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Greater Breastfeeding in Early Infancy Is Associated with Slower Weight Gain among High Birth Weight Infants

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Abstract

Objective—To examine whether feeding patterns from birth to age 6 months modify the association between birth weight and weight at 7–12 months of age.

Study design—Longitudinal mixed models were used to examine feeding trajectories across categories of birth weight and weight at 7–12 months of age in 1799 mother-infant dyads enrolled in the Infant Feeding Practices Study II. The percentage of breast milk received and the average daily formula consumption were calculated from birth to 6 months of age. Birth weights were classified as high (>4000 g) and normal (≤4000 g). Weights at 7–12 months of age were categorized as high (z score >1) or normal (z score ≤1). A secondary analysis was performed using categories defined by birth weight adjusted for gestational age percentiles (>90th and 10th–90th percentile).

Results—High birth weight (HBW) infants with high weights at 7–12 months of age demonstrated a rapid decline in the percentage of breast milk feedings compared with HBW infants with normal weights at 7–12 months of age. Normal birth weight infants with high weights at 7–12 months of age received a lower percentage of breast milk and had greater absolute intakes of formula than those with normal weights at 7–12 months of age; these associations did not vary over time. Results were similar when infants were categorized by birth weight percentiles.

Conclusions—A lower proportion of breast milk feedings was associated with excess weight at 7–12 months of age in HBW infants. These findings suggest an initial target for obesity prevention programs focusing on the first 6 months after birth.

Many factors that are present in the first 1000 days of life (ie, from conception to age 2 years) possess a strong relationship with later weight,¹ but a high birth weight (HBW, >4000 g) is a consistent predictor of later overweight or obesity in childhood, adolescence, and adulthood.^{2–10} In a large prospective cohort study, the prevalence of obesity was nearly double among HBW infants from early childhood to adolescence compared with normal birth weight (NBW, 2500–3999 g) infants.¹¹ Moreover, 36% of youth who were obese

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at 14 years of age had a birth weight ≥ 4000 g.¹¹ In addition to obesity, HBW infants also have increased risk for comorbid medical problems including type 2 diabetes^{12,13} and cardiovascular concerns.^{14–16}

Given these concerns, a better understanding of the mechanisms that shape the association between HBW and later obesity is needed.⁹ Prenatal (eg, prepregnancy overweight/obesity and diabetes mellitus)¹⁷ and postnatal influences (eg, breast milk feeding, introduction to cereal, feeding practices, and eating behaviors)^{2,18,19} appear to be important in determining later weight trajectories.¹⁹ An understanding of potentially modifiable practices may provide insight as to how HBW infants become obese children and inform targeted prevention efforts to improve growth patterns and reduce the risk for overweight/obesity.

Exclusive breastfeeding is protective against high weight²⁰ and is recommended by the American Academy of Pediatrics for the first 6 months.²¹ Because breastfeeding rates can be improved with education and support,^{22–25} we examined associations between feeding practices from birth to 6 months of age and weight-for-age in months 7–12 of infancy using observational data from the Infant Feeding Practices Study II. We hypothesized that HBW infants would receive a lower percentage of breast milk and consume more formula than NBW infants. We further hypothesized that HBW infants with high weight *z* scores at 7–12 months of age would consume a lower percentage of breast milk and higher volume of formula compared with HBW infants with a normal weight *z* score at 7–12 months of age.

Methods

The Infant Feeding Practices Study II (IFPS II) was a longitudinal survey of 4902 women in the US conducted by the Food and Drug Administration and Centers for Disease Control and Prevention from May 2005 to June 2007. Mother-infant dyads were eligible if the mother was ≥ 18 years of age and the infant was a singleton born at ≥ 35 weeks of gestation with a birth weight ≥ 2.25 kg. Infants were ineligible if they had an illness or condition that would impair feeding in the first year. Following the completion of an initial prenatal questionnaire, mothers completed postnatal questionnaires monthly (neonatal, months 2, 3, 4, 5, 6, 7) and then every 7 weeks (months 9, 10.5, 12) until the infant was 12 months of age. Additional information about the IFPS II is presented elsewhere.²⁶ Given that this was a secondary analysis of deidentified data, the current study was not considered human subjects research by the Cincinnati Children's Hospital Medical Center Institutional Review Board and did not require Institutional Review Board approval.

Maternal information collected prenatally included age, race and ethnicity, parity, smoking, prepregnancy body mass index (BMI), and poverty-to-income ratio. Gestational weight gain was assessed via self-report at the first postnatal survey. Delivery and neonatal information included gestational age (in weeks), method of delivery, infant sex, and birth weight (in grams). Following the definition used in 2 recent meta-analyses, absolute birth weight was categorized as high (≥ 4000 g) or normal (< 2500 and < 4000 g).^{9,10} Based on sex-specific fetal growth reference tables,²⁷ birth weight percentiles were classified as large for gestational age (LGA, birth weight > 90 th percentile) or appropriate for gestational age (AGA, 10th–90th percentile).

At each postnatal questionnaire from birth to 6 months, mothers completed a food frequency measure reporting the average number of infant feedings of breast milk, formula, and other milk (eg, soy, rice milk) per day during the previous 7 days. The percentage breast milk variable was calculated at each postnatal survey as follows²⁸: [(number of breast milk feedings)/(number of breast milk + formula + cow's milk + other milk feedings)] × 100%. The percentage of breast milk was calculated for each completed postnatal survey through 6 months; mother-infant dyads could have up to 6 measurements.

Mothers who offered formula to their infants during the first 6 months were asked to indicate the approximate number of ounces consumed per feeding from birth to 6 months. Response options included 1–2, 3–4, 5–6, 7–8, and 8 or more ounces. Response options were converted to the midpoint (ie, 1.5, 3.5, 5.5, 7.5, and 8.5).²⁹ The midpoint formula consumption and the average number of formula feedings per day were used to estimate the average daily formula consumption in ounces per month from birth to 6 months. Because not all mothers offered formula in the first 6 months, only those reporting formula feedings during at least 1 measured time point were included in analyses using this variable. Once an infant had been given formula on a postnatal survey, the infant remained in the formula group for all subsequent time points even if reverting back to exclusive breastmilk.

