Published in final edited form as:

Pediatrics. 2010 June ; 125(6): e1419–e1426. doi:10.1542/peds.2009-2746.

Infant Weight Gain and School-age Blood Pressure and Cognition in Former Preterm Infants

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Abstract

OBJECTIVES—More rapid infant weight gain may be associated with better neurodevelopment but also with higher blood pressure (BP). The objective of this study was to determine the extent to which infant weight gain is associated with systolic BP (SBP) and IQ at school age in former preterm, low birth weight infants.

METHODS—We studied 911 participants in the Infant Health and Development Program, an 8-center longitudinal study of children born at 37 weeks' gestation and 2500 g. Study staff weighed participants at term and at 4 and 12 months' corrected ages; measured BP 3 times at 6.5 years; and administered the Wechsler Intelligence Scale for Children, Third Edition (WISC-III), an IQ test, at 8 years. In linear regression, we modeled our exposure “infant weight gain” as the 12-month weight z score adjusted for the term weight z score.

RESULTS—Median (interquartile range) weight z score was -0.7 (-1.5 to -0.0) at 12 months. Mean $\pm$ SD SBP at 6.5 years was 104.2 ± 8.4 mm Hg, and mean $\pm$ SD WISC-III total score at 8 years was 91 ± 18 . Adjusting for child gender, age, and race and maternal education, income, age, IQ, and smoking, for each z score additional weight gain from term to 12 months, SBP was 0.7 mm Hg higher and WISC-III total score was 1.9 points higher.

CONCLUSIONS—In preterm infants, there seem to be modest neurodevelopmental advantages of more rapid weight gain in the first year of life and only small BP-related effects.

Keywords

preterm infant; infant; blood pressure; cognition; fetal programming; growth and development; postnatal growth; small for gestational age

Slow postnatal weight gain is associated with impaired neurodevelopment in former preterm infants.¹⁻⁴ Less widely appreciated is that rapid infant weight gain may have risks, including adverse cardiometabolic consequences such as higher blood pressure (BP)^{5,6} and other features of the metabolic syndrome,^{7,8} although research in this area has focused largely on term populations. In preterm infants, results of a randomized trial performed in the 1990s suggested that a trade-off may exist between neuro-cognitive benefits and adverse cardiometabolic consequences of rapid infant weight gain. In that trial, preterm infants who received a nutrient-enriched formula for 1 month after birth gained more weight and had better cognitive function in infancy and at school age^{9,10} than infants who received standard formula, but at age 13 to 16 years, they had higher diastolic BP and greater insulin resistance^{11,12}; however, that study followed only a small proportion of the original participants to adolescence and included only infants who weighed <1500 g at birth.

Most observational studies of infant weight gain and neurodevelopment in preterm infants have focused on weight gain during the NICU hospitalization and suggest that more rapid weight gain is associated with better cognitive outcomes in infancy^{2,3} and at school age⁴; however, little is known about the effect on cognitive outcomes of infant weight gain after NICU discharge. One study of infants <28 weeks' gestation found that faster weight gain from NICU discharge through age 2 years was associated with better reading scores at 8 years.¹³ Another study¹⁴ of infants who weighed <1500 g at birth found that small head size at 8 months of age predicted lower IQ and academic achievement scores at school age. We could not identify a study of infant weight gain and later cognition in preterm infants that included infants 32 weeks' gestation or 1500 g birth weight.

With respect to cardiometabolic outcomes, in term populations, rapid infant weight gain is associated with higher BP and hypertension^{5,6}; however, few data exist for preterm infants. Two studies^{15,16} of preterm infants found no association of more rapid weight gain through age 2 years with higher BP in adolescence. In contrast, in another study,¹⁷ at age 21 years, those in the highest quartile of systolic BP (SBP) had been heavier in infancy than those in the lowest quartile. None of those studies examined increments of weight gain shorter than 2 years or include larger or more mature preterm infants.

Given the large number of preterm births in the United States (12.7% of births in 2005 were preterm¹⁸), the burden of neurodevelopmental disabilities in survivors of preterm birth,¹⁹ and the epidemic problem of obesity and related disorders in our society,^{20,21} we need more information about how infant weight gain is associated both with neurodevelopment and with cardiometabolic health in preterm infants. Only by understanding both the risks and the benefits of more rapid weight gain will we be able to optimize growth and nutrition goals for this vulnerable population. The aim of this study was to examine the extent to which weight gain in the first year of life is associated with SBP and IQ at school age in a large cohort of low birth weight, preterm infants.

