INFANT FEEDING MODE IS ASSOCIATED WITH DIFFERENCES IN POSTPARTUM WEIGHT CHANGE AND PERCENT BODY FAT FROM 2 TO 16 WEEKS

by

NICOLE MOTOYASU

(Under the Direction of Alex Kojo Anderson)

ABSTRACT

Excessive gestational weight gain and postpartum weight change (PPWC) are contributing factors to the prevalence of obesity among women of childbearing age. This study investigated whether mothers' (N=77) PPWC and percent body fat (%body fat) differed by infant feeding mode (predominantly breastfeeding vs. formula-feeding). Formula-feeding mothers tended to be obese (BMI > 30.0), Black, and WIC participants. Anthropometry and %body fat (by air displacement plethysmography) were assessed at 2, 8 and 16 weeks postpartum. Repeated measures ANCOVA adjusting for self-reported pre-pregnancy weight revealed that breastfeeding mothers' weight and %body fat declined from 2 to 16 weeks (-3.63 kg, -2.05 %body fat), while formula-feeding mothers' weight and %body fat increased (0.26 kg, 0.19 %body fat). X^2 tests revealed that formula-feeding mothers were heavier on average at all time points, and retained more weight and %body fat, outcomes that may increase the risk of maternal obesity.

INDEX WORDS: Breastfeeding, Formula-feeding, Body composition, weight change, air displacement plethysmography

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DEDICATION

The time I spent working with the Los Angeles Police Department Devonshire Division Police Activity League Supporters continues to be the most influential learning experience in my life. I started teaching classes when I was seventeen and grew up along side my students. Through their eyes I was able to see the coming of age experience from so many perspectives. Courtesy, humility, integrity, self-control, perseverance, and indomitable spirit, all the tenants of taekwondo, were truly exemplified through my time as their Kyo Sa Nim. I am driven to pursue research, education, and knowledge in order to build a better community for them. Everyone needs a P.A.L.

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CHAPTER 1

INTRODUCTION

Prevalence of obesity is high among women of childbearing age; excessive weight gain during pregnancy and postpartum weight retention are contributing factors (1, 2). When coupled with weight gain that tends to occur with age, failure to return to pre-pregnancy weight can contribute to long-term maternal obesity and chronic metabolic diseases (3-5). The metabolic changes evoked by initiation of lactation cause greater energy utilization and mobilization of fat stores, attenuating some of the weight and body fat gained during pregnancy (6-8). However, there are many other confounding factors that play a role in postpartum weight loss: socioeconomic status, excess gestational weight gain, pre-pregnancy weight, education, diet quality, and physical activity levels (1, 9-12).

Although efforts to promote breastfeeding may be seen as an overall public health strategy to optimize the health of American women and infants, the evidence is inconsistent regarding breastfeeding's protective effects on postpartum weight retention and body composition (2). This study investigated differences between predominantly breastfeeding and predominantly formula-feeding mothers' weight change (PPWC) and changes in percent body fat (%body fat) from 2 to 16 weeks postpartum.

HYPOTHESIS

Predominantly formula-feeding mothers will have greater PPWC and less %body fat change compared to predominantly breastfeeding mothers from 2 to 16 weeks postpartum.

SPECIFIC AIMS

This study compares changes in maternal weight and percent body fat among breastfeeding mothers compared to formula-feeding mothers from 2 to 16 weeks postpartum.

Specific Aim #1—Describe differences in maternal PPWC based on infant feeding mode. Our hypothesis is that formula-feeding mothers will have greater weight retention than breastfeeding mothers from 2 to 16 weeks postpartum.

Specific Aim #2—Identify differences in maternal %body fat based on infant feeding mode. Our hypothesis is that formula-feeding mothers will show less reduction in body fat percentage than breastfeeding mothers between 2 to 16 weeks postpartum

CHAPTER 2

LITERATURE REVIEW

INTRODUCTION

Postpartum weight retention (PPWR) is an important health concern for women of childbearing age, as it can be a contributing factor to long term obesity (1). PPWR is defined as the amount of weight that remains at a specific postpartum time point minus the pregravid weight. This accounts for the weight of accumulated breast tissue used during lactation in addition to remaining fat mass gained during pregnancy (1). The 1988 National Maternal and Infant Health Survey data reports modest levels of PPWR to be about 1.3 kg (2.9 lbs.) at 10-18 months postpartum (13). Data collected from the Nurses' Health Study (N = 190) indicates that every kilogram gained per year during the ages of 18-28 increased the risk for developing Type 2 diabetes by 49% and 31% for cardiovascular disease (14). These findings highlight the importance of maintaining a healthy weight across the lifespan; and underscore the importance of losing the weight gained during pregnancy. Further, maternal obesity has been linked to an increased risk of obesity in offspring, especially among daughters (15, 16).

During pregnancy, it is expected that mothers gain fat mass. These gains are necessary to accommodate the growth and development of a healthy fetus as well as preparing the body for lactogenesis. If fat accrual is not reconciled

during the postpartum period it can increase the risk of obesity, metabolic disorders and dysfunction, as well as cardiovascular diseases. Based on these risk factors, it is important to understand the impact infant feeding mode can have on maternal body composition changes in the postpartum period. Among the many factors influencing postpartum weight and %body fat, those reviewed include ancillary factors such as race, demographics, and parity, as well as factors related to maternal behavior such as gestational weight gain (GWG) and infant feeding mode. The following review of literature will summarize current research that examines factors affecting maternal PPWR and %body fat with a focus on the implications of infant feeding mode.

FACTORS INFLUENCING POSTPARTUM WEIGHT RETENTION

Ancillary factors effects on PPWR: race, socioeconomic disparity, and parity

Basal metabolic rate, overall breastfeeding attitudes and beliefs, and socioeconomic status are different between White and Black women. Black women have 10% lower basal metabolic rate when compared to White counterparts after controlling for lean mass, BMI, and %body fat (17). Black mothers may have a more difficult time losing weight gained during pregnancy compared to White mothers, regardless of the impact of infant feeding. Black mothers also have a lower rate of breastfeeding initiation compared to both White mothers and other minority groups (18). The breastfeeding rates for Black mothers are 58.9% initiation, 30.1% at 6 months, and 12.5% at 12 months.

In comparison, White mothers had a 16.3% higher initiation rate, 16.5% higher at 6 months, and 11.8% higher rate at 12 months (19). Obeng et al. (2015) identifies several determinants against breastfeeding among mothers in the Black community including: lack of familial support, negative perceptions surrounding infants feeding from the breasts, lack of resources, and an unsupportive work environment (20). Black mothers also reported difficulty initiating breastfeeding due to a lack of maternal role models and the belief that feeding the infant from the breast was considered an act of incest in some Black churches (20).

Black women in the USA make less money compared to White women (21); the disparity in wages increase between White women (+28%) and Black women (+21%) from 1990-2002 (21). Relative to Black women residing in Georgia, living in the South had a greater detrimental effect on the wage gap between White and Black women by adding an addition 2% to the 2002 calculated wage difference (21). Higher levels of poverty are positively associated with higher abdominal fat and higher BMIs, as wells as other challenges, which relate directly to weight status and choice of feeding mode (22).

Primiparous women are more likely to have higher GWG and %body fat gains during pregnancy compared to multiparous women, as well as more PPWR when measured at 6 months postpartum (23, 24). First time mothers may begin their next pregnancy still retaining a proportion of previous GWG, which may

have adverse health outcomes for the subsequent fetus. These particular lifestyle and demographic factors have compounding effects on both PPWR and %body fat.

Gestational weight gain: effects on PPWR and %body fat

For optimal maternal weight outcomes, the IOM guidelines recommend normal weight mothers gain 25-35lbs, and for mother who are obese pre-pregnancy, a weight gain of 11-20lbs is recommended, as excess gestational weight gain may decrease the likelihood of returning to pre-pregnancy weight (1). Several associations have been drawn relating GWG to PPWR at different postpartum time periods. Evidence is sorted into three different time periods: short term (less than 11 weeks), intermediate (3 months – 1 year), and long term (greater than 3 years).

Among intermediate and long-term studies, the overall consensus supports a moderate strength of the association between GWG above IOM recommendations and greater PPWR. Data from the Danish National Birth Cohort (DNBC) links GWG to higher PPWR. Women who reported gaining more than 20kg during pregnancy had 6.2-fold higher odds of retaining more than 5kg at 6 months postpartum compared to women who gained only 10-15kg during pregnancy (25). Long-term gains in maternal weight related to excessive GWG correlated with a 1kg increase in PPWR during the 6 month postpartum period (26). Evidence suggests that effects of PPWR were long lasting and persisted to 7 years postpartum. Even if some weight was lost by 18 months postpartum,

PPWR still had positive effects on weight (+0.48 kg)(26). This highlights the importance of weight loss during the first 6 months postpartum and the lasting effects that long term PPWR can induce on mothers several years into the future.

Relating GWG directly to PPWR is difficult due to several factors including dietary intake, physical activity, breastfeeding behaviors, and the fact that pre-pregnancy weight is typically based on self-reported weight status. Higher amounts of GWG are strongly associated with more PPWR and less odds of a mother returning to her pre-pregnancy weight (2, 5, 27). Self-reports tend to underestimate weight status, especially among overweight individuals (28-30). This may actually cause overestimations in PPWR and contribute to a decreased success rate when assessing whether women return to pre-pregnancy weight.

The rationale for reducing PPWR is usually directed at the health benefits of maintaining a healthy weight and reducing the odds of beginning subsequent pregnancies at an increased BMI; however attention should also be given to the effects of GWG on postpartum body composition, specifically %body fat. Butte et al. (2005) used Dual-Energy X-ray Absorptiometry (DXA) to measure body composition in women (N=63) 2, 6, and 27 weeks postpartum. The results showed GWG correlated with postpartum weight and fat retention (p=.001)(31). Body fat changes in the postpartum period are more pronounced for obese women compared to other BMI groups. Lederman et al. (1997) compared gains in fat mass among a population of New York City pregnant women (14-37 weeks gestation). Obese women (classified as BMI >29) who gained within the IOM

(1990) guidelines lost -0.6kg of fat while those that gained above gained 3.1 kg of fat (32).

Infant feeding mode: breastfeeding vs. formula-feeding

Energy Demands of Lactation

Resting metabolic rate (RMR) is expected to be higher in lactating women to account for the amount of milk produced, energy content of milk, and the energetic efficiency of milk synthesis. Room respiration calorimetry measures conducted by Butte et al. (2005) estimated the minimum energy requirement of exclusive breastfeeding to be 1.4 times basal metabolic rate plus an additional 2000 kJ/day to support milk production (33).

Although there is evidence to show statistically significant higher RMRs among lactating and non-lactating women across studies, the differences are not expected to be the sole contributor to weight change. Other factors associated with lactation, such as increased appetite, lack of education about general healthy diet, lack of knowledge about nutrient needs during lactation can contribute to overconsumption of calories inhibiting weight loss.