Infant weight and length were obtained by maternal report on postnatal questionnaires at the month 3, 5, 7, and 12 surveys. The appointment date and measurements were obtained from the infant's most recent doctor's appointment. Because of concerns about parent-reported infant length,²⁸ we used weight *z* scores rather than weight-for-length or length measurements. Infants with at least 2 weight measurements were included, and at least 1 measurement must have been obtained at the month 7 (n = 414) or 12 (n = 1385) survey. Weight-for-age *z* scores were calculated using the sex-specific Centers for Disease Control and Prevention national growth reference data.³⁰ Biologically implausible *z* scores were excluded. Weight was dichotomized as a *z* score >1 (high) or ≤1 (normal) at 7–12 months of age.²⁸

Descriptive statistics are reported as means (with SDs) or medians (with IQRs) and frequencies unless otherwise indicated. Longitudinal mixed effects models were fit using restricted maximum likelihood with an unstructured covariance pattern to allow for an unbalanced data structure (ie, unequal number of measurements and measurement intervals) and correlations between infants. Several models were estimated to determine the most robust statistical model for the associations between group and feeding practices from birth to 6 months. Full group analyses examined feeding practices across categories of absolute birth weight (high vs normal) and birth weight percentile (LGA vs AGA).

Three models were estimated. Model 1 was an unadjusted linear model examining the relationship between group and feeding trajectories. Model 2 was composed of model 1 with adjustment for covariates that could potentially alter the association between early feeding or birth weight: mother's age, prepregnancy BMI, race/ethnicity (white used as reference), poverty-to-income ratio, gestational age (not used for LGA or AGA comparisons), and infant sex (male as reference). Model 3 was composed of model 2 with a quadratic component to determine if trajectories were nonlinear. The respective terms age and age²

were used to capture the linear and non-linear effects of time (chronological infant age) on the outcome variable, and whether the outcome varied as a function of group (ie, group \times infant age interaction). Random intercepts and random slopes were included to allow for infant-specific variation in the intercepts and rates of change. For all models, goodness-of-fit was estimated using deviance ($-2 \times \log$ -likelihood), Akaike's information criteria, and Bayesian information criteria for which lower values represent better model fit. All analyses were conducted in Stata 15 (StataCorp LP, College Station, Texas) and using the function "mixed," the procedure for estimating multilevel mixed-effects regression models.

Results

Birth weight was available for 3389 infants. Of these, 1521 mother-infant pairs were excluded for missing weight information at 7–12 months of age, and 68 were excluded for missing covariate information. The final sample size was 1799 (HBW, $n = 209$) for the analysis of percentage breast milk and 1265 (HBW, $n = 133$) for the average daily formula consumption. Because not all infants received formula and the timing of introduction varied, the sample size and mean number of observations is lower for formula consumption than analyses examining percentage breast milk. Information at all 6 postnatal surveys was available for 1267 (70.4%) respondents for the percentage breast milk outcome and 521 (41.2%) for average daily formula consumption. Mean observations across all full group and subgroup analyses ranged from 5.5–5.6 for percentage breast milk and 4.5–4.6 on average daily formula consumption.

Mothers of HBW infants were more likely to have a greater prepregnancy BMI and gestational weight gain and were more likely to be white, multiparous, and less likely to smoke relative to mothers of NBW infants (Table I). HBW infants were more likely to be male, born by cesarean delivery, and had a longer gestation. Thirty-three percent of HBW infants ($n = 69$) and 17% of NBW infants ($n = 277$) had high weight z scores (>1) at 7–12 months of age.

Of the 209 HBW infants, 85% ($n = 177$) were also LGA using birth weight percentiles and the remaining 15% ($n = 32$) were AGA. Sixty-four infants who were previously coded as NBW were classified as small-for-gestational age (<10 th percentile)²⁷ and subsequently removed from the LGA vs AGA analyses. Of the 1526 remaining NBW infants, 4% ($n = 61$) were classified as LGA and the remainder were AGA ($n = 1465$). For these groups, the final sample sizes for percentage breast milk and daily formula consumption were 1735 (LGA, $n = 238$) and 1217 (LGA, $n = 156$), respectively. Thirty-six percent of LGA infants ($n = 87$) and 17% of AGA infants ($n = 254$) had high weight z scores at 7–12 months of age.

For the whole sample, breast milk comprised 67.08% ($SD = 42.68$) of total milk feeds at the first postnatal questionnaire and 47.31% ($SD = 47.03$) in month 6. In the first postnatal survey, 24% of mothers fed 0% breast milk, rising to 47% at 6 months. Feeding 100% breast milk was reported by 48% of mothers in the first postnatal questionnaire and 34% of mothers at 6 months. Among the subset of mothers who fed formula, the mean volumes were 18.81 ($SD = 14.56$) and 26.22 ($SD = 14.44$) ounces per day initially and at month 6.

The median number of formula feedings per day in the first postnatal survey was 6 (IQR, 2–8) and 5 (IQR, 3–6) at month 6.

A drop in the percentage of breast milk feedings occurred in all participants in the first few months; this decline leveled off over time (Table II and Figure 1; available at www.jpeds.com). Daily formula consumption increased in early infancy and leveled off in later months. No significant effects of group or group \times infant age were found for percentage of breast milk feedings or formula consumption. Results were similar when analyzed using LGA and AGA birth weight percentiles (Table III and Figure 2; available at www.jpeds.com).

The percentage of breast milk feedings gradually declined across the first 6 months of infancy for HBW infants (Table IV). HBW infants with high weights at 7–12 months of age demonstrated an early nonlinear decline in the percentage of breast milk feedings (a significant interaction of HBW-high weight group and infant age²) from birth to 6 months compared with HBW infants with normal weights at 7–12 months of age (Figure 3). Although formula intake increased over time, there was no significant group or group \times infant age interaction. In the LGA infants, the percentage of breast milk feedings decreased and formula intake increased over time (Table V; available at www.jpeds.com). LGA infants with high weights at 7–12 months of age demonstrated a greater decrease in the percentage of breast milk compared with LGA infants with normal weights at 7–12 months of age though the nonlinear interaction failed to reach significance (Figure 4; available at www.jpeds.com).

The percentage of breast milk feeding rapidly decreased in the early months for all NBW infants (Table VI; available at www.jpeds.com). A main effect of group indicated that NBW infants with high weights at 7–12 months of age received a lower percentage of breast milk compared with those with normal weights at 7–12 months of age and this relationship did not vary over time. Across all NBW infants, formula consumption rapidly increased in the early months and then leveled off. Compared with NBW infants with normal weights at 7–12 months of age, those with high weights at 7–12 months of age received more ounces of formula per day and this relationship did not vary over time (Figure 5; available at www.jpeds.com). Findings were similar for AGA infants with normal or high weights at 7–12 months of age (Table VII and Figure 6; available at www.jpeds.com).

