman E, Gershoni-Baruch R, Ainsworth P, Daly M, Garber J, Olssonm H, Sun P, Narod S. 2004. Breast-feeding and the risk of breast cancer in BRCA1 and BRCA2 mutation carriers. *J Natl Cancer Inst* 96: 1094–1098.
- Kehler H, Chaput K, Tough S. 2009. Risk factors for cessation of breastfeeding prior to six months postpartum among a community sample of women in Calgary, Alberta. *Can J Public Health* 100: 376-380.
- Kirkland V, Fein S. 2003. Characterizing reasons for breastfeeding cessation throughout the first year postpartum using the construct of thriving. *J Hum Lactation* 19: 278–285.
- Kitsantas P, Pawloski L. 2010. Maternal obesity, health status during pregnant, and breastfeeding initiation and duration. *J Mater-Fetal Neonat Med* 23: 135-141.
- Kopelman P. 2000. Physiopathology of prolactin secretion in obesity. *Inter J Obesity* 24 (S2): S104-S108.
- Krause K, Lovelady C. 2011. Predictors of breastfeeding in overweight and obese women: data from Active Mothers Postpartum (AMP). *Matern Child Health J* 15: 367-375.
- Kronborg H, Vaeth M. 2004. The influence of psychosocial factors on the duration of breastfeeding. *Scan J of Pub Health* 32: 210-216.
- Kugyelka J, Rasmussen K, Frongillo E Jr. 2004. Maternal obesity negatively affects breastfeeding success among Hispanic but not Black women. *J Nutr* 134: 1746-1753.
- Lawrence R, Lawrence R. 2005. *Breastfeeding: a guide for the medical profession*. 6th Ed. Philadelphia: Elsevier Mosby.
- Lawson K, Tulloch M. 1995. Breastfeeding duration: Prenatal intentions and postnatal practices. *J Adv Nurs* 22: 841-849.

- Lewallen L, Dick M, Flowers J, Powell W, Zickefoose K, Wall Y, Price Z. 2006. Breastfeeding support and early cessation. *JOGNN* 35: 166–172.
- Li R, Jewell S, Grummer-Strawn LM. 2003. Maternal obesity and breastfeeding practices. *Am J Clin Nutr* 77: 931-936.
- Lipworth L, Hsieh C-c, Wide L, Ekblom A, Yu S-z, Yu G-p, Xu B, Hellerstein S, Carlstrom K, Trichopoulos D, Adami H-O. 1999. Maternal pregnancy hormone levels in an area with a high incidence (Boston, USA) and in an area with a low incidence (Shanghai, China) of breast cancer. *Br J of Cancer* 79: 7-12.
- Liu J, Smith M, Dobre M, Ferguson J. 2009. Maternal obesity and breast-feeding practices among white and black women. *Obesity* 18: 175-182.
- Manganaro R, Mami C, Marrone T, Marseglia L, Gemelli M. 2001. Incidence of dehydration and hypernatremia in exclusively breast-fed infants. *J Pediatr* 139: 673–675.
- Manstead A, Proffitt C, Smart, J. 1983. Predicting and understanding mothers' infant-feeding intentions and behavior: Testing the theory of reasoned action. *J Person Soc Psych* 44: 657-671.
- Manios Y, Grammatikaki E, Kondaki K, Ioannou E, Anastasiadou A, Birbilis M. 2009. The effect of maternal obesity on initiation and duration of breast-feeding in Greece: The GENESIS study. *Public Health Nutr* 12: 517-524.
- McCarter-Spaulding D, Kearney M. 2001. Parenting self-efficacy and perception of insufficient breast milk. *JOGNN* 30: 515–522.
- Mendez M, Monteiro C, Popkin B. 2005. Overweight exceeds underweight among women in most developing countries. *Am J Clin Nutr* 81: 714 –21.
- Metzger M, McDade T. 2010. Breastfeeding as obesity prevention in the United States: A sibling difference model. *Am J Hum Biol* 22: 291-296.
- Mok E, Multon C, Piguel L, Barroso E, Goua V, Christin P, Perez M-J, Hankard R. 2008. Decreased full breastfeeding, altered practices, perceptions, and infant weight change of pre-pregnant obese women: a need for extra support. *Pediatrics* 121: e1319-e1324.
- Mulford C. 1992. The Mother-Baby Assessment (MBA): An “Apgar score” for breastfeeding. *J Hum Lac* 8: 79-82.