Duration and Exclusivity of Breastfeeding

Exclusive breastfeeding is defined by the World Health Organization as no other food or liquid supplementing an infant's diet other than breast milk (34). Exclusive breastfeeding is recommended for the first 6 months of life, after which point, breast milk can be supplemented with other complementary food sources (31). Women who breastfed for longer and with increased intensity (5-6 mo. of

predominantly breastfeeding) lose weight more rapidly between 3-6 months and have less PPWR at 12 months compared to predominantly formula-feeding mothers (35, 36). Martin el al. (2014) also reported breastfeeding duration to be inversely associated with PPWR and that every additional week of breastfeeding, in any form, between 0-12 mo. postpartum was associated with a 0.04 kg decrease in PPWR (37). An inverse relationship was also found in a long term study, which correlated each 10 week increase in breastfeeding duration during the 6 month postpartum period to a 0.1kg lower weight at 7 years (26).

Obese women (BMI >30) have a combination of hormonal and metabolic characteristics, which influence the capacity of mammary gland development and reduce expected breastfeeding success rate (38). Obese mothers have more difficulty initiating and successfully breastfeeding, and therefore do not benefit from the protective effects of breastfeeding on PPWR. Breastfeeding in normal weight women protected from retaining more than 5kg (OR 0.68) at 7 years postpartum (26). No protective effects were seen in obese women who were classified as BMI greater than 35.0 (26). These results are linked to evidence associating maternal obesity to poor lactation performance (38).

A study conducted by Ota et al. (2008) found non-significant weight differences between women with eight or more lactation events per day compared to women with fewer than eight lactation events per day in the first month postpartum. Weight was objectively measured in the third trimester and then at one month postpartum, which would eliminate any self-report error. As

GWG did not differ significantly between the groups, no associations were found between infant feeding mode and weight in new mothers (39). At the later end of the early postpartum period, Laskey et al. (1998) studied exclusive breastfeeding mothers (no introduction of non-breast milk nutrition) and formula-feeding mothers, and found no weight loss differences between the groups (40). Weight was objectively measured at 17 days after discharge from hospital and again at 3 months postpartum, but no data were analyzed to assess BMI classification differences between groups or differences in GWG.

Participant reporting bias can distort the effects of breastfeeding and the methodologies to obtain diet and physical activity assessments are usually an increased study burden for participants. Convenience sampling, which typically includes only White non-Hispanic mothers from a narrow socioeconomic range also limit the generalizability of any significant findings (41).

Infant feeding mode: effects on PPWR

Neville et al. (2014) conducted a review of literature and found of 22 prospective studies examining weight change in the early postpartum months (1-3 mo.), 73% of studies found no significant association between breastfeeding and weight change (2). However, there was a direct relationship between breastfeeding and weight change in studies when either pre-pregnancy weight or PPWR were objectively obtained rather than utilizing self report data (2).

In a review conducted by He et al. (2015) analyzing studies specifically assessing differences in weight change between formula-feeding and

breastfeeding mothers, there was enough consistent evidence to support the claim that breastfeeding lead to decreased PPWR (3). Specifically during the 3-6 month postpartum period, Krause et al. (2010) found breastfeeding mothers to have 1.38 kg lower PPWR compared to formula-feeding mothers (42). Dujmovic et al. (2014) assessed daily energy intake along with feeding mode, within the same time, and found lactating women retained significantly less weight ($p = 0.01$) (102% of pre-pregnancy weight) compared to non-lactating women (105% of pre-pregnancy weight) despite both groups self-reporting a consumption of 25% more kcals than recommended by DRIs for body weight and height. This timeframe is of increased importance as infant feeding mode is determined, and the trajectory of weight change begins. There was variation among studies in adjusting for important confounding variables such as pre-pregnancy weight, breastfeeding duration, and GWG. Breastfeeding definition was also variable among the studies, but all studies included in the review examined differences between a breastfeeding group and a non-breastfeeding group.

Infant feeding mode: effects on %body fat

Neville et al. (2014) compiled 18 postpartum analyses (out of 45), which provided adequate weight and body composition measurement data (2). The pooled analysis of these studies showed only weak associations between breastfeeding and reductions in adiposity.

Bradshaw et al. (1988) and Sidebottom et al. (2001) conducted studies, which found a positive effect of breastfeeding on % BF (43, 44). Bradshaw et al.

(1988) measured %body fat using skinfold measurements between a lactating group and a formula-feeding group with similar levels of reported physical activity. The lactating group exhibited decreases in adipose tissue, while the bottle feeding group had a slight increase in adipose tissue during the first 4 weeks postpartum (43). Opposing patterns of body composition change also occurred between the groups. After 16 weeks postpartum, bottle feeding mothers showed significant gains in body fat while fat declined in lactating mothers(43).

Changes due to infant feeding mode can be seen as early as 6 weeks. Sidebottom et al. (2001) observed lower skinfold thickness measurements, at three different sites, amongst women who exclusively breastfed their infants compared to mothers that were non-exclusive feeders (44). These changes occurred despite both groups having similar overall weight loss (44). Although a significant influence of breastfeeding on %body fat was observed in both studies, the findings are limited by small sample sizes and lack of subject diversity (White women only). Therefore, findings lack a considerable amount of external validity.

Compared to the previously mentioned studies, Mullaney et al. (2015) had a large sample size (N = 470) and had the ability to control for several confounding variables including: maternal obesity, breastfeeding duration, physical activity level, dietary quality, and infant birth weight (45). Comparing diet quality scores (survey based) along side bioelectrical impedance analysis taken at 4 months postpartum, exclusively breastfeeding mothers were more likely to increase in adiposity regardless of having better diet quality scores (45).

Overall, the data support body composition changes occurring differently depending on lactation status, but with a limited number of studies examining weight loss and body composition in tandem a strong association cannot be drawn. There is adequate evidence to support the need for more research examining the direct effects of infant feeding mode on %body fat, specifically during the intermediate postpartum time period (3 months – 1 year), as well as a need to extend the duration of studies to observe possible long-term effects.

CONCLUSION

Overall, there is inconsistent evidence that infant feeding mode affects changes in PPWR and %body fat for mothers. There are several key factors influencing PPWR, including: energy demands of lactation, duration and exclusivity of breastfeeding, gestational weight gain, and demographic characteristics. Breastfeeding mothers have a slight advantage compared to formula-feeding mothers in reducing PPWR due to the extra energy expenditure exerted via lactation metabolism.

More research specifically assessing both PPWR and %body fat together should be conducted to examine the strength of the association in diverse populations and at different postpartum time periods. Although there are known differences in maternal weight status based on feeding mode, closer examination into the directionality of the weight changes, specifically among formula-feeding mothers, is warranted to expand current knowledge. In addition identifying more conclusive differences in maternal body fat percent based on infant feeding mode

can direct intervention efforts and lead to reducing obesity related health disparities.

This study aims to compare changes in PPWC and %body fat among breastfeeding mothers and formula-feeding mothers from 2 to 16 weeks postpartum.

Specific Aim #1—Describe differences in maternal PPWC based on infant feeding mode. Our hypothesis is that formula-feeding mothers will have greater weight retention than breastfeeding mothers from 2 to 16 weeks postpartum.

Specific Aim #2—Identify differences in maternal %body fat based on infant feeding mode. Our hypothesis is that formula-feeding mothers will show less reduction in body fat percentage than breastfeeding mothers between 2 to 16 weeks postpartum.

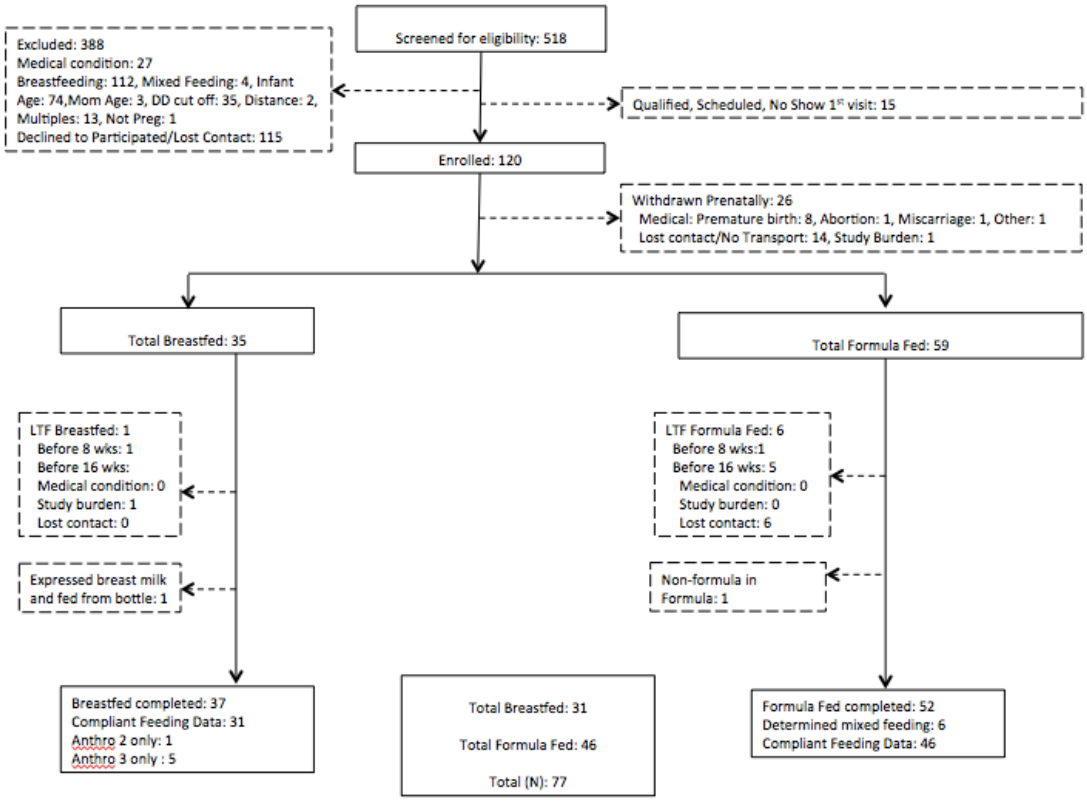
CHAPTER 3

METHODS AND APPROACH

STUDY DESIGN

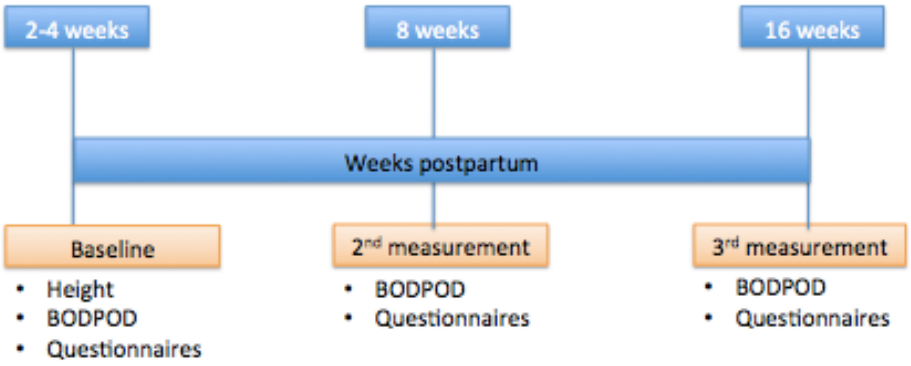
The research was conducted in the Child Nutrition Laboratory in the River's Crossing Building on the University of Georgia's Athens campus. The study is a prospective cohort study in which the effects of infant feeding mode on maternal weight retention and percent body fat were measured using air displacement plethysmography (BOD POD). Recruitment occurred after 12 weeks gestation or ≤ 28 days postpartum and data collection occurred during regularly scheduled postpartum visits. See consort diagram below:

Figure 1. Consort diagram



The visits for assessments were scheduled for, 2-4 weeks postpartum, 8 weeks postpartum, and 16 weeks postpartum. Participants self-reported pre-pregnancy weight, which, in combination with measured height from lab visits, was used to calculate pre-pregnancy body mass index (BMI). BMI was assessed to determine GWG according to the 2009 IOM guidelines (1). In addition, the researchers engaged in telephone and email contact with the participants for the duration of the study. See figure below for timeline of data collection.