Discussion

A robust association exists among infants born at a HBW and later risk for overweight/obesity^{2–4,7–10,15}; however, not all HBW infants follow this trajectory. To better understand the association between modifiable factors and risk for excess weight among HBW infants, we examined breast and formula feeding from birth to age 6 months. It was hypothesized that, irrespective of weight status at 7–12 months of age, infants born heavy (HBW and LGA) would receive a lower ratio of breast to nonbreast milk and consume more formula compared with infants born at a normal weight (NBW and AGA). However, these differences were not found, regardless of how infant birth weight was defined (using absolute birth weight or birth weight percentiles). These results are consistent with one other

retrospective study that found no differences between NBW and HBW infants on infant eating behaviors or maternal feeding practices.¹⁹

We also hypothesized that infants born heavy (HBW or LGA) with a high weight at 7–12 months of age would consume a lower percentage of breast milk and higher volume of formula compared with infants born heavy and with a normal weight at 7–12 months of age. The results showed that among HBW infants with high weight at 7–12 months of age (based on a previously used criterion),²⁸ breast milk feeding rapidly declined in the earliest months, compared with HBW infants with a normal weight at 7–12 months of age. In other words, among infants who were heavy at birth, other milks/formula were introduced earlier in infants with high weights at 7–12 months of age than in those with normal weights at 7–12 months of age. Findings were similar regardless of whether infants born heavy was defined as HBW or LGA.

Infants born at a normal weight who proceeded on a high weight trajectory at 7–12 months of age consumed a lower percentage of breast milk and had greater formula intake compared with those with normal weight at 7–12 months of age. Our results are consistent with findings that have shown that HBW infants who achieved a normal weight-for-length at 7–8 months of age appeared to respond better to internal cues of satiety compared with HBW infants with a high weight-for-length.¹⁹ Moreover, others have shown that heavy offspring born to mothers with overweight/obesity and diabetes have rapidly rising BMIs in the first several years of life.¹⁷ Taken together, both pre- and postnatal factors may elevate risk for continued weight gain among infants born heavy.

In the current study, infants who were born heavy and showed a gradual reduction in breast milk feedings also showed slower weight gain than those with a more rapid reduction in breast milk. These results suggest that a greater proportion of breast milk feedings may buffer against high weight at 7–12 months of age. Prolongation of breastfeeding has received much attention^{20,31,32} as a method to reduce the risk of overweight.²⁰ In a retrospective cohort study, breastfeeding 12 months was associated with a similar BMI at 4 years among AGA and LGA infants,³³ suggesting that a longer duration of breastfeeding may protect against excessive weight gain for infants born heavy. Further, formula is considered more energy-dense and has a higher protein content than breast milk and the use of formula has been associated with greater weight gain from 3–6 and 6–9 months, compared with the intakes and growth patterns of breastfed infants.³⁴

Although the current study examined potentially modifiable feeding practices, it is important to reflect on other predictors of breastfeeding difficulty such as maternal weight, delivery mode, and maternal gestational diabetes mellitus (GDM) that could be confounding the association between breastfeeding and later weight status in infants born heavy. Maternal overweight/obesity has been previously associated with reduced intention to breastfeed, shortened duration of breastfeeding, and delayed onset of lactogenesis II,³⁵ although the mechanisms that drive these relationships (eg, anatomic, psychosocial) are not well understood.³⁶ Although our study showed a larger proportion of prepregnancy overweight/obesity among mothers of infants with HBW and high weight at 7–12 months of age (72.5%) compared with those with normal weights at 7–12 months of age (63.6%),

this difference was not statistically significant. Delivery mode may also contribute to poor breastfeeding^{37–39} as emergency cesarean delivery is associated with shortened breastfeeding duration compared with spontaneous vaginal delivery.⁴⁰ However, our study showed no differences between HBW subgroups on method of delivery.

Maternal GDM is a risk factor increasing the likelihood of delivering a heavy infant and reduced duration of breastfeeding. Although BMI at age 1 year has been shown to differ between LGA infants born to mothers with and without GDM,⁴¹ and breastfeeding at least 3 months appears protective against overweight in children born to mothers with GDM,⁴² the current study did not find differences in maternal GDM between the HBW subgroups. Overall our study did not find relationships between breast milk feedings and other prenatal and intrauterine indicators that are traditionally associated with reduced breastfeeding.

Encouragingly, breastfeeding practices can be increased following brief education.^{23–25,43} For example, telephone-based support increased the duration of any and exclusive breastfeeding among obese women.²² The current findings convey the importance of addressing early feeding and providing support to mothers of infants born heavy to curtail a high weight trajectory and potentially impact later obesity. Furthermore, the critical period of infancy which encompasses multiple well-child visits in the first year of life may be an appropriate front line for tailoring anticipatory guidance and education strategies around sustained breastfeeding specifically for mothers of infants born heavy.

Although HBW infants have almost double the prevalence of overweight/obesity at later ages compared with NBW infants, it is still the minority of either population that become obese.¹¹ It may be that this relatively low incidence resulted in failure to find group differences between our HBW and NBW groups. Breastfeeding was not different between these groups but did distinguish between HBW infants with normal or high weights at 7–12 months of age. These findings suggest that following a sample of HBW infants over time and examining mechanisms that may be associated with excess weight gain would be a productive avenue for developing prevention programs to mitigate obesity risk among infants at high risk for obesity (ie, birth weight > 4000 g).⁴⁴

The current investigation is not without limitations. Because these data come from an observational study, lack of causality and possible confounding are important methodologic concerns. Although the current study controlled for prenatal and sociodemographic characteristics, there are likely other factors that could not be adjusted for that may impact these results. In addition, data were collected via maternal report which may contain inaccuracies, specifically with report of absolute birth weight, gestational age, and weight at 7–12 months of age. Generalization of these findings is also a concern. Compared with women who participated in other nationally representative surveys,²⁶ mothers in the IFPS II were more likely to be older, employed, and more highly educated. They were more likely to breastfeed for longer durations, to have fewer children, and were less likely to be low income or smoke. Finally, these data are more than 10 years old and although breastfeeding has been largely stable over recent years (eg, 2005–2008 vs 2009–2012),⁴⁵ additional contemporary analysis and HBW specific cohort studies are needed to enhance understanding of the HBW-obesity pathway. A strength of the study was the longitudinal

mixed modeling approach that allowed for an examination of feeding practices over birth to age 6 months.