METHODS

Study Design and Participants

We studied participants in the Infant Health and Development Project (IHDP), an 8-center longitudinal study of preterm (< 37 completed weeks' gestation), low birth weight (< 2500 g) infants. Details of recruitment and follow-up were published previously.²² Briefly, in 1985 and 1986, the IHDP recruited infants for a randomized trial of a postdischarge early child development intervention. For multiple births, 1 child was chosen at random for the primary analyses, and the sibling was assigned to the same study group. The primary outcomes of the trial related to cognitive development, behavior, and health status. Results have been reported through age 18 years.^{22–25} Institutional review boards for all participating centers approved the study, and caregivers provided written informed consent.

For this analysis, we included IHDP participants with complete exposure and outcome data. For cognitive analyses, of the 1060 children enrolled, 957 (90%) completed the Wechsler Intelligence Scale for Children-III (WISC-III) at 8 years, and, of those, 905 also had data on term and 12-month weights. For BP analyses, eligible children were from the 7 study sites that conducted a clinical examination including BP at age 6.5 years. Of the 931 eligible children, 809 (87%) completed any part of the age 6.5 year examination and 694 had BP data. The main reason for missing BP data was that the study visit was completed by telephone or home visit rather than at the IHDP study site. Of the children with any BP data, 666 also had data on term and 12-month weights. Thus, the final sample was 911, 905 of whom we included in the cognitive analyses and 666 of whom we included in the BP analyses.

Measurements

Infant Anthropometry—IHDP study staff weighed and measured infants at term (40 weeks' post-menstrual age) and at 4 and 12 months corrected for prematurity by using a calibrated infant balance scale; recumbent length board; and standard sized, nonstretchable measuring tape for head circumference.²⁶

Child Cognition at Age 8 Years—Trained assessors who were unaware of the child's history administered the WISC-III, a comprehensive intelligence test, at the IHDP study sites.²⁴

Child BP at Age 6.5 Years—Study staff measured BP 3 times in the right arm by auscultation ($n = 156$) or automated oscillometric device ($n = 510$). The correct cuff size was chosen on the basis of the measured mid-arm circumference.

Covariates—Study staff collected data from the medical record and through interviews and questionnaires regarding parental and child demographic, social, economic, and health information. Maternal intelligence was measured by using the Peabody Picture Vocabulary Test–Revised. Gestational age (GA) was estimated by using a modification of the Ballard assessment.²⁷

Analysis

Our primary outcomes were the WISC-III scores at age 8 years and mean SBP at age 6.5 years. We chose SBP because it predicts later outcomes better than diastolic BP.²⁸ Our primary predictor was infant weight gain from term to age 12 months corrected for prematurity. Term is 40 weeks' postmenstrual age; the age corrected for prematurity is the chronological age in days minus the number of days by which the participant was born before 40 weeks. We also examined weight gain from term to 4 months and from 4 to 12 months, and we assessed infant growth in length, weight-for-length, and head circumference.

We calculated *z* scores for age for the anthropometric measurements on the basis of the Centers for Disease Control and Prevention growth charts,²⁹ comparing measurements at 4 and 12 months corrected for prematurity to the reference population at 4 and 12 months' chronological age. Similarly, we compared measurements at term in this study with the reference population at birth. Using multivariable linear regression, in our primary analysis, we modeled infant weight gain as the 12-month weight-for-age *z* score adjusted for the term weight-for-age *z* score, which represents the change from term to 12 months. We used this method in previous studies.^{6,30}

We used the same approach in secondary analyses, modeling growth as the later size *z* score adjusted for the earlier size *z* score. We also used logistic regression to calculate an adjusted odds ratio (aOR) for high BP, defined as SBP in the top gender- and BP measurement method-specific decile. We used multinomial logistic regression to calculate the odds of having a normal (>85) WISC-III total score compared with low (<70) or borderline (70 to <85).

To control for confounding, in our models, we included parental and child covariates that are associated with infant weight gain, cognition, and/or BP, including the child's gender, GA, and race/ethnicity; mother's age, smoking status, and education level; and house hold income. We also controlled for the IHDP study group (intervention versus control) and the child's exact age in days. For the cognitive analyses, we controlled for maternal IQ and for the BP analyses, the BP method (auscultation or automated device), and the child's status at BP measurement (fully cooperative, somewhat cooperative, or uncooperative). We did not include preeclampsia or gestational weight gain because adding them did not alter the effect estimates.