Figure 2. Study Design



IRB APPROVAL

The University of Georgia Institutional Review Boards on Human Subjects approved all methods and procedures prior to subject recruitment and project implementation. Protocol ID#2013102510

PARTICIPANTS

Participants included healthy postpartum women ages 18-45 y and their healthy infants. Inclusion criteria included: (a) willingness to participate in the study with newborn, (b) not planning to move from the study area before 6

months postpartum and (c) newborn is born full-term (≥ 37 weeks gestation and normal birth weight [≥ 2.5kg]). Exclusion criteria included (a) medications known to influence weight and body composition (e.g., corticosteroids), (b) conditions known to affect pregnancy outcome (e.g., gestational diabetes, hypertension), and (c) multiple fetus pregnancy.

Recruitment took place in Athens and surrounding areas via mailed postcards, WIC referral, bus ads, and local pregnancy clinic referrals. Monetary ($65 for the 2 week and 8 week postpartum measurements and $80 for the 16 week postpartum measurement) incentives were provided. We recruited mothers who either intended to predominantly breastfed or to predominantly formula feed for the 16 week study period to minimize “mixed” feeders

Mother-infant dyads were classified as either breastfeeding or formula-feeding based on questionnaire data at 2, 8, and 16 weeks postpartum. Breastfeeding was defined as predominantly breastfeeding if at least 80% of feedings were breast milk during the study period (5). Formula feeding was defined as at least 80% of feedings occurring via bottle containing infant formula for the duration of the study. Mixed feeding mothers, those who added solid foods or non-formula supplements to the bottle were not included in the final analysis. Infant 24-hour feeding logs were kept at 2, 4, 6, 8 and 12 weeks after delivery to determine the proportion of breastfeeding or formula-feedings. Mixed feeding mothers were excluded from the analysis if they did not meet either the at least 80% breastfeeding or 80% formula-feeding parameters.

Participants' racial group was self-identified. Black mothers and mothers self-identifying as biracial Black and White classified as Black for purposes of analysis. Mothers' classification were entered into the BOD POD using the Ortiz equation for their body composition assessment (46). All other mothers body composition assessment in the BOD POD were done using the Siri equation (47). This method was selected to control for body composition differences among different racial groups.

MATERNAL BODY COMPOSITION AND ANTHROPOMETRICS

Height was taken one time during the first appointment, and weight was measured during each visit for body composition measurement. On each testing day, participants arrived at the research laboratory with their infants. Participants had been previously instructed to not eat or drink anything for at least 2 hours before the scheduled time.

Height measurements were obtained using the Seca 264 digital stadiometer. Each participant was measured twice and an average of the two measurements was taken to the nearest hundredth of a centimeter.

Body composition and weight were measured using the non-invasive BOD POD body composition system (COSMED USA Inc., Concord, CA) during scheduled visits at 2-4, 8, and 16 weeks postpartum. Weight was measured using the pre-calibrated BODPOD system scale. During the body composition measurement, subjects were required to wear tight fitting clothing and a swim-cap. Participants were also required to sit and remain as still as possible inside

the testing chamber of the BOD POD during the body composition measurement. Trained research assistants conducted all measurements.

Several different approaches are available for measuring body composition, including DXA and air displacement plethysmosgraphy and both have been used in studies investigating racial differences in body composition. DXA (duel energy X-ray absorptiometry) is a 3-compartment body composition measurement procedure that utilizes a small-dose x-ray beam to measure bone mineral density. Lean soft tissue absorption is subtracted out from results. ADP is a body composition technique that uses air displacement plethysmosgraphy (ADP) to measure body density. ADP utilizes a two compartment model in which includes only fat mass and fat-free mass. (48). Algorithms accounting for the bone density differences among different races are applied to increase the accuracy of measurements. Siri (1956) and Brozek et al. (1963) are appropriate body density formula equations used for White and Black women, respectively (47) (49).

BODY MASS INDEX (BMI)

Pre-pregnancy BMI was calculated using measured height and self-reported pre-pregnancy weight. Weight gain during pregnancy was classified as appropriate or excessive based on 2009 IOM GWG guidelines (1). Weight class was determined using BMI measurements and women were categorized as either normal weight (BMI 18.5 -24.9), overweight (25.0- 29.9), or obese (BMI > 30.0).

Postpartum weight change (PPWC) was calculated using the 2-week body mass as a baseline (27) measurement. The 2-week measurement was selected over the self-reported pre-pregnancy weight to reduce self-report error and ensure each participant was measured using the same techniques and measurement devices. PPWC at the 8 week measurement was calculated as the difference between the 8 week body mass and 2 week body mass. The final PPWC measurement was calculated as the difference between the 16 week body mass and the 2 week body mass, and provides a measure of weight change in the early postpartum period. Positive numbers indicated an increase in weight from 2 to 8 or 16 weeks postpartum while negative numbers indicated a reduction in weight during that time. Change in percent body fat (%body fat) was calculated as the difference between the 2 week %body fat measurement and the 8 week %body fat measurement. Final change in %body fat was calculated as the difference between the 16 week %body fat and the 2 week %body fat. Positive numbers indicated a gain in %body fat and negative numbers indicated a reduction of %body fat for the duration of the study.

DATA COLLECTION

Questionnaires were administered during each visit. The questionnaires were used to collect information on socio-demographics, health, and type and mode of infant feeding practices, as well as sleeping habits and soothing practices, at each study time point. See Appendix B for questionnaires, which included:

- University of Georgia Department of Foods and Nutrition 2, 8, 16 week Postpartum Survey
    - Health history, alcohol use, infant feeding practices, self-reported pre-pregnancy weight, physical activity
- 24 hour infant feeding logs
    - 2 weeks, 4 weeks, 6 weeks, 8 weeks, 10 weeks, 12 weeks
    - Data used to determine infant feeding group assignment.

STATISTICAL ANALYSIS

Demographic characteristics (age, sex, race, etc.) of participants were t tests compared between groups using descriptive statistics. χ^2 analysis (categorical variables) were used to determine differences in demographic, race, marital status, and participation in government assistance programs between the infant feeding modes at 2 weeks, 8 weeks, and 16 weeks postpartum (SPSS version 15.0, SPSS Inc., Chicago IL, USA). The level of statistical significance is defined as $P < 0.05$. A repeated measure mixed ANOVA was used to determine the effects of feeding mode on weight and body fat percentage (SAS version 9.4, SAS Institute Inc., Cary, NC, USA). A repeated measure ANCOVA was used to analyze the effects of confounding variables (self-reported pre-pregnancy weight and race). Repeated measures ANCOVA results indicated by a significant interaction for self-reported pregnancy weight and feeding mode, but not race; therefore, race was not included in the final analysis as a confounding variable.

CHAPTER 4

RESULTS

BASELINE DEMOGRAPHICS

Among the 77 women included in the study, 40% of mothers predominantly breastfed their infants. Compared to predominantly breastfeeding mothers, predominantly formula-feeding mothers were more likely to be Black, younger, have less education, and be single (Table 1). Formula-feeding mothers were more likely to participate in WIC (45.5%) and SNAP (40.3%) federal assistance programs.

Table 1. Baseline characteristics of participants

	Breastfeeding (n=31)	Formula Feeding (n=46)
Age (y) Mean (SE)	33.71 (0.74)	26.65 (0.64)
Race (%)		
Black	6.5	69.6
White	93.6	30.4
Pre-pregnancy BMI[a] Mean (SE)	25.05 (0.91)	28.53 (0.89)
BMI ≤18.6-24.99	58.1	30.4
BMI 25-29.99	25.8	45.8
BMI >30	16.1	43.5
Highest Level of Education (%)		
<12 years of education	0	13.0
High School Diploma	0	26.1
>12 years of education	74.2	56.5
no response	25.8	4.4
Marital Status (%)		
married	67.7	21.7
not married, but living w/ partner	3.2	15.2
single	3.2	54.4
other	0.0	4.4
no response	25.8	4.4
SNAP participation (%)	1.3	40.3
WIC participation (%)	7.8	45.5
GWG above IOM recommendations (%)	41.3	71.1

SE, standard error

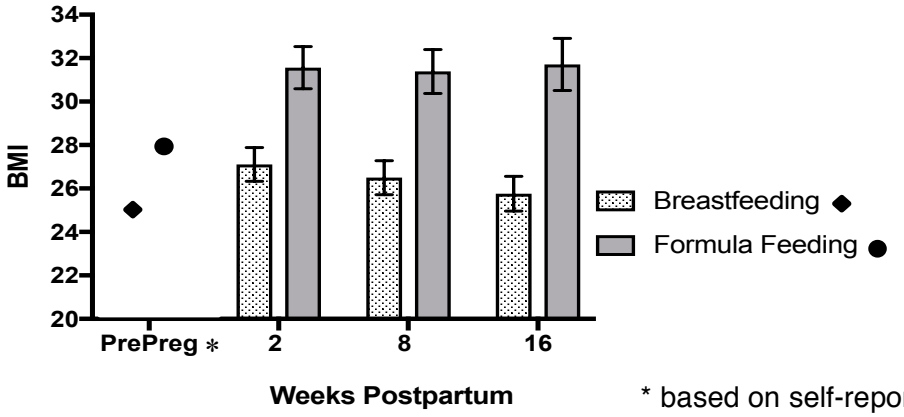
[a] based on self-reported pre-pregnancy weight

COMPARISON OF WEIGHT STATUS BETWEEN BREASTFEEDING AND FORMULA-FEEDING MOTHERS

BMI and Obesity Prevalence Differences Based on Infant Feeding Mode

There was a significant difference in self-reported pre-pregnancy weight between groups (p = 0.03). Formula-feeding mothers weighed more compared to breastfeeding mothers (76.50 kg ± 2.45 vs. 68.46 kg ± 2.69) and had a higher pre-pregnancy BMI (28.53 ± 5.96 vs. 25.05 ± 5.07). From 2 to 16 weeks postpartum formula-feeding mothers had an increase in mean BMI (31.7) compared to their pre-pregnancy status (28.5) (Fig. 3.). In contrast, among breastfeeding mothers, mean 16 week BMI (25.8) had increased less compared to their pre-pregnancy BMI (25.0).