In conclusion, although there is a strong association between HBW and later overweight/obesity, not all HBW infants will follow this trajectory. The current study examined relationships between feeding practices among categories of birth weight and weight at 7–12 months of age. HBW infants with later high weight-for-age showed an early decline in breast milk intake over the first 6 months of life compared with HBW infants with normal weights at 7–12 months of age. These associations held regardless of whether HBW was defined by absolute birth weight or birth weight percentiles. Given the complexity of accurately calculating gestational age,^{46–48} absolute birth weight appears to be an equally appropriate as well as established risk marker¹ for future excess weight. Future studies should seek to elucidate other variables (eg, complementary feeding, sleep) that may be implicated in the HBW-obesity association. ■

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Glossary

HBW	High birth weight
NBW	Normal birth weight
IFPS II	Infant Feeding Practices Study II
BMI	Body mass index
LGA	Large for gestational age
AGA	Appropriate for gestational age
GDM	Gestational diabetes mellitus

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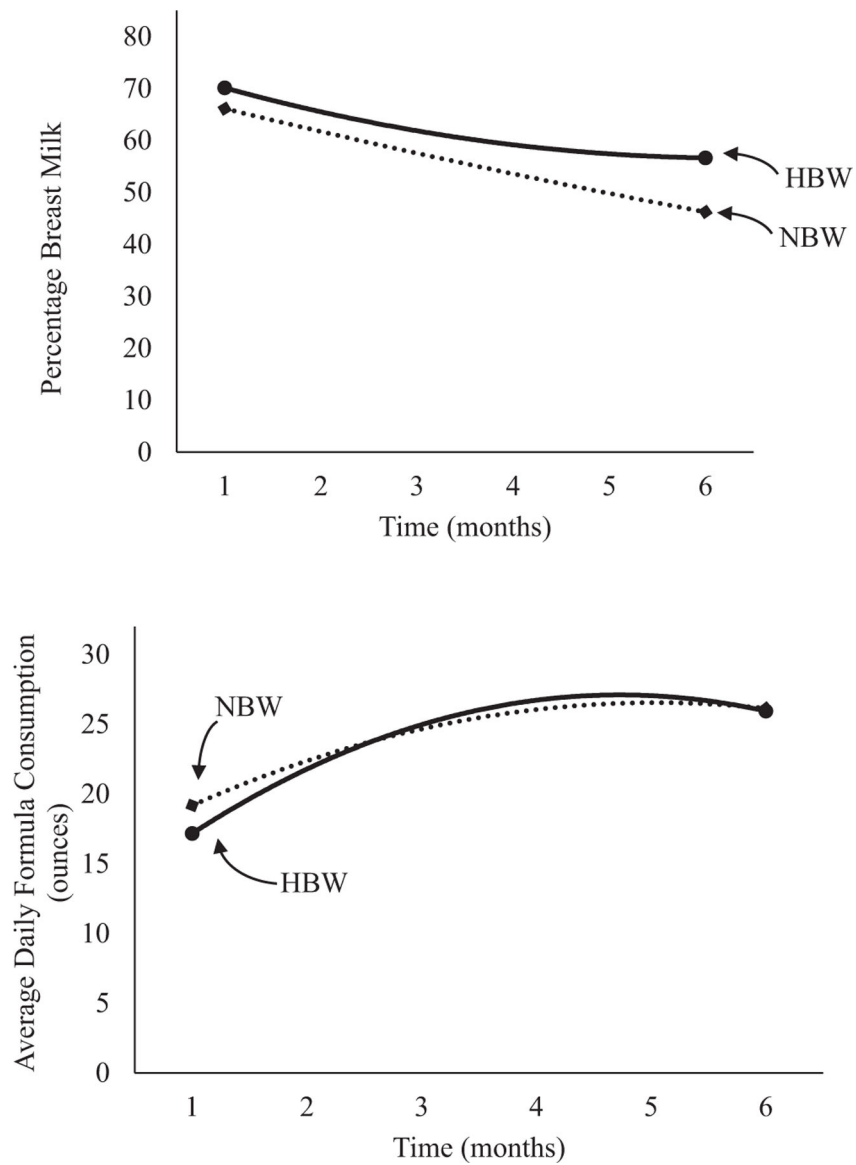


Figure 1. Unadjusted percentage breast milk and average daily formula consumption stratified by absolute birth weight.