To assess for possible effect modification by neonatal complications, we stratified the sample by the presence or absence of any of the following: 5-minute Apgar score <5; bronchopulmonary dysplasia; necrotizing enterocolitis; or grade 3 or 4 intraventricular hemorrhage. We performed additional analyses stratified by GA (<32 weeks or ≥32 weeks), and by fetal growth status with small for GA defined as birth weight <10th percentile for GA on the basis of a contemporary national reference.³¹ We used SAS 9.1 (SAS Institute Inc, Cary, NC) for all analyses.

RESULTS

For the overall sample of 911, the median (range) birth weight was 1.87 (0.54–2.50) kg and the median (range) GA was 34.0 (25–37) weeks. Mean $\pm$ SD SBP was 104.2 ± 8.4 mm Hg (range: 71 to 143 mm Hg); mean $\pm$ SD total WISC-III score at 8 years was 91 ± 18 points (range: 40 to 147 points). Table 1 lists characteristics of the participants and their mothers in the BP and cognitive analyses. Compared with the children who were included in the BP analyses, children in the cognitive analyses were less likely to be black (53% vs 58%), but the groups were similar with respect to birth weight and GA, as well as size at term and 12 months (data not shown).

Table 2 lists z scores on the basis of Centers for Disease Control and Prevention growth charts for weight, length, weight-for-length, and head circumference. A z score of 0 represents the median for the reference population. On average, participants remained below average for weight, length, and head circumference relative to the reference population through infancy but by age 8 years had caught up to the reference population.

After controlling for child and maternal covariates (Table 3, model 2), we found that more rapid infant weight gain was associated with slightly higher SBP (0.7 mm Hg per z score weight gain [95% confidence interval [CI]: 0.1–1.3), and with moderately better cognition. For each additional z score weight gain from term to 12 months corrected for prematurity, the total WISC-III score was 1.9 points higher (95% CI: 1.0–2.8); associations of weight gain with WISC-III performance and verbal scales were similar in magnitude and direction. Figure 1 is a spline showing the adjusted association of infant weight at 12 months with mean WISC-III (Fig 1A) score and mean SBP (Fig 1B). It seems from Fig 1A that the association of 12-month weight z score with WISC-III is driven largely by the infants who were lightest at 12 months of age (ie, those with weight z score less than -2).

Adjusting for the same maternal and child covariates, compared with having a low WISC-III total score, the odds of having a normal score was 50% higher per additional z score weight gain from term to 12 months (aOR: 1.50 [95% CI: 1.18–1.90]); and compared with a borderline score, the odds of having a normal score was 32% higher (aOR: 1.32 [95% CI: 1.04–1.67]). For high SBP, the aOR was 1.02 (95% CI: 0.78–1.33), a null finding with CIs that do not exclude clinically meaningful effects.

Examining infant growth from term to 4 months of age (Table 4), the effect of weight gain and linear growth seemed to be stronger than growth in the same parameters from 4 to 12 months. From term to 4 months, associations exist with WISC-III scores for weight gain and linear growth but not weight-for-length growth, suggesting that linear growth rather than excess weight gain is driving the association of growth with WISC-III scores. We also observed small associations of weight gain and linear growth but not weight-for-length growth from term to 4 months with SBP.

From 4 to 12 months, infant head growth was associated with better cognition (2.9 WISC-III total points [95% CI: 1.8–4.0]), as was infant growth in weight-for-length (2.0 WISC-III total points [95% CI: 1.1–2.9]). Head and weight-for-length growth from 4 to 12 months seemed to have independent effects on WISC-III total score. In a model that included both

weight-for-length and head growth from 4 to 12 months, the effect of head growth on WISC-III total score was 2.5 points per *z* score (95% CI: 1.3–3.7); the effect of weight-for-length growth was 1.1 points per *z* score (95% CI: 0.1–2.0).

Table 5 shows analyses stratified by categories of GA, fetal growth, and neonatal complications. The association of term to 12-month weight gain with SBP was stronger in infants who were ≥32 weeks' gestation (1.1 mm Hg [95% CI: 0.3–1.9]) than in infants who were <32 weeks' gestation (−0.5 mm Hg [95% CI: −1.7 to 0.7]) with a borderline significant *P* value for the interaction term (.046).