- Neifert, M. 2001. Prevention of breastfeeding tragedies. *Pediatr Clin North Am* 48: 273-297.
- Neubauer S, Ferris A, Chase C, Fanelli J, Thompson C, Lammi-Keefe C, Clark R, Jensen R, Bendel R, Green K. 1993. Delayed lactogenesis in women with insulin-dependent diabetes mellitus. *Am J Clin Nutr* 58: 54–60.
- Neville M, Morton J. 2001a. Physiology and endocrine changes underlying human lactogenesis II. *J Nutr* 131: 3005S-3008S.
- Neville M. 2001b. Lactogenesis: The transition from pregnancy to lactation. *Pediatr Clin N Am* 48: 35-52.
- Neville M, Keller R, Seacat J, Lutes V, Neifert M, Casey C, Allen J, Archer P. 1988. Studies in human lactation: milk volumes in lactating women during the onset of lactation and full lactation. *Am J Clin Nutr* 48: 1375-1386.
- Newcomb P, Storer B, Longnecker M, Mittendorf R, Greenberg E, Clapp R, Burke K, Willett W, MacMahon B. 1994. Lactation and a reduced risk of premenopausal breast cancer. *N Engl J Med* 330: 81–87.
- Newton R, Rudestam K. 1999. *Your statistical consultant: answers to your data analysis questions*. Thousand Oaks, CA: SAGE Publications, Inc.
- Noel-Weiss J, Rupp A, Cragg B, Bassett V, & Woodend D. 2006. Randomized controlled trial to determine effects of prenatal breastfeeding workshop on maternal breastfeeding self-efficacy and breastfeeding duration. *J Obstet Gynecol & Neonatal Nurs* 35: 616-624.
- Nommsen-Rivers L, Chantry C, Peerson J, Cohen R, Dewey K. 2010. Delayed onset of lactogenesis among first-time mothers is related to maternal obesity and factors associated with ineffective breastfeeding. *Am J Clin Nutr* 92: 574-584.
- O'Campo P, Faden R, Gielen A, Wang M. 1992. Prenatal factors associated with breastfeeding duration: Recommendations for prenatal interventions. *Birth* 19: 195-201.
- Oddy W, Jianghong L, Landsborough L, Kendall G, Henderson S, Downie J. 2006. The association of maternal overweight and obesity with breastfeeding duration. *J Pediatr* 149: 185-191.
- Otsuka K, Dennis C-L, Tatsuoka H, Jimba M. 2008. The relationship between breastfeeding self-efficacy and perceived insufficient milk among Japanese mothers. *JOGNN* 37: 546-555.

- Perez-Escamilla R, Mejia L, Dewey K. 1992. Neonatal feeding patterns and reports of insufficient milk among low-income urban Mexican mothers. *Ecology of Food and Nutrition* 27: 91-102.
- Perez-Escamilla R, Segura-Millán S, Pollitt E, Dewey K. 1993. Determinants of lactation performance across time in an urban population from Mexico. *Soc Sci Med* 37: 1069-1078.
- Pijl H, Koppeschaar HPF, Willekens FLA, Frolich M, Meinders AE. 1993. The influence of serotonergic neurotransmission on pituitary hormone release in obese and non-obese females. *Acta Endocrinol.* 128: 319–24.
- Potischman N, Troisi R, Thadhani R, Hoover R, Dodd K, Davis W, Sluss P, Hsieh C-C, Ballard-Barbash R. 2005. Pregnancy hormone concentrations across ethnic groups: implications for later cancer risk. *Cancer Epidemiol Biomarkers Prev* 14: 1514-1520.
- PRAMS (Pregnancy Risk Assessment Monitoring System, Minnesota). 2006. Summary Book 2002-2003. Retrieved March 31, 2011 from http://www.health.state.mn.us/divs/cfh/prams/mnprams2002_2003sb.pdf
- Pruzinsky T, Cash T. 2002. Understanding body images: Historical and contemporary perspectives. In T.F. Cash, & T. Pruzinsky (Eds.), *Body Images: A Handbook of Theory, Research and Clinical Practice*. New York, NY: Guilford Press.
- Punthmatharith B, Singh J. 2005. A psychometric assessment of the H & H Lactation Scale in a sample of Thai mothers using a repeated measurement design. *Nurs Res* 54: 313–323.
- Quarles A, Williams P, Hoyle D, Brimeyer M, Williams A. 1994. Mother's intention, age, education, and the duration and management of breastfeeding. *Mat Child Nurs* 22: 102-108.
- Rallis S, Skouteris E, Wertheim S, Paxton J. 2007. Predictors of body image during the first year postpartum: A prospective study. *Women Health* 45: 87–104.
- Rasmussen K, Dieterich C, Zelek S, Altabet J, Kjolhede C. 2010. Interventions to increase the duration of breastfeeding in obese mothers; The Bassett Improving Breastfeeding Study. *Breastfeeding Medicine* 0: 1-7.
- Rasmussen K, Lee V, Ledkovsky T, Kjolhede C. 2006. A description of lactation counseling practices that are used with obese mothers. *J Hum Lac* 23: 322-327.