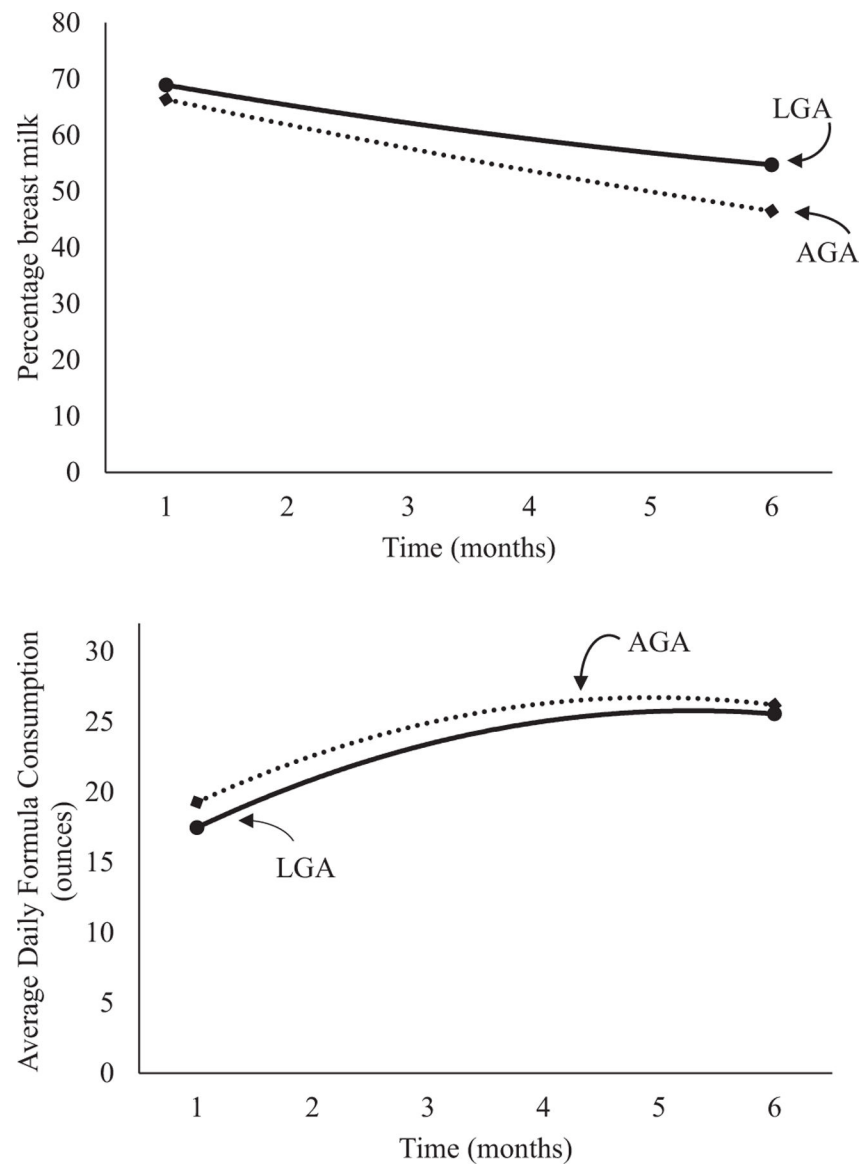


Figure 2. Unadjusted percentage breast milk and average daily formula consumption for infants by birth weight percentiles.

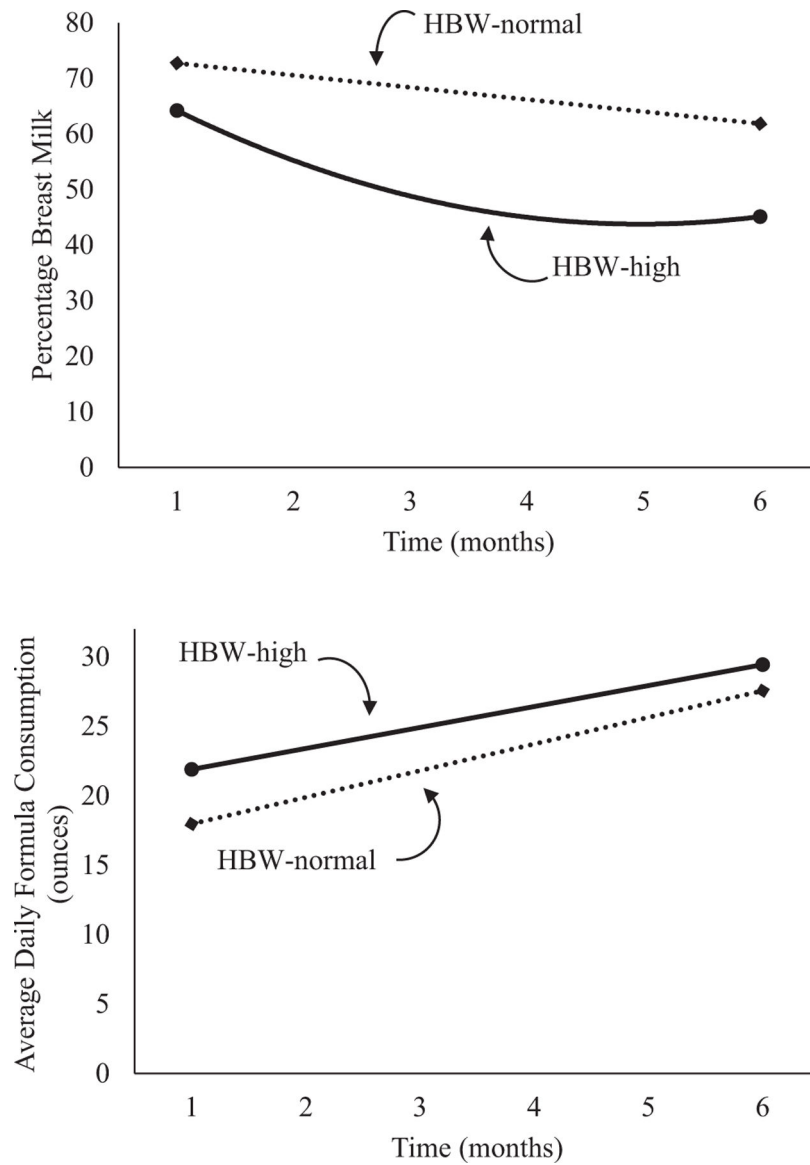


Figure 3. Unadjusted percentage breast milk and average daily formula consumption stratified by categories of HBW and weight z score at 7–12 months of age.