Figure 3. **Formula-feeding mothers entered the study with a higher mean BMI compared to breastfeeding mothers and still had significantly higher mean BMI by 16 weeks**

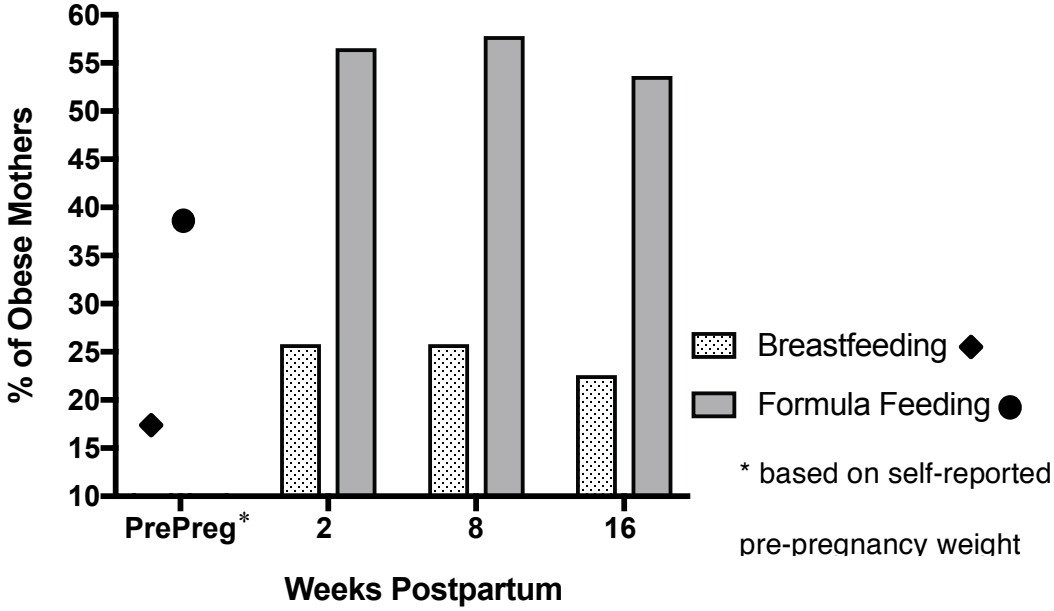


* based on self-reported pre-pregnancy weight

The majority of the breastfeeding group was normal weight (51.6%) pre-pregnancy, while 44.4 % of the formula-feeding group was obese (BMI > 30) pre-

pregnancy using self-reported weight to calculate BMI (Fig. 4.). Formula-feeding mothers began the study with higher obesity prevalence and maintained obesity prevalence by 16 weeks postpartum.

Figure 4. **Formula-feeding mothers had higher pre-pregnancy obesity prevalence compared to breastfeeding mothers and increased in obesity prevalence by**

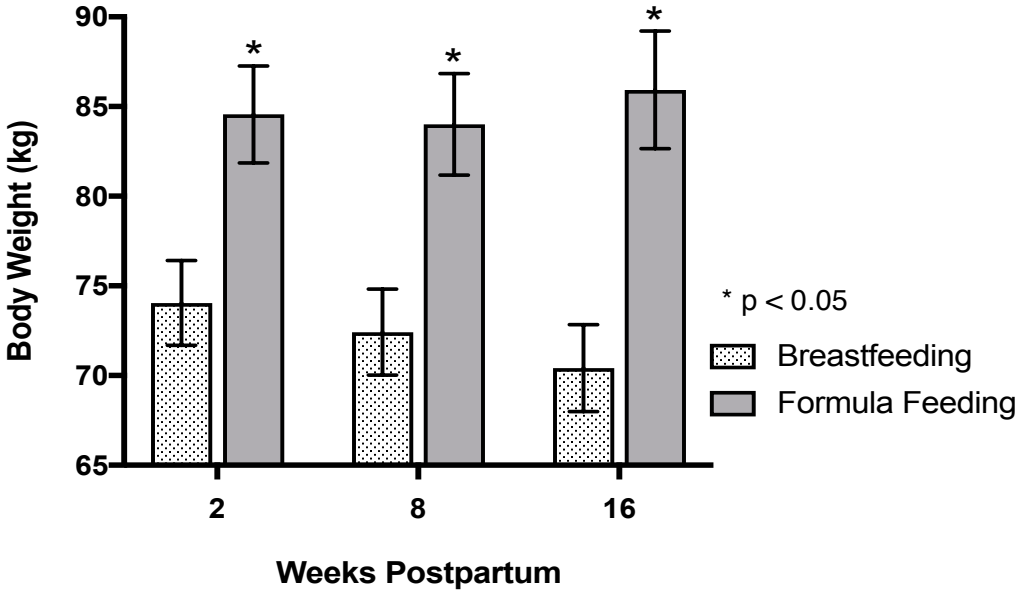


Body Mass Differences Based on Infant Feeding Mode

Results of the repeated Measure ANCOVA including, feeding mode and time as variables and self-reported pre-pregnancy weight as a covariate revealed an interaction of feeding mode by time, with breastfeeding mothers consistently having lower weights from 2- to 16 weeks. As shown in Fig. 5, feeding groups differ in weight at all time points. From 2-8 weeks postpartum, formula-feeding mothers initially lost weight, but gained weight from 8-16 weeks, for a net change of +0.26 kg from 2-16 weeks. Breastfeeding mothers lost weight from 2-8 weeks

and continued to lose weight from 8-16 weeks, for a total mean weight loss of -3.63kg. Chi square tests for independence also revealed that while 87% of breastfeeding mothers lost weight between 2 and 16 weeks, only 54% of formula-feeding mothers lost weight during that period. Neither breastfeeding nor formula-feeding mother showed significant differences in weight between the 3 measurement points.

Figure 5. **Among Formula-feeding mothers, weight did not change from 2 to 16 weeks postpartum while breastfeeding mothers weighed significantly less at each time**

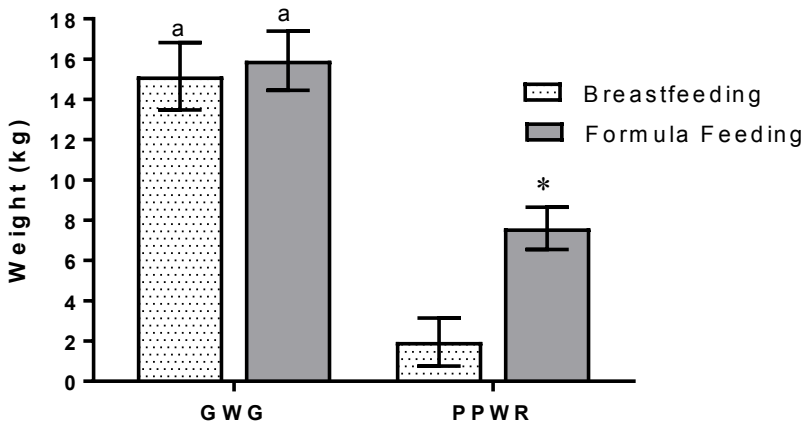


SPECIFIC AIM #1: DIFFERENCES IN WEIGHT RETENTION BASED ON INFANT FEEDING MODE

Univariate ANOVA with self-reported pre-pregnancy weight as a covariate reveal gestational weight gain was similar between the two groups (p=0.81). Gestational weight gain was calculated using self-reported pre-pregnancy weight

and self-reported weight at delivery. When using weight retention calculated via self-reported pre-pregnancy weights there was a significant difference between the groups ($p < 0.01$), and formula-feeding mothers retained more weight compared to breastfeeding mothers (7.41 kg ± 1.07 vs. 2.21 kg ± 1.22). Formula-feeding mothers (9.42 kg ± 0.91) and breastfeeding mothers (13.39 kg ± 0.78) had a significant mean difference between mean GWG and mean PPWR ($p < 0.001$) when calculated using self-report data.

Figure 6. **Although GWG was similar between groups, formula-feeding mothers retain more weight compared to breastfeeding mothers***

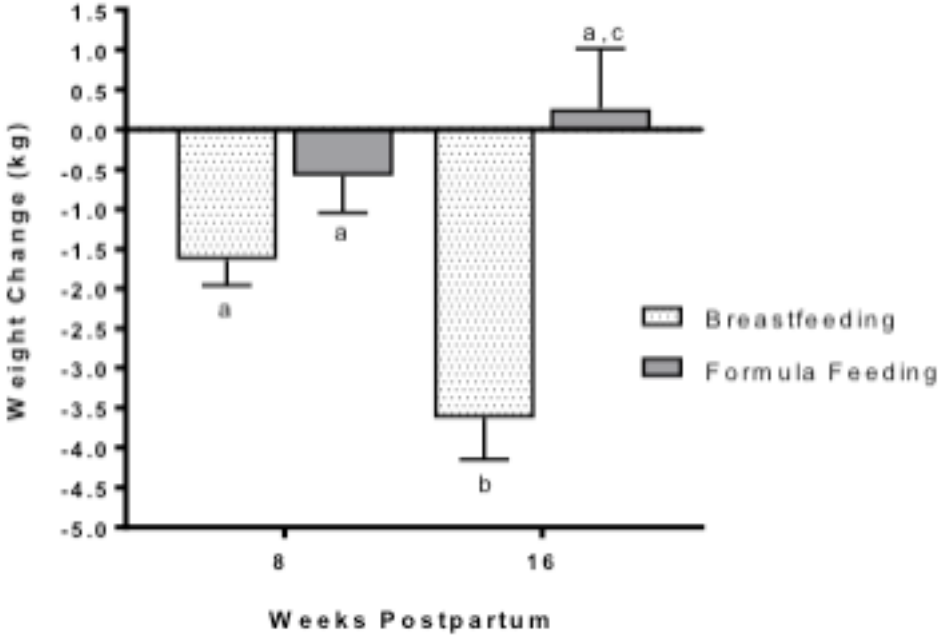


*Weight retention calculated using self-reported pre-pregnancy weight.

To minimize the impact of GWG self-report bias on PPWR this study used 2 week postpartum weight measurements to assess weight change from 2-16 weeks postpartum. Overall mean PPWC was -3.63 kg for breastfeeding mothers and 0.26 kg for formula-feeding mothers at 16 weeks postpartum, indicating that breastfeeding mothers came closer to returning to their pre-pregnancy weight compared to formula-feeding mothers (Fig. 7). Results from post hoc test reveal

both formula-feeding mothers ($p < 0.01$) and breastfeeding mothers ($p < 0.01$) have significant mean PPWC between the 8 week PPWC measurement and the 16 week PPWC measurement. On average formula-feeding mothers had a positive weight retention pattern from 2-8 weeks, but then gained back the weight originally lost and surpassed their mean 2 week weight by 16 weeks postpartum.