- Rasmussen K, Kjolhede C. 2004. Prepregnant overweight and obesity diminish the prolactin response to suckling in the first week postpartum. *Pediatrics* 113: e465-471.
- Riordan J. 2005. *Anatomy and physiology of lactation*. 3rd Ed. Sudbury, MA: Jones and Bartlett Publishers.
- Riva E, Banderali G, Agostini C, Silano M, Radaelli G, Giovannini M. 1999. Factors associated with initiation and duration of breastfeeding in Italy. *Acta Poediatr.* 88: 411–15.
- Rosenblatt K, Thomas D. 1993. Lactation and the risk of epithelial ovarian cancer. WHO Collaborative Study of Neoplasia and Steroid contraceptives. *Int J Epidemiol* 22: 192–197.
- Rutishauser I, Carlin J. 1992. Body mass index and duration of breast feeding: a survival analysis during the first six months of life. *J Epidemiol Community Health* 46: 559-565.
- Sacco L, Caulfield L, Gittelsohn J, Martinez H. 2006. The conceptualization of perceived insufficient milk among Mexican mothers. *J Hum Lactation* 22: 277–286.
- Schluter P, Carter S, Percival T. 2006. Exclusive and any breastfeeding rates of Pacific infants in Auckland: Data from the Pacific Islands Families First Two Years of Life Study. *Pub Health Nut* 9: 692–699.
- Scott J, Binns C, Oddy W, Graham K. 2006. Predictors of breastfeeding duration: evidence from a cohort study. *Pediatrics* 117: e646-e655.
- Scott J & Binns C. 1999. Factors associated with the initiation and duration of breastfeeding: A review of the literature. *Breastfeed Review* 7: 5-16.
- Segura-Millan S, Dewey K, Perez-Escamilla R 1994. Factors associated with perceived insufficient milk in a low-income urban population in Mexico. *J Nutr* 124: 202-212.
- Sheehan D, Krueger P, Watt S, Sword W, Bridle B. 2001. The Ontario Mother and Infant Survey: breastfeeding outcomes. *J Hum Lac* 17: 211–219.
- Skouteris H, Carr E, Wertheim, Paxton S, Duncombe D. 2005. A prospective study of factors that lead to body dissatisfaction during pregnancy. *Body Image* 2: 347–61.
- Strang V, Sullivan P. 1985. Body image attitudes during pregnancy and the postpartum period. *J Obstet Gynecol & Neonatal Nurs* 14: 332-337.

- Thompson J, Heinberg L, Altabe M & Tantleff-Dunn S. 1999. An introduction to the concept of body image disturbance: History, definitions and descriptions. In J. Thompson, L. Heinberg, M. Altabe, & S. Tantleff-Dunn (Eds.), *Exacting Beauty: Theory, Assessment, and Treatment of Body Image Disturbance*. Washington, DC: American Psychological Association.
- Tully J, Dewey K. 1985. Private fears, global loss: A cross-cultural study of the insufficient milk syndrome. *Med Anth* 9: 225-243.
- UCLA: Academic Technology Services, Statistical Consulting Group. Statistical computing seminars: Survival analysis with SAS. from http://www.ats.ucla.edu/stat/sas/seminars/sas_survival/default.htm (accessed February 12, 2011).
- Walker L, Freeland-Graves J. 1998. Lifestyle factors related to postpartum weight gain and body image in bottle- and breastfeeding women. *J Obstet Gynecol & Neonatal Nurs* 27: 151–60.
- Walker, L. 1998. Weight-related distress in the early months after childbirth. *West J Nurs Res* 20: 30-44.
- Walker L, Timmerman G, Kim M, Sterling B. 2002. Relationships between body image and depressive symptoms during postpartum in ethnically diverse, low income women. *Women Health* 36: 101–21.
- Wiles R. 1993. “I’m not fat, I’m pregnant.” The impact of pregnancy on fat women’s body language. *Health Psychol Update* 12: 16-21.
- Wojnar D. 2004. Maternal perceptions of early breastfeeding experiences and breastfeeding outcomes at 6 weeks. *Clin Effectiveness in Nurs* 8: 93–100.
- World Health Organization (WHO). 2003. *Global strategy for infant and young child feeding*. Geneva, Switzerland.
- World Health Organization (WHO). 2003. *Overweight and obesity fact sheet*. Global Strategy On Diet, Physical Activity and Health.
- Wright C, Parkinson K, Drewett R. 2004. Why are babies weaned early? Data from a prospective population based cohort study. *Archives of Diseases of Children* 89: 813–816.