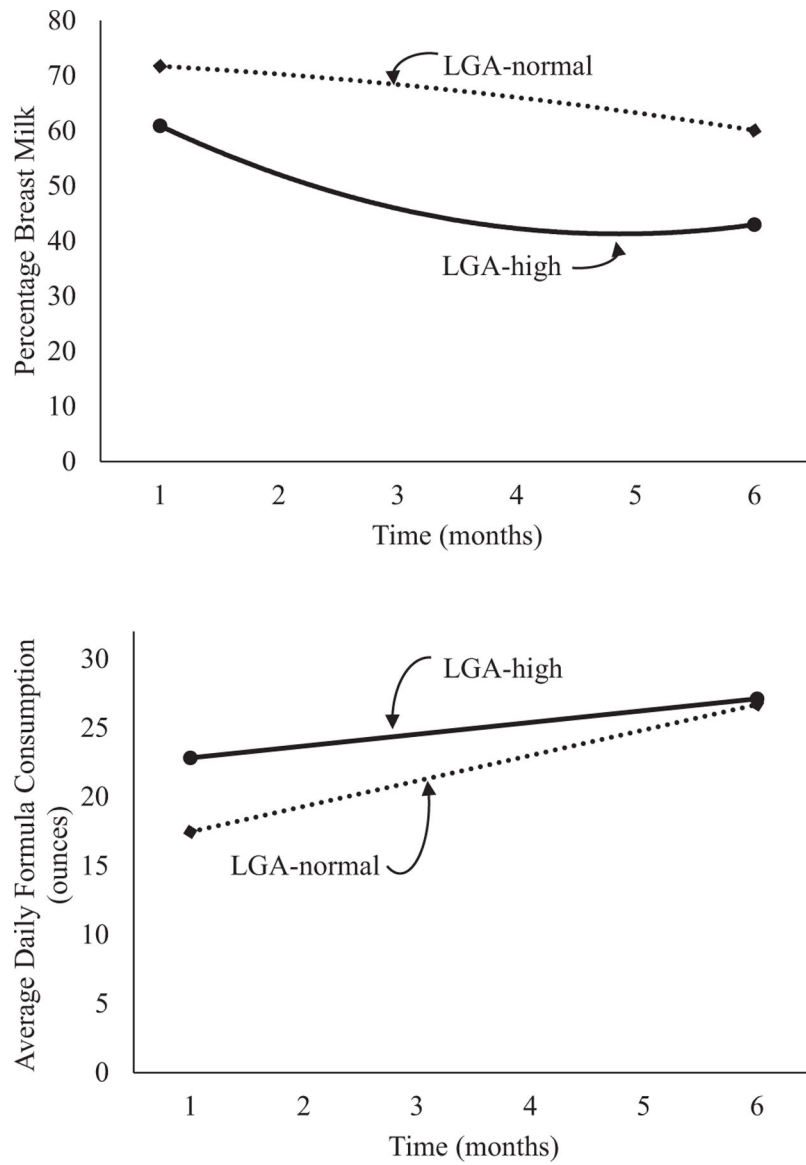


Figure 4. Unadjusted percentage breast milk and average daily formula consumption stratified by categories of LGA and weight z score at 7–12 months of age.

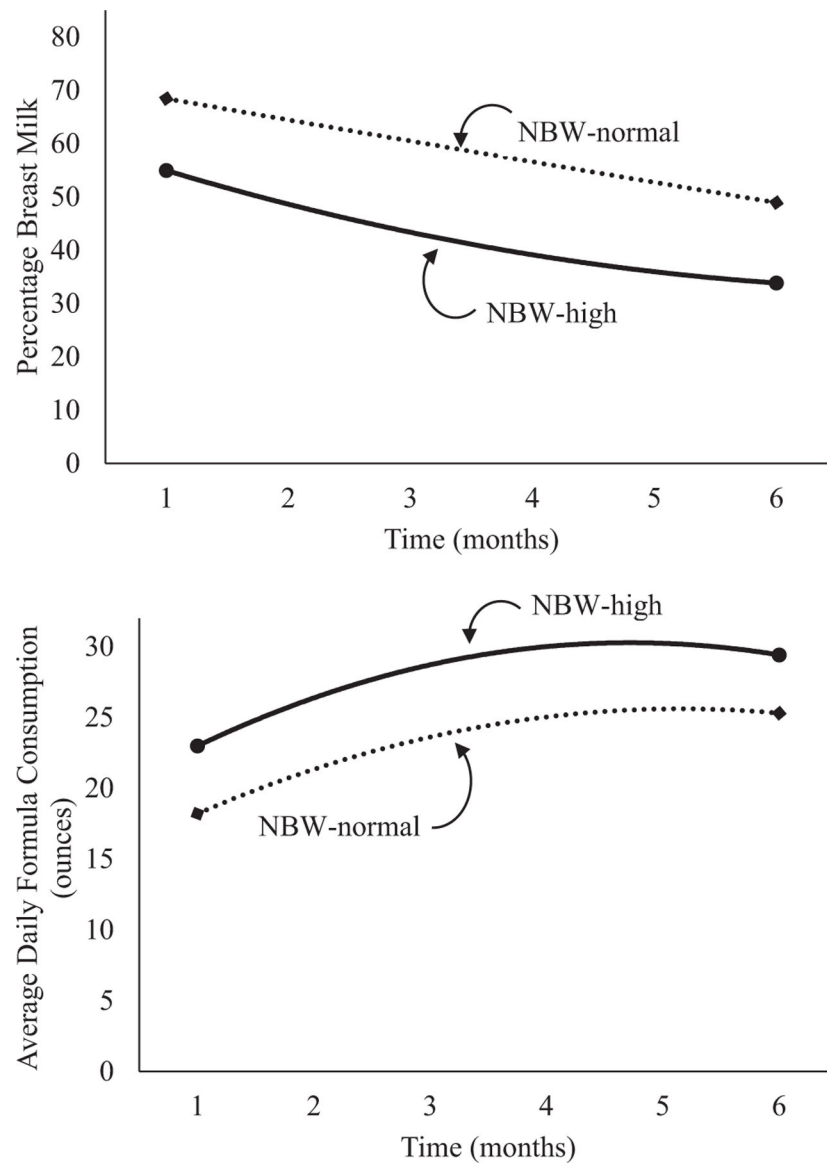


Figure 5. Unadjusted percentage breast milk and average daily formula consumption stratified by categories of NBW and weight z score at 7–12 months of age.