Figure 7. Breastfeeding mothers lost weight from 2- to 16 weeks postpartum, while formula-feeding mothers showed no change over this period



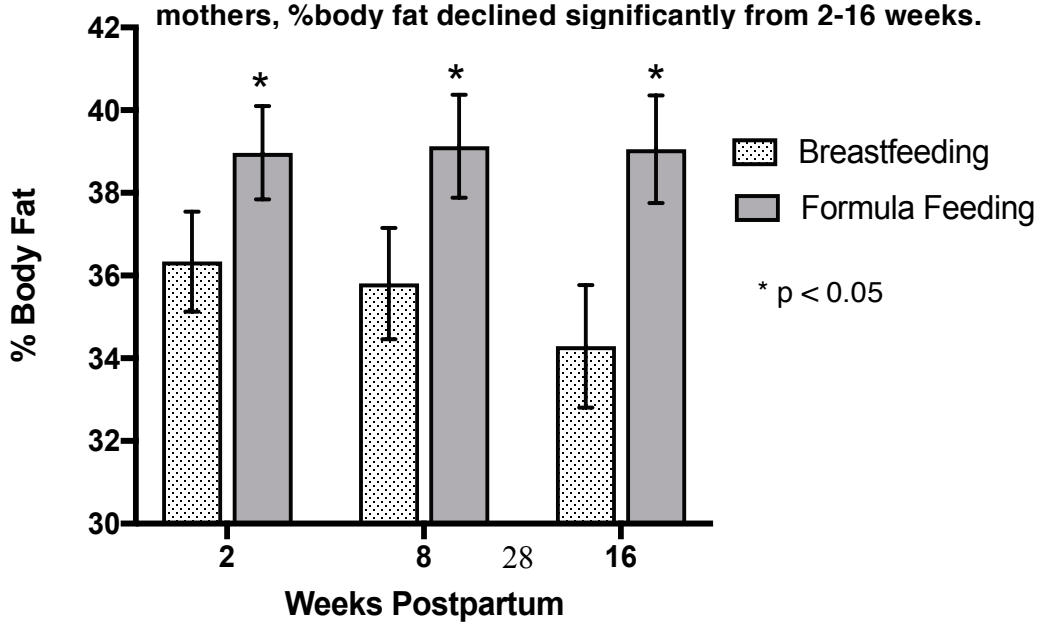
a, a nonsigfificant**.** b, a $p < 0.05$. c, a $p < 0.05$. b, c $p < 0.05$.

Based on χ^2 analysis there was a significant interaction between feeding mode and PPWR <2.3 kg ($p = 0.005$), but not for PPWR <0 kg. A significant proportion of breastfeeding mothers had less than 5 lbs of PPWR compared to formula-feeding mothers at 16 weeks postpartum.

SPECIFIC AIM #2: DESCRIBE DIFFERENCES IN MATERNAL PERCENT BODY FAT BASED ON INFANT FEEDING MODE

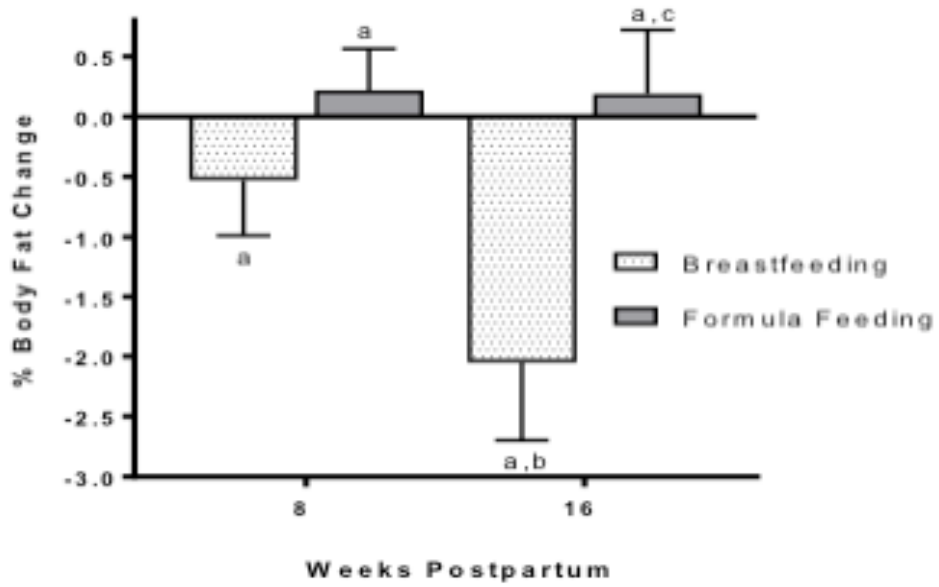
Formula-feeding mothers had significantly higher %body fat ($p = 0.04$) at the 2 week postpartum measurement (39.0% ±1.24 vs. 36.3% ± 1.21). At 8 weeks postpartum there was a significant difference in %body fat between the groups ($p = 0.03$) and breastfeeding mothers had lost %body fat (-0.53%) while formula-feeding mothers had gained (0.16%). From 8-16 weeks postpartum formula-feeding mothers lost 0.07% body fat, but still remained at a higher %body fat compared to their mean 2 week measurement (Fig. 8). Breastfeeding mothers lost 1.52% body fat in the same time and had reduced %body fat in comparison to their mean %body fat at 2 weeks postpartum. Neither breastfeeding nor formula-feeding mother showed significant differences in %body fat between the 3 measurement points.

Figure 8. **Percent body fat was significantly higher for formula-feeding mothers at all time points. For breastfeeding mothers, but not for formula-feeding mothers, %body fat declined significantly from 2-16 weeks.**



The change in %body fat was calculated using the 2 week measurement as a baseline. Change at 8 weeks reflects the difference in %body fat between weeks 2 and 8, while the change at 16 weeks reflects the difference in %body fat from weeks 2 and 16. Percent body fat change results were similar to weight loss, with a larger proportion of breastfeeding mothers (74%) losing %body fat compared to formula-feeding mothers (40%) from 2- 16 weeks postpartum. Breastfeeding mothers' percent body fat declining (-2.05%) during the duration of the study (Fig. 9) while formula-feeding mothers had a slight increase (0.19%). There was a significant difference comparing the %body fat change between the 8 week calculation and the 16 week calculation for formula feeding mothers (p=0.03), but not for breastfeeding mothers.

Figure 9. **Formula-feeding mothers increased %body fat from 2-16 weeks, while breastfeeding mothers decreased %body fat**



Results for Aims 1 and 2 indicate that during the duration of the study, breastfeeding mothers had less PPWC (Fig. 7) and showed decreases in %body fat (Fig. 9) while formula-feeding mothers had opposite results and showed increases in both body weight and %body fat. Infant feeding mode had significant effects on weight retention and %body fat among mothers during the first 16 weeks postpartum.

CHAPTER 5

DISCUSSION

Normal, healthy women will gain weight and body fat during pregnancy with the desired outcome being to return to pre-pregnancy weight by the sixth month postpartum (1). Findings from this longitudinal cohort study, designed to identify differences in PPWC and %body fat based on infant feeding mode, revealed formula-feeding mothers retained more weight compared to breastfeeding mothers. There were also differences in maternal %body fat based on infant feeding mode. Formula-feeding mothers had less change in percent body fat compared to breastfeeding mothers, which indicates formula feeding did not have a positive effect on postpartum %body fat loss. Formula-feeding mothers also increased mean %body fat during the duration of the study.

INFANT FEEDING MODE EFFECT ON POSTPARTUM WEIGHT CHANGE

There were differences in PPWC between the two groups apparent at 8 weeks, with a significant difference emerging by 16 weeks. Two recent reviews of breastfeeding and weight outcomes concluded that there is no significant relationship between infant feeding mode, specifically effect of breastfeeding versus formula-feeding on PPWC (2, 3). Studies comparing PPWR from birth to 3 months postpartum find little or no influence of feeding mode (11, 42, 50, 51). However, studies with extended duration did find an association between

breastfeeding and PPWR past 6 months postpartum (52-54). There is high variation among these studies in adjusting for confounding variables and measuring weight outcomes, which mediate the effect size of results.

Differences in how PPWR is measured and defined contribute to inconsistency among findings, and in our study the use of self-reported pre-pregnancy weight was omitted and replaced with the 2 week postpartum measurement as baseline for both PPWC and %body fat change. The proportion of obese mothers may be affected by self-report bias. There is an increased likelihood the proportion of overweight and obese mothers is underreported as there can be error due to self-reported weight (28, 29, 55). The parameters defining feeding modes are also variable. In our study we have a very conservative definition of predominately breastfeeding qualifying as >80% of feedings from breast milk at the breast based on data gathered from infant feeding logs. Mixed feeders were not included in this analysis.

Short-term studies, which do not include measures of weight status beyond about 3 months postpartum, may not be of sufficient duration to detect a significant weight difference (3). Observed effects of infant feeding mode on weight in this study did not really become apparent until16 weeks postpartum. In contrast to this study, Dewey et al. (1993) assessed women over the first year postpartum in a study of women who breastfed for a long duration, and with high intensity (5-6 mo. of predominantly breastfeeding) (36). Findings indicated that predominantly breastfeeding mothers lost weight more rapidly between 3-6

months and had less PPWR at 12 months than predominantly formula-feeding mothers (36).

There are notable metabolic effects attributable to the initiation and duration of breastfeeding (56). Room respiration calorimetry measures conducted by Butte et al. (2003) estimated the energy cost of lactation when exclusively breastfeeding is estimated at 2.49 MJ/day and 2.24 MJ/day when partially breastfeeding (31). Raajii et al. (1991) estimated energy requirements of lactation to be approximately 650 kilocalories per day utilized for breast milk production suggesting breastfeeding mothers have a higher baseline energy expenditure compared to formula-feeding mothers (8). The increased energy required by lactation may not be enough to facilitate weight loss in overweight women without the addition of other energy expending factors such as exercise. A study conducted by Lovelady (2011) determined that overweight women needed energy restriction of 2029 kJ/d and aerobic exercise 4 days per week, in addition to the energy deficit of lactation, to promote weight loss of 0.5kg/wk (57).

Compounding differences between infant feeding modes are differences in the resting metabolic rates (RMR) among different racial groups, and in particular Black women may be at a disadvantage when compared to others with respect to postpartum weight loss. In previous studies, Shook et al. (2014) measured the RMR and body composition of Black women (n= 38) compared to White women (n= 141). Based on their results, Black women had higher BMI, as well as lower RMR when compared to their White counterparts (58). These data indicate that

Black women may have lower RMR than other races, and compounded with lack of energy expenditure from breastfeeding may hinder or prevent postpartum weight loss, which is relevant to the present study, given that the majority of formulas feeding mothers in this study were Black.

INFANT FEEDING MODE AND PERCENT BODY FAT

Formula feeding was positively associated with higher levels of body fat both pre-pregnancy and up to 16 weeks postpartum. %Body fat change was only significant at the 16 week measurement for breastfeeding mothers, who had lost on average -2.05% body fat from their 2 week measurement and formula-feeding mothers had gained and average of 0.19% body fat. Lactogenesis mobilizes fat stores for the production of milk giving breastfeeding mothers an advantage in reducing adipose gained during pregnancy. Changes due to infant feeding mode can be seen as early as 6 weeks. Sidebottom et al. (2001) observed lower skinfold thickness measurements, at three different sites, amongst women who exclusively breastfed their infants compared to mothers that were non-exclusive feeders (44). These changes occurred despite both groups having similar overall weight loss (44). The findings summarized in the Sidebottom et al. study are similar to the results in our study in which there were not significant differences within groups at the different measurements (2 weeks vs. 8 weeks vs. 16weeks), but there was a significant difference in total %body fat change between formula feeding mothers and breastfeeding mothers by 16 weeks.