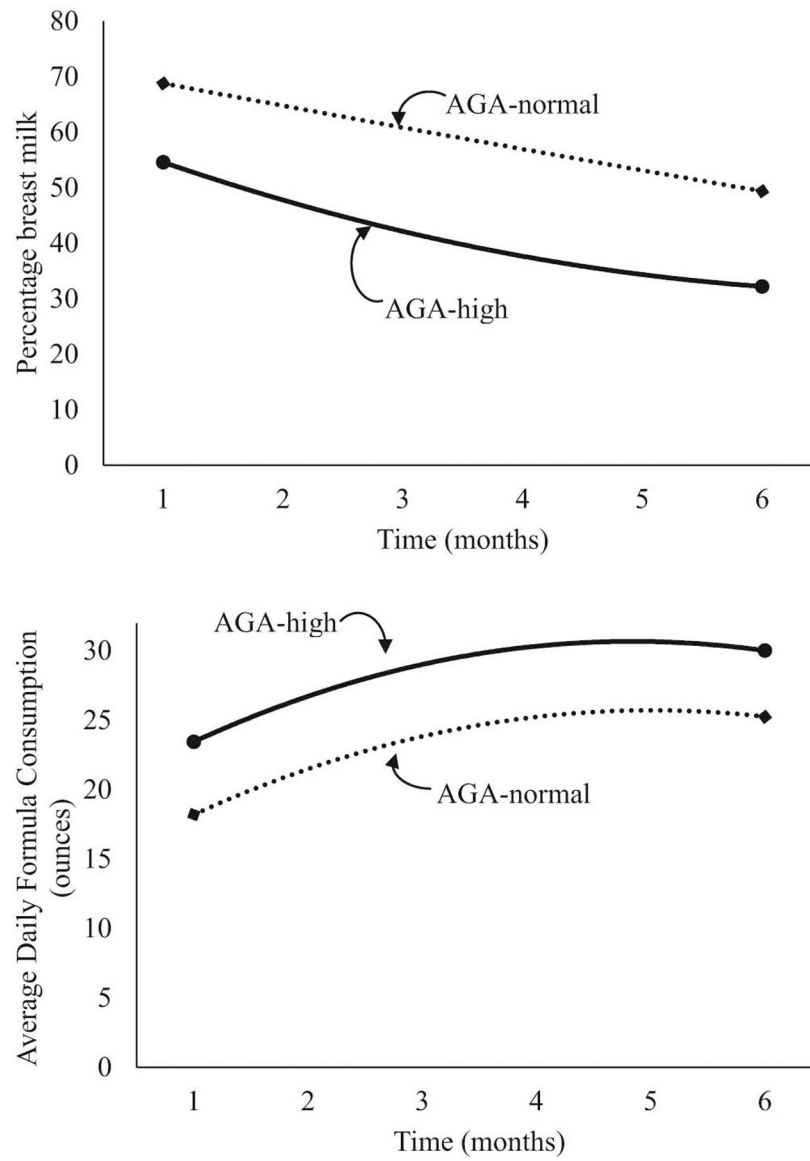


Figure 6. Unadjusted percentage breast milk and average daily formula consumption stratified by categories of AGA and weight z score at 7–12 months of age.

Table I.

Baseline demographics and dyadic characteristics as a function of infant absolute birth weight

Characteristics	NBW (n = 1590)	HBW (n = 209)	P value
Mother			
Prepregnancy BMI, kg/m ²	26.44 ± 6.51	28.83 ± 7.46	<.001
Gestational weight gain, kg	13.70 ± 6.09	15.69 ± 6.94	<.001
Age, y	29.70 ± 5.36	30.11 ± 4.91	.29
Primiparous, %	29.8	20.9	<.01
Prenatal smoking, %	7.4	2.4	<.01
<185% PIR, %	36.7	35.4	.93
Caucasian, %	86.6	91.4	<.001
Cesarean delivery, %	27.8	37.3	<.01
Gestational diabetes, %	6.5	7.8	.77
Infant			
Birth weight, g	3379.15 ± 357.10	4267.91 ± 222.73	<.001
Infant sex, % male	47.8	62.2	<.001
Gestational age, wk	39.26 ± 1.23	39.99 ± 1.02	<.001

PIR, poverty-to-income ratio.

Table II.

Unadjusted and adjusted* longitudinal mixed models for the association between absolute birth weight group and percentage breast milk (n = 1799) and daily formula consumption (n = 1265) between birth to 6 months

Variable	Model 1 β (95% CI)		Model 2* β (95% CI)		Model 3* β (95% CI)	
	Percentage breast milk	Daily formula consumption	Percentage breast milk	Daily formula consumption	Percentage breast milk	Daily formula consumption
HBW	3.27 (-3.11, 9.64)	-1.36 (-4.26, 1.54)	4.57 (-1.89, 11.04)	-2.06 (-4.99, 0.86)	5.03 (-1.46, 11.53)	-1.99 (-5.03, 1.04)
Age	-0.94 (-1.02, -0.86) [‡]	0.42 (0.37, 0.47) [‡]	-0.94 (-1.02, -0.86) [‡]	0.42 (0.37, 0.47) [‡]	-1.14 (-1.27, -1.01) [‡]	0.90 (0.79, 1.01) [‡]
HBW × age	0.28 (.04, 0.52) [‡]	.05 (-0.10, 0.19)	0.28 (.04, 0.51) [‡]	.04 (-0.10, 0.19)	.07 (-0.30, 0.44)	0.11 (-0.22, 0.43)
Age ²					.01 (.00, .01) [‡]	-.02 (-.03, -.02) [‡]
HBW × age ²					.01 (-.00, .02)	-.00 (-.02, .01)
Model Fit Statistics						
Deviance	87 930	44 286	87 870	44 230	87 844	44 130
AIC	87 947	44 302	87 902	44 262	87 881	44 167
BIC	88 005	44 355	88 017	44 369	88 011	44 287

AIC, Akaike's information criterion; BIC, Bayesian information criterion.

* Models are adjusted for mother's age, prepregnancy BMI, gestational age, infant sex, race/ethnicity, and PIR.

[‡] P < .001.

[‡] P < .05.

Unadjusted and adjusted* longitudinal mixed models for the association between categories of birth weight-for-gestational age group and percentage breast milk (n = 1735) and daily formula consumption (n = 1217) between birth to 6 months

Table III.

Variable	Model 1 β (95% CI)		Model 2* β (95% CI)		Model 3* β (95% CI)	
	Percentage breast milk	Daily formula consumption	Percentage breast milk	Daily formula consumption	Percentage breast milk	Daily formula consumption
LGA	2.67 (-3.38, 8.72)	-2.19 (-4.92, 0.54)	4.43 (-1.62, 10.48)	-2.44 (-5.17, 0.29)	4.24 (-1.85, 10.33)	-2.18 (-5.05, 0.69)
Age	-0.94 (-1.03, -0.86) [†]	0.42 (0.37, 0.47) [†]	-0.95 (-1.02, -0.86) [†]	0.42 (0.37, 0.47) [†]	-1.20 (-1.33, -1.06) [†]	0.92 (0.80, 1.03) [†]
LGA × age	0.28 (.05, 0.51) [‡]	.01 (-0.13, 0.15)	0.28 (.05, 0.51) [‡]	.01 (-0.12, 0.15)	0.34 (-0.01, 0.70)	-.04 (-0.36, 0.27)
Age ²					.01 (.01, .02) [†]	-.02 (-.03, -.02) [†]
LGA × age ²					-.00 (-.02, .01)	.00 (-.01, .02)
Model fit statistics						
Deviance	84 842	42 558	84 786	42 506	84 760	42 408
AIC	84 858	42 575	84 817	42 536	84 795	42 443
BIC	84 915	42 628	84 924	42 636	84 917	42 556

* Models are adjusted for mother's age, prepregnancy BMI, infant sex, race/ethnicity, and PIR.

[†] $P < .001$.

[‡] $P < .05$.

Unadjusted and adjusted* longitudinal mixed models for the association between categories of HBW group/weight-for-age status and percentage breast milk (n = 209) and daily formula consumption (n = 133) between birth to 6 months

Table IV.

Variable	Model 1 β (95% CI)		Model 2* β (95% CI)		Model 3* β (95% CI)	
	Percentage breast milk	Daily formula consumption	Percentage breast milk	Percentage breast milk	Percentage breast milk	Percentage breast milk
HBW-high	-10.57 (-22.84, 1.70)	4.22 (-1.28, 9.72)	-8.29 (-20.72, 4.14)	-7.26 (-19.72, 5.20)		
Age	-0.52 (-0.74, -0.30) [†]	0.48 (0.29, 0.68) [†]	-0.52 (-0.74, -0.30) [†]	-0.75 (-1.10, -0.39) [†]		
HBW-high × age	-0.43 (-0.81, -.05)	-.09 (-0.39, 0.22)	-0.43 (-0.82, -.05)	-0.94 (-1.55, -0.34) [‡]		
Age ²				.01 (-.00, .02)		
HBW-high × age ²				.03 (.00, .05) [‡]		
Model fit statistics						
Deviance	10 036	4650	10 018	10 002		
AIC	10 052	4666	10 051	10 038		
BIC	10 092	4701	10 133	10 130		

HBW-high, HBW infants with high weight-for-age.

* Models are adjusted for mother's age, prepregnancy BMI, gestational age, infant sex, race/ethnicity, and PIR.

[†] P < .001.

[‡] P < .05.

Table V.

Unadjusted and adjusted* longitudinal mixed models for the association between categories of large-for-gestational age/weight-for-age status and percentage breast milk (n = 238) and daily formula consumption (n = 156) between birth to 6 months

Empty Cell	Model 1 β (95% CI)		Model 2* β (95% CI)		Model 3* β (95% CI)	
	Percentage breast milk	Daily formula consumption	Percentage breast milk	Percentage breast milk	Percentage breast milk	Percentage breast milk
LGA-high	-6.28 (-18.18, 5.62)	5.31 (-0.67, 11.29)	-3.54 (-15.53, 8.45)	-0.57 (-13.12, 12.18)		
Age	-0.51 (-0.73, -0.30) [‡]	0.49 (0.32, 0.66) [‡]	-0.51 (-0.73, -0.30) [‡]	-0.58 (-0.93, -0.23) [‡]		
LGA-high × age	-0.40 (-0.76, -0.04) [‡]	-0.13 (-0.39, 0.13)	-0.40 (-0.76, -0.04) [‡]	-0.91 (-1.67, -0.14) [‡]		
Age ²				.00 (-.01, .02)		
LGA-high × age ²				.02 (-.01, .04)		
Model fit statistics						
Deviance	11 370	6076	11 350	11 346		
AIC	11 387	5291	11 381	11 380		
BIC	11 429	5327	11 459	11 469		

LGA-high, LGA infants with high weight-for-age.

* Models are adjusted for mother's age, prepregnancy BMI, infant sex, race/ethnicity, and PIR.

[‡] P < .001.

[‡] P < .05.

Table VI.

Unadjusted and adjusted* longitudinal mixed models for the association between categories of NBW group/weight-for-age status and percentage breast milk (n = 1590) and daily formula consumption (n = 1132) between birth to 6 months

Empty Cell	Model 1 β (95% CI)		Model 2* β (95% CI)		Model 3* β (95% CI)	
	Percentage breast milk	Daily formula consumption	Percentage breast milk	Daily formula consumption	Percentage breast milk	Daily formula consumption
NBW-high	-13.87 (-19.60, -8.14) [†]	6.29 (3.93, 8.64) [†]	-12.22 (-17.90, -6.54)	5.68 (3.35, 8.01) [†]	-11.67 (-17.41, -5.93) [†]	5.34 (2.86, 7.82) [†]
Age	-0.92 (-1.01, -0.83) [†]	0.43 (0.38, 0.49) [†]	-0.92 (-1.01, -0.83) [†]	0.44 (0.38, 0.49) [†]	-1.09 (-1.24, -0.95) [†]	0.90 (0.77, 1.02) [†]
NBW-high × age	-0.10 (-0.32, 0.12)	-0.09 (-0.20, .04)	-0.10 (-0.32, 0.12)	-0.08 (-0.20, .04)	-0.27 (-0.62, .08)	-0.01 (-0.29, 0.27)
Age ²					.01 (.00, .01) [‡]	-0.02 (-0.03, -0.02) [‡]
NBW-high × age ²					.01 (-0.01, .02)	-0.00 (-0.01, .01)
Model fit statistics						
Deviance	77 802	39 592	77 758	39 538	77 740	39 456
AIC	77 818	39 608	77 790	39 571	77 777	39 492
BIC	77 875	39 660	77 903	39 675	77 905	39 610

NBW-high, NBW infants with high weight-for-age.

* Models are adjusted for mother's age, prepregnancy BMI, gestational age, infant sex, race/ethnicity, and PIR.

[†] P < .001.

[‡] P < .05.

Table VII.

Unadjusted and adjusted* longitudinal mixed models for the association between categories of appropriate-for-gestational age/weight-for-age status and percentage breast milk (n = 1497) and daily formula consumption (n = 1061) between birth to 6 months[†]

Empty Cell	Model 1 β (95% CI)		Model 2* β (95% CI)		Model 3* β (95% CI)	
	Percentage breast milk	Daily formula consumption	Percentage breast milk	Daily formula consumption	Percentage breast milk	Daily formula consumption
AGA-high	-14.66 (-21.02, -8.30) [†]	7.14 (4.29, 9.99) [†]	-13.42 (-19.94, -7.10) [†]	6.50 (3.68, 9.33) [†]	-11.22 (-18.06, -4.39) [†]	6.90 (3.14, 10.65) [†]
Age	-0.92 (-1.02, -0.83) [†]	0.43 (0.37, 0.49) [†]	-0.92 (-1.02, -0.83) [†]	0.43 (0.38, 0.49) [†]	-1.14 (-1.29, -0.99) [†]	0.94 (0.81, 1.07) [†]
AGA-high × age	-0.13 (-0.36, 0.10)	-0.08 (-0.20, .05)	-0.12 (-0.35, 0.11)	-0.08 (-0.20, .05)	-0.47 (-0.95, .01)	-0.15 (-0.55, 0.25)
Age ²					.01 (.00, .02) [†]	-.02 (-0.03, -.02) [†]
AGA-high × age ²					.01 (-0.00, .02)	.00 (-0.01, .01)
Model fit statistics						
Deviance	73 368	37 222	73 332	37 174	73 306	37 090
AIC	73 385	37 238	73 363	37 204	73 341	37 125
BIC	73 441	37 290	73 468	37 301	73 461	37 235

AGA-high, AGA infants with high weight-for-age.

* Models are adjusted for mother's age, prepregnancy BMI, infant sex, race/ethnicity, and PIR.

[†] P < .001.