The results of the present study differed from previous research conducted by Wosje and Kalkwarf (2004), in which a larger sample size (N =196) of lactating and non-lactating mothers was assessed using DXA. They found that lactating women experienced less change in %body fat compared to the non-lactating group (7). Wosje and Kalkwarf noted a -0.7% loss in whole body percent fat in nonlactating women, while our study showed a gain of 0.19% during a comparable duration of time postpartum. The percent body fat lost was greater in our study for the breastfeeding group (-2.05% vs. -0.2%), however; more detailed body composition measurements can be assessed when using a 4 a 2-compartment body composition model compared to a 4-compartment model.

There is some evidence to suggest that the decline in breastfeeding mothers' body fat percentage may be based on appetite-regulating and lipolysis-regulating hormone concentrations. Based on a cross-sectional analysis of lactating vs. nonlactating women of similar age and BMI (3-6 months postpartum), lactating women had increased levels of the anorexigenic hormone peptide YY (PYY), which may contribute to increased mobilization of fat and decreased body fat stores (59). This may explain the decreases in %body fat seen in the breastfeeding mothers in our study compared to the increased %body fat seen amongst formula-feeding mothers with presumably lower concentrations of PYY.

DEMOGRAPHIC DIFFERENCES AND EFFECTS ON POSTPARTUM WEIGHT RETENTION

The demographic characteristics of the participants also reveal that Black mothers were more likely to formula feed their infants compared to White mothers. In Georgia, women have an obesity prevalence of 30.6% and Black adults have the highest obesity rate (37.8%) among racial groups, which is substantially higher than the national average of 30.7% (60). Among our sample of mostly low income, Black formula-feeding mothers 44.4% reported a pre-pregnancy BMI above 30.0 (Table 1.).

Obeng et al. (2015) suggests several barriers to breastfeeding among mothers in the Black community including: lack of familial support, negative perceptions surrounding infants feeding from the breasts, lack of resources, and an unsupportive work environment (20). Black mothers reported difficulty initiating breastfeeding due to a lack of maternal role models and the belief that feeding the infant from the breast was considered an act of incest in some Black churches (20). Also, as evident in the study population of the present study (Table 1.), formula-feeding mothers were more likely to participate in government assistance programs such as WIC and SNAP. 40.3% of formula-feeding mothers participated in SNAP, which has also been linked to a higher prevalence of obesity among participants (61). Despite the increase in support packages and assistance for breastfeeding mothers participating in WIC, there is still a need for additional education about postpartum weight loss for formula-feeding mothers.

IMPLICATIONS

Breastfeeding disparities have both negative economic and health implications for the mother, in addition to the excess PPWR and %body fat as evidenced by this study. Suboptimal breastfeeding rates have been associated with more cases and deaths from breast cancer, type 2 diabetes, hypertension, and myocardial infarction (62). Formula feeding had a direct association with negative PPWC outcomes. Formula-feeding mothers were also initially heavier and more likely to be Black, both factors that contribute to the increased annual excess cost of maternal disease. Based on 2014 US dollar amounts the cost annual cost of disease was $357.54 among Black mothers compared to White mothers (62).

While current breastfeeding promotion efforts are focused on breastfeeding initiation, this study provides evidence that initiation is not enough to see an impact on postpartum weight. Based on the demographic characteristics of this sample, women most likely to benefit from postpartum effects of breastfeeding on weight loss are less likely to choose breastfeeding as their mode of infant feeding. Formula-feeding mothers in our study also had a lower socioeconomic status, putting them at higher risk for obesity and poor diet (63). For this specific population of mothers, efforts to reduce obesity prevalence should focus on promoting breastfeeding for at least 16 weeks postpartum.

CHAPTER 6

LIMITATIONS

Randomized designs are not feasible for a clinical nutrition study assessing infant feeding modes for ethical restraints. Participants in this study were able to self-select the infant feeding practice they desired. This could lead to selection bias. Unequal racial dispersion between study groups allows for plausibility of a race effect on weight outcomes independent from feeding mode and in this study, the majority of formula-feeding mothers were Black, while the majority of breastfeeding mothers were White. The small sample size of the study could have contributed to lack of statistically significant findings of PPWC and %body fat within groups. As this study was conducted in a single site, located in Athens, Georgia region, findings may not be generalizable to other geographical areas of the USA (64). Pre-pregnancy weight was self-reported on the baseline questionnaire, which may have lead to increased error in the calculated GWG. Self-reported weight has been documented to be systematically underreported (28). Finally, measures of dietary intake were not assessed. Diet quality and differences in energy intake may be a potential confounding factor.

CHAPTER 7

CONCLUSION

Current data provides no definitive evidence to support a strong association between breastfeeding and weight outcomes in the short-term postpartum period when compared to formula-feeding. Findings from many studies indicated that formula-feeding mothers did not lose as much weight as breastfeeding mothers. Results from this study indicate that during 2-16 weeks postpartum predominantly breastfeeding mothers had less PPWC and decreased in %body fat. In contrast, formula-feeding mothers had opposite results, and as a whole were further away from their self-reported pre-pregnancy weight and had higher %body fat compared to breastfeeders.

Formula-feeding mothers should be encouraged to seek weight management counseling in the early months postpartum to deter further weight gain and reduce the risk of developing chronic metabolic diseases associated with high %body fat. Predominantly breastfeeding for 16 weeks was shown to have protective effects against PPWC and %body fat.

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APPENDIX A

Approved by University of Georgia
Institutional Review Board
Protocol # MOD00001638
Approved on: 6/12/2015
For use through: 11/16/2015

UNIVERSITY OF GEORGIA
CONSENT FORM
Role of Infant Feeding, Childhood Food Habits and Early Childhood Adiposity

Researcher's Statement
We are asking you to take part in a research study titled "Role of Infant Feeding, Childhood Food Habits and Early Childhood Adiposity." Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. This form is designed to give you the information about the study so you can decide whether to be in the study or not. Participation in the study is voluntary. Your decision to participate, or not will not affect the services or care you receive anywhere. Please take the time to read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information. When all your questions have been answered, you can decide if you want to be in the study or not. This process is called "informed consent." A copy of this form will be given to you.

Principal Investigator: Dr. Alex Anderson
Department of Foods and Nutrition
Telephone: 706-542-7614
Email: fianko@uga.edu

Co-Investigator: Dr. Leann Birch
Department of Foods and Nutrition
Telephone: 706-542-2899
Email: llb15@uga.edu

Purpose of the Study
The aim is to assess how type, mode and amount of early infant feeding (breastfeeding, bottle feeding either breast milk, or formula) affect the infant's growth and body fat. Your participation in this study will help provide important new information that will not only inform scientists and policy makers but will also guide providers who care for new mothers and infants.

Eligibility
You are qualified to volunteer for this study if you are: (a) 18-45 years old, (b) the biological mother of a newborn not more than 2 weeks old and who was born full-term (≥ 37 weeks gestation and normal birth weight [≥ 2.5 kg], (c) willing to participate in the study with your newborn, and (d) not planning to move from the study area before your newborn turns 6 months old. You don't qualify to participate in this study if: (a) you take any steroid containing medication known to influence weight and body composition such as corticosteroids, (b) your infant is a product of multiple fetus pregnancy, (c) your newborn was born with a congenital malformation, (d) you plan to put your baby up for adoption, or (e) if you fail to complete body composition measurements. Should you decide to withdraw from the study or be terminated by the researchers for any reason, your newborn will also be withdrawn. If your newborn does not take either the free feeding bottle and/or nipples provided by the research team you may both continue to participate in the study for the body composition assessment.

Study Procedures
If you agree to participate, you will be asked to take part in the following study related procedures in 3 visits over 4 months:

Body Composition – Your and your child's body composition will be measured using the BOD POD and PEA POD body composition systems, respectively to occur at 2, 8, and 16 weeks postpartum. The body composition will be measured using non-invasive machines known as the BOD POD and PEA POD. During the body composition testing, you will be required to wear tight fitting clothing and a swim-cap for the measurement. You will also be required to sit and remain as still as possible inside the testing chamber of the BOD POD during the body composition measurement. The entire body composition measurement will last for approximately 5-10 minutes in duration. A trained research assistant under the supervision of Drs. Alex Anderson and Leann Birch will conduct all measurements. Your height (only one time at the 1st trimester testing session) and weight will be measured during each visit for body composition measurement. On each testing day, you will arrive with your newborn at our research laboratory and you should NOT eat or drink anything at least 2 hours before the scheduled time.

Infant Feeding – You will be asked how you are feeding your child.

- If you will breastfeed your child, you will also be asked if you will be breastfeeding your newborn at the breast or with expressed breast milk by a feeding bottle.
- If you will feed expressed breast milk by the bottle at least 80% of the time, you will be randomly assigned to receive free infant feeding bottles of either 5 oz. or 8 oz. size. This means that some participants will be asked to feed their infant using a 5 oz. bottle and others will be asked to feed their infant using an 8 oz. bottle. Your group assignment will be determined by chance, similar to flipping a coin. All bottles are commercially available BPA free plastic bottles (Medela, Inc.) and will be provided by the researchers at no cost to you. On six "feeding diary" days you will be asked to feed your infant using the assigned bottle type/size and record how much breast milk is consumed. This at-home diary will occur at weeks 2, 4, 6, 8, 10 and 12 after delivery. There are no restrictions on the amount or frequency which you choose to feed your child. The only additional time commitment required after the feeding is the time it takes to record the amount of breast milk naturally consumed by your child (approximately 15 minutes per "feeding diary" day with less than 2 minutes per feeding).
- If you will breastfeed your newborn directly at the breast, you will be provided with an infant scale and instructed on how to weigh your baby before and after feeding episodes at the breast at specified times to estimate your child's intake of breast milk. You will be asked to record your newborn's weight and breast milk intake for a total of six "feeding diary" days. These at-home measurements will occur at weeks 2, 4, 6, 8, 10 and 12 after delivery. Based on typical infant intake, we estimate the time commitment will be approximately 60 minutes on each of these recorded days.
- If you will formula feed your newborn, you will be randomly assigned receive free infant feeding bottles of either 5 oz. or 8 oz. size. This means that some participants will be asked to feed their infant using a 5 oz. bottle and others will be asked to feed their infant using an 8 oz. bottle. Your group assignment will be determined by chance, similar to flipping a coin. All bottles are commercially available BPA free plastic bottles (Medela, Inc.) and will be provided by the researchers at no cost to you. On six "feeding diary" days you will be asked to feed your infant using the assigned bottle type/size and record how much formula is consumed. This at-home diary will occur at weeks 2, 4, 6, 8, 10 and 12 after delivery. There are no restrictions on the amount or frequency which you choose to feed your child. The only additional time commitment required after the feeding is the time it takes to record the amount of formula naturally consumed by your child (approximately 15 minutes per "feeding diary" day with less than 2 minutes per feeding).

Infant Food Intake Records and Submission - We will ask you to record feeding information using either a provided handwritten food log, or by using Baby Connect, an application that is available via computer, tablet and smartphone. If you choose to use the Baby Connect application, the researcher will provide you with a gifted subscription to the application. Data recorded using Baby Connect can be submitted to the researcher via email at your convenience. Data recorded using handwritten logs can be submitted to the researcher via US mail. The researcher will provide you with a stamped and addressed envelope for each submission.

Questionnaire for Data Collection – For the purposes of data collection a number of questionnaires will be used during follow-up visits of the study. The questionnaires will be used in a face-to-face interview format to collect information on socio-demographic, health, and type and mode of infant feeding practices, as well as sleeping habits and soothing practices, at the different study time points. The Infant Feeding Practices Survey II will be used to collect information about the brand and type of commercial formula, the extent to which breast milk and other fluids are fed by bottle, and average volume consumed per feeding episode. The questionnaire will also ask about frequency of feeding. Another questionnaire will also ask you to report on the child's health (diarrhea and any type of infection) and any medication use at each of the scheduled postpartum visits. Coinciding with each body composition measurement appointment, you will also be asked to complete three, 24-hour dietary intake records online using the multiple-pass Automated Self-Administered 24-hour Dietary Recall (ASA24) hosted through the National Cancer Institute, for a total of 18 days of dietary recall records over the course of the study. Each body composition and data collection session in the research laboratory will be approximately 30-60 minutes in duration.

Risks and discomforts

Body composition measurements: The discomforts or stresses that may be faced during this research are minor physical discomfort from the body composition measurements. You may experience physical discomfort during the body composition assessments because you will be measured in a confined space and asked to remain still. These measurements will be obtained quickly. You will also have access to an emergency button inside the BOD POD to press should you become claustrophobic or uncomfortable during the body composition measurement to stop the testing at any time

Infant feeding and dietary recall: The discomfort or stress that you may face may be minor psychological discomfort from the questions about your diet, infant feeding practice and health history. This information however, is important so that we may correctly evaluate how these influence your weight gain and body composition changes during pregnancy, and your child's growth, weight and body composition.

- To minimize the discomfort or stress, all body composition measurements and interviews for data collection will take place in private rooms. You have the right to discontinue your participation in the study or not answer any question you don't want to answer at any time. All individually-identifiable information will be kept strictly confidential and your name and other identifying information will be kept under lock and key, and will not be shared with anyone outside of the research team.

Benefits

While there are no direct benefits for participants, this research study will provide data that will inform researchers and clinicians regarding the impact of pregnancy weight gain and body composition changes on pregnancy outcome, as well as type and mode of infant feeding on infant weight, growth and adiposity. The knowledge to be gained from this study will guide future decisions on appropriate weight and fat gain during pregnancy and mode of infant feeding during early childhood.

Incentives for participation

You will receive a monetary incentive of up to $350 for completing all visits for body composition measurements, completing infant weight and feeding logs, and data collection. The monetary incentive is to compensate you for your time participating in the study. If you choose to withdraw from the study at any point, you will receive the monetary incentive commensurate with your participation. The researchers will collect your signature on a receipt/honorarium form at each study visit so that you ca be paid as follows: $25 for each of the six (6) 24-hour weight and infant feeding logs, $60 for each of the laboratory visits at 2 and 8 weeks postpartum as well as $80 at the 16 week visit for body composition measurement and data collection. This information will be stored separately from your data and shared only with members of the research team. You will only receive incentive for the very first visit if you and your newborn are found to be eligible, provide a written consent and complete the day's measurement and body composition testing; You will also receive copies of body composition test results on both you and your child each time you are measured.

Privacy/Confidentiality

Every effort will be taken to protect your identify. To accomplish this, you will be assigned a numeric subject participation code, which will be used on all data collected during your participation in this research. No individually-identifiable information about you, or provided during the research, will be shared with others without your permission, except if necessary to protect your rights or welfare (for example, if you are injured and need emergency care), or if required by law when the researchers observe signs of abuse or neglect of your child. A master list with your name and corresponding numeric code and consent forms will be kept separate from testing data and locked at all times, and accessed only by the core research team. Records linking code numbers to names will be destroyed five years from the end of the study. All other documents, including questionnaires and body composition test results will only have your participant numerical code.

Participation in this research includes weight, height/length and body composition measurements on you and your newborn. Dietary, physical activity, health and infant feeding information will also be gathered. Any information gathered from your participation is for research purposes only and will not be used for diagnostic or therapeutic testing and will not be linked to any individually identifiable information. You will not be identified in any report or publication from this study.

Taking part is voluntary

Your involvement in the study is voluntary, and you may choose not to participate or stop at any time without penalty or loss of benefits to which you are otherwise entitled. If you decide to discontinue/withdraw from the study or if the researchers terminate your participation without regard to your consent as described due to the health of your newborn, all information/data collected from or about both of you up to the point of withdrawal will be kept as part of the study and may continue to be analyzed, unless you make a written request to remove, return, or destroy the information.

If you are injured by this research

The researchers will exercise all reasonable care to protect you from harm as a result of your participation. In the event that any research-related activities result in an injury, the sole responsibility of the researchers will be to arrange for your transportation to an appropriate health care facility. If you think that you have suffered a research-related injury, you should seek immediate medical attention and then contact Drs. Alex Anderson or Leann Birch right away at 706-542-7614 or 706-542-2899. In the event that you suffer a research-related injury, your medical expenses will be your responsibility or that of your third-party payer, although you are not precluded from seeking to collect compensation for injury related to malpractice, fault, or blame on the part of those involved in the research.

Approved by University of Georgia
Institutional Review Board
Protocol # MOD00001638
Approved on: 6/12/2015
For use through: 11/16/2015

Permission to be photographed

Please provide initials below if you consent for photography and subsequent use of your image and that of your newborn for research-related purposes, such as presentations and publications related to this research study. You may still participate in this study even if you are not willing to have your photograph taken.

_____ I am willing to have my photograph taken and used as described above

_____ I do not want to have my photograph taken and or used as described above

You may be contacted for a follow-up study in the future based on your written permission.

[ ] Yes, I agree to allow the researchers of this study to contact me in the future for a follow-up study
[ ] No, I do not want the researchers of this study to contact me in the future for a follow-up study.
I understand that if I am contacted to participate in any future studies a separate consent will be obtained for participation in those studies.

Address: _____

Email: _____

Telephone Number(s): _____

If you have questions

The main researchers conducting this study are Drs. Alex Anderson and Leann Birch, both professors at the University of Georgia. Please ask any questions you have now. If you have questions later, you may contact Drs. Alex Anderson and Leann Birch at fianko@uga.edu or llb15@uga.edu or at 706-542-7614 or 706-542-2899. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at 706.542.3199 or irb@uga.edu.

Research Subject's Consent to Participate in Research:

To voluntarily agree to take part in this study, you must sign on the line below. Your signature below indicates that you have read or had read to you this entire consent form, and have had all of your questions answered.

Name of Researcher	Signature	Date

Name of Participant	Signature	Date

Please sign both copies, keep one and return one to the researcher.

APPENDIX B

DEPARTMENT OF FOODS AND NUTRITON

UNIVERSITY OF GEORGIA

(Baseline Data)

ID #: _____ Date __/__/__

Telephone #: (home) _____ (work) _____

Demographics

1. Date of Birth: ___/___/___ 2. Age: _____

3. Marital Status: [ ]$_1$ Married [ ]$_2$ Single [ ]$_3$ Divorced [ ]$_4$ Other _____

4. Ethnicity: [ ]$_1$ White [ ]$_2$ Black/African American [ ]$_3$ Hispanics

5. How many years of formal schooling have you completed? (Highschool=12 yrs) _____

6. Are you working: [ ]$_1$ Full-Time [ ]$_2$ Part-Time [ ]$_3$ Not working

7. If working, how many hours per week? _____

8. How many weeks after the baby is born do you plan to return to work?

[ ]$_1$ Fewer than 4 weeks [ ]$_2$ 4 to 6 weeks [ ]$_3$ 7 to 9 weeks

[ ]$_4$ 10 to 12 weeks [ ]$_5$ 13 to 16 weeks [ ]$_6$ 17 to 20 weeks [ ]$_7 \geq$ 21 weeks

9. What will you do with your baby while you are working? (Please check all that apply)

[ ]$_1$ My baby will be cared for by a family member [ ]$_2$ My baby will be cared for by someone not in my family

[ ]$_3$ I will keep my baby with me while I work outside my home [ ]$_4$ Baby will be at Childcare

[ ]$_5$ I will keep my baby with me while I work at home [ ]$_6$ I have not decided yet

Infant Feeding

1. How do you plan to feed the baby you are carrying in the first few weeks?

[ ]$_1$ Exclusively breastfeed (breast milk only)

[ ]$_2$ Breast and formula feeding

[ ]$_3$ Only formula feeding (***if not breastfeeding go to health history***)

2. Do you plan to continue breastfeeding after you return to work?

[ ]$_1$ Yes [ ]$_2$ No [ ]$_3$ Do not plan to work after the baby's birth

3. How old do you think your baby will be when you completely stop breastfeeding? ___ Months

4. Using 1 to mean "Not at all Confident" and 5 to mean "Very Confident," how confident are you that you will be able to breastfeed until the baby is the age you marked in Question 4?

Not at all Confident				Very Confident
(1)	(2)	(3)	(4)	(5)
[ ]	[ ]	[ ]	[ ]	[ ]

5. Using 1 to mean "Very Uncomfortable" and 5 to mean "Very Comfortable," how comfortable would you be in the following situations?

	1	2	3	4	5
Nursing your baby in the presence of close women friends & relatives					
Nursing your baby in the presence of men & women who are close friends					
Nursing your baby in the presence of men & women who are not close friends					

6. When is your baby due? (Please write in month and day)

Month: _____ Day: _____ Year: _____

Health History

1. Are you allergic to, sensitive to, or intolerant of any foods or medications? [ ]1 Yes [ ]2 No

If yes, please specify _____

2. Do you have any chronic illnesses? [ ]1 Yes [ ]2 No

If yes, please specify _____

3. Are you currently taking any medication either prescribed by a doctor or purchased over the counter at least once a week that has effect on your weight or body composition?

[ ]1 Yes [ ]2 No

If yes, please specify _____

4. Have you had gestational diabetes with this or previous pregnancy?

[ ]1 Yes [ ]2 No [ ]3 Don't know

5. Have you had hypertension or pre-eclampsia with this previous pregnancy?

[ ]1 Yes [ ]2 No [ ]3 Don't' know

6. Are you currently taking any vitamins, minerals, herbs or health food supplements at least once per week on a regular basis? [ ]1 Yes [ ]2 No

Supplement Name	Amount	Frequency	How long	Reason

7. Do you currently drink or use alcohol? [ ]1 Yes [ ]2 No

If yes, how much drink per day _____; per week _____

8. Are you currently following a special diet? (Vegetarian, diabetic, low fat, lactose free)

[ ]1 Yes [ ]2 No

If yes, what kind? _____

9. Is this diet being prescribed by your health care provider? [ ]1 Yes [ ]2 No

10. Have you consciously tried to loss weight or gain weight? [ ]1 Yes [ ]2 No

If yes, please specify which _____

12. Do you currently participate in regular physical activity? [ ]1 Yes [ ]2 No

If yes, how often do you exercise? _____

If yes, what type of exercise do you normally participate in? _____

13. Do you have any condition that prevents you from being physically active?

[ ]1 Yes [ ]2 No

If yes, please specify _____

14. How many live children have you given birth to? _____

Anthropometry

1. How tall are you? _____ Feet _____ Inches

2. What was your weight before you became pregnant? _____ Pounds

APPENDIX C

DEPARTMENT OF FOODS AND NUTRITON
UNIVERSITY OF GEORGIA

2 Weeks Postpartum

ID #: _____ Date __/__/__

Health History

1. Did you have any complications during delivery? [ ]1 Yes [ ]2 No

If yes, please specify _____

2. Are you currently taking any medication either prescribed by a doctor or purchased over the Counter at least once a week that has effect on your weight or body composition? [ ]1 Yes [ ]2 No

If yes, please specify _____

3. Are you currently taking any vitamins, minerals, herbs or health food supplements at least once per week on a regular basis? [ ]1 Yes [ ]2 No

Supplement Name	Amount	Frequency	How Long	Reason

4. Did you consume alcohol during pregnancy? [ ]1 Yes [ ]2 No

If yes, how often? _____

What type? [ ]1 Wine [ ]2 Beer [ ]3 Liquor

5. Do you currently consume alcohol? [ ]1 Yes [ ]2 No

If yes, how often? _____

What type? [ ]1 Wine [ ]2 Beer [ ]3 Liquor

5. Did you smoke cigarettes during pregnancy?

6. Do you currently smoke or use any form of tobacco? [ ]1 Yes [ ]2 No

If yes, how much do you smoke per day _____; per week _____

7. Are you currently following a special diet? (Vegetarian, diabetic, low fat, lactose free)

[ ]1 Yes [ ]2 No

If yes, what kind? _____

8. Is this diet being prescribed by your health care provider? [ ]1 Yes [ ]2 No

9. Have you consciously tried to lose weight or gain weight? [ ]1 Yes [ ]2 No

If yes, please specify which _____

10. Do you currently participate in regular physical activity? [ ]1 Yes [ ]2 No

If yes, how often do you exercise per week? _____

If yes, what type of exercise do you normally participate in? _____

11. What is the average duration of a typical exercise session? _____

12. Do you have any condition that prevents you from being physically active? [ ]1 Yes [ ]2 No

If yes, please specify _____

13. Does your infant have any special health condition? [ ]1 Yes [ ]2 No

If yes, please specify _____

14. Gestational age at delivery _____ weeks.

15. Delivery type: [ ]1 Vaginal delivery (spontaneous) [ ]2 Cesarean delivery

16. Date of delivery: ___/___/___

17. Were you diagnosed as having gestational diabetes during pregnancy? [ ]1 Yes [ ]2 No

18. Were you diagnosed as having pregnancy induced hypertension? [ ]1 Yes [ ]2 No

19. Were you diagnosed as having preeclampsia during pregnancy? [ ]1 Yes [ ]2 No

Infant Feeding Practice

1. How are you feeding your newborn?

[ ]1 Exclusive breastfeeding (breastmilk as the only food or fluid so far given to the child)

[ ]2 Breast and formula feeding

[ ]3 Formula feeding

2. If not exclusively breastfeeding or exclusive formula feeding, what proportion of the infant's nutrition come from breastmilk? _____

3. If the infant is receiving foods other than breastmilk, how old was the infant when you introduced other non-breastmilk foods to the infant? _____

4. Please, list the type of non-breastmilk foods and their daily frequency

_____

_____

_____

5. How soon after delivery was your infant put to the breast? _____

6. Are you still breastfeeding your baby? [ ]1 Yes [ ]2 No

If no, how old was your baby when you stopped breastfeeding? _____

If no, why did you stop breastfeeding?

_____

_____

_____

7. If yes above, how long would you like to breastfeed your baby? _____

8. If breastfeeding, on the average how many times per day do you breastfeed your baby?

_____

9. If mixed feeding, how old was your baby when you first introduced something other than breastmilk or infant formula? _____

10. Please, list non-milk based food items fed to the baby.

_____

_____

11. If formula feeding, has your baby received anything besides infant formula? [ ]1 Yes [ ]2 No

12. If yes, please specify what was given to the infant _____

_____

_____

_____

Anthropometry

1. How tall are you? _____ Feet _____ inches
2. What was your weight before you became pregnant? _____ Pounds
3. How much weight did you gain during your pregnancy? _____ Pounds
4. What was your total weight at delivery? _____ Pounds
5. What was the infant's birth weight? _____ pounds _____ ounces
6. What was the infant's birth length? _____ Inches

DEPARTMENT OF FOODS AND NUTRITON
UNIVERSITY OF GEORGIA

8 Weeks Postpartum

ID #: _____ Date __/__/__

1. Are you currently taking any medication either prescribed by a doctor or purchased over the counter at least once a week that has effect on your weight or body composition? [ ]1 Yes [ ]2 No

If yes, please specify _____

2. Are you currently taking any vitamins, minerals, herbs or health food supplements at least once per week on a regular basis? [ ]1 Yes [ ]2 No

Supplement Name	Amount	Frequency	How Long	Reason

3. Do you currently drink or use alcohol? [ ]1 Yes [ ]2 No

If yes, how much drink per day _____; per week _____

4. What type? [ ]1 Wine [ ]2 Beer [ ]3 Liquor

5. Do you currently smoke or use any form of tobacco? [ ]1 Yes [ ]2 No

6. Are you currently following a special diet? (Vegetarian, diabetic, low fat, lactose free)

[ ]1 Yes [ ]2 No

If yes, what kind? _____

7. Is this diet being prescribed by your health care provider? [ ]1 Yes [ ]2 No

8. Have you consciously tried to lose weight or gain weight? [ ]1 Yes [ ]2 No

If yes, please specify which _____

9. Do you currently participate in regular physical activity? [ ]1 Yes [ ]2 No

If yes, how often do you exercise per week? _____

If yes, what type of exercise do you normally participate in? _____

10. What is the average duration of a typical exercise session? _____

11. Do you have any condition that prevents you from being physically active? [ ]1 Yes [ ]2 No

If yes, please specify _____

12. Does your infant have any special health condition? [ ]1 Yes [ ]2 No

If yes, please specify _____

Infant Feeding Practice

1. How are you feeding your newborn?

[ ]1 Exclusive breastfeeding (breastmilk as the only food or fluid so far given to the child)

[ ]2 Breast and formula feeding

[ ]3 Formula feeding

2. If not exclusively breastfeeding or exclusive formula feeding, what proportion of the infant's nutrition come from breastmilk? _____

3. If the infant is receiving foods other than breastmilk, how old was the infant when you introduced other non-breastmilk foods to the infant? _____

4. Please, list the type of non-breastmilk foods and their daily frequency

_____

_____

_____

5. Are you still breastfeeding your baby? [ ]1 Yes [ ]2 No

If no, how old was your baby when you stopped breastfeeding? _____

If no, why did you stop breastfeeding?

_____

_____

_____

6. If yes above, how long would you like to breastfeed your baby? _____

7. If breastfeeding, on the average how many times per day do you breastfeed your baby?

_____

8. If mixed feeding, how old was your baby when you first introduced something other than breastmilk or infant formula? _____

9. Please, list non-milk based food items fed to the baby.

_____

_____

10. If formula feeding, has your baby received anything besides infant formula? [ ]1 Yes [ ]2 No

11. If yes, please specify what was given to the infant _____

_____

DEPARTMENT OF FOODS AND NUTRITON
UNIVERSITY OF GEORGIA

16 Weeks Postpartum

ID #: _____ Date __/__/__

1. Are you currently taking any medication either prescribed by a doctor or purchased over the counter at least once a week that has effect on your weight or body composition? [ ]1 Yes [ ]2 No

If yes, please specify _____

2. Are you currently taking any vitamins, minerals, herbs or health food supplements at least once per week on a regular basis? [ ]1 Yes [ ]2 No

Supplement Name	Amount	Frequency	How Long	Reason

3. Do you currently drink or use alcohol? [ ]1 Yes [ ]2 No

If yes, how much drink per day _____; per week _____

4. What type? [ ]1 Wine [ ]2 Beer [ ]3 Liquor

5. Do you currently smoke or use any form of tobacco? [ ]1 Yes [ ]2 No

6. Are you currently following a special diet? (Vegetarian, diabetic, low fat, lactose free)

[ ]1 Yes [ ]2 No

If yes, what kind? _____

7. Is this diet being prescribed by your health care provider? [ ]1 Yes [ ]2 No

8. Have you consciously tried to lose weight or gain weight? [ ]1 Yes [ ]2 No

If yes, please specify which _____

9. Do you currently participate in regular physical activity? [ ]1 Yes [ ]2 No

If yes, how often do you exercise per week? _____

If yes, what type of exercise do you normally participate in? _____

10. What is the average duration of a typical exercise session? _____

11. Do you have any condition that prevents you from being physically active? [ ]1 Yes [ ]2 No

If yes, please specify _____

12. Does your infant have any special health condition? [ ]1 Yes [ ]2 No

If yes, please specify _____

Infant Feeding Practice

1. How are you feeding your newborn?

[ ]1 Exclusive breastfeeding (breastmilk as the only food or fluid so far given to the child)

[ ]2 Breast and formula feeding

[ ]3 Formula feeding

2. If not exclusively breastfeeding or exclusive formula feeding, what proportion of the infant's nutrition come from breastmilk? _____

3. If the infant is receiving foods other than breastmilk, how old was the infant when you introduced other non-breastmilk foods to the infant? _____

4. Please, list the type of non-breastmilk foods and their daily frequency

_____

_____

_____

5. Are you still breastfeeding your baby? [ ]1 Yes [ ]2 No

If no, how old was your baby when you stopped breastfeeding? _____

If no, why did you stop breastfeeding?

_____

_____

_____

6. If yes above, how long would you like to breastfeed your baby? _____

7. If breastfeeding, on the average how many times per day do you breastfeed your baby?

_____

8. If mixed feeding, how old was your baby when you first introduced something other than breastmilk or infant formula? _____

9. Please, list non-milk based food items fed to the baby.

_____

_____

10. If formula feeding, has your baby received anything besides infant formula? [ ]1 Yes [ ]2 No

11. If yes, please specify what was given to the infant _____

_____

APPENDIX D

Infant Feeding Logs ($25/each)

WHEN

Please complete your 6 Feeding Logs for the study on the following dates:

2 week: April 1
4 week: April 15
6 week: April 29
8 week: May 13
10 week: May 27
12 week: June 10
*If you miss this day, it's okay! Do it another day that week

HOW

Using the log in the folder, please record a full 24 hours of your baby's food intake. (If you start at 2am, go until 2am the next day).

Record the TIME of each feeding, the content of the bottle (oz) before and the content of the bottle (oz) after the feeding.

GET PAID

When you have completed a log, send it to us and you'll receive $25 for it!

1. Take a picture of the log with your phone and email or text it to: growth@uga.edu
2. Mail the original log to us using the stamped envelope in this folder

Maternal and Infant Growth Study, Child Nutrition Laboratory, UGA
850 College Station Road, River's Crossing Bldg, Rm 65, 706-542-7611

2WEEK **Infant Feeding Log** Subject ID __RIF76_____

Date	Time of Day	Weight Before Feeding (g)	Weight After Feeding (g)	Special Notes

4 WEEK **Infant Feeding Log** Subject ID _____

Date	Time of Day	Content of Bottle (Ounces Before Feeding)	Content of Bottle (Ounces After Feeding)	Special Notes