DISCUSSION

In this large cohort of preterm, low birth weight infants, we found that more rapid weight gain from term to age 12 months was associated with modestly better cognitive outcomes at school age. Although small IQ differences are not clinically significant for individuals, shifting the IQ curve of a population upward by a few points can have an important impact.^{32,33} We also observed a small association of more rapid infant weight gain with school age BP that was present only among infants who were born at ≥32 weeks' gestation.

Although several studies have examined NICU weight gain^{1–3} in relation to long-term outcomes, few studies have specifically examined postdischarge weight gain in infancy, which is important to guide postdischarge nutritional support. Our finding that more rapid weight gain from term to 12 months was associated with higher IQ at school age is consistent with an Australian study of infants who were born at <28 weeks' gestation,¹³ which found that reading scores at age 8 years were 2.6 points higher per *z* score additional weight gain from discharge to age 2 years. Our study extends those findings, suggesting that the association of faster weight gain with better cognitive outcomes exists for preterm infants across the full range of gestational ages, not just in extremely preterm infants.

In contrast to our study, the Australian study¹³ did not find an association of more rapid weight gain with higher IQ; however, those authors examined weight gain averaged over 2 years, whereas we examined weight gain in 2 intervals during the first year of life. The first 2 postnatal years constitute a critical period for brain growth and development, but brain growth is particularly rapid in the first year of life. Also, certain developmental processes, such as dendritic growth, predominate in the first year.³⁴ Our findings suggest that weight gain in the first year of life, particularly in the first 4 months after term, reflects developmental processes that are more important for later IQ than processes that occur later in infancy.

We also found that infant growth in length, weight-for-length, and head circumference were associated with higher school age IQ. The association of head growth with later IQ was noted in several previous studies in preterm^{13,14} and term³⁵ populations. Our study provides new information about the timing of head growth, suggesting that the critical period for head growth with respect to later IQ for preterm infants extends at least through the end of the first year of life. Nutritional support for preterm infants currently focuses on enhancing the nutritional content of breast milk or for formula through 9 months of age,³⁶ but practices that

optimize caloric intake for older infants who consume a mixed diet that includes solid foods might also help to optimize head growth and neurodevelopmental outcomes.

With respect to infant weight gain and later BP, our results suggest that more rapid weight gain from term to age 1 year has a small influence on later BP among infants born at 32 weeks' gestation, a population that was not included in any previous study that we could identify. Two previous studies^{15,16} of former preterm infants who were <32 weeks' gestation found no correlation of infant weight z scores with BP in late adolescence. In contrast, a study¹⁷ of preterm infants who were <28 weeks' gestation found that those in the highest quartile of SBP at age 21 years had been heavier in infancy than those in the lowest BP quartile. The significance of a 1.1-mm Hg increase in BP per SD weight gain is small from a clinical standpoint but has importance at the population level with respect to prevention of hypertension and related cardiovascular diseases.³⁷

Our study is unique in that we assessed both long-term benefits and risks of more rapid weight gain in the same cohort. We measured IQ and BP at school age, when such measures are highly correlated with adult outcomes.^{38–40} Another strength is that we controlled for numerous potentially confounding variables, including maternal IQ. Also, we were able to assess relatively short periods of weight gain within the first 12 months of life, which is helpful in pinpointing critical periods for the development of BP and cognitive abilities. One limitation of our study is that the cohort was born in the 1980s, when NICU practices differed from current practices; however, even if weight gain in the cohort was different from what is seen currently, the magnitude of associations of weight gain and our outcomes may be similar. On average, mothers of the infants in our cohort represented the lower end of the socioeconomic spectrum, possibly limiting generalizability, although we studied infants from 8 centers across the United States and our cohort included preterm infants across the full range of GAs. We did not have measures of insulin resistance or other cardiovascular risk factors, so by focusing simply on BP, we may be underestimating the degree of cardiovascular risk in preterm infants that is related to infant weight gain.

CONCLUSIONS

We found that in preterm infants, more rapid weight gain from term to age 12 months was associated with moderately better cognition, as well as slightly higher BP. Increased nutritional support for preterm infants after NICU discharge might benefit long-term neurodevelopmental outcomes, with only a small effect on BP-related health.

Acknowledgments

This study was funded by NIH grants K23 DK083817, R01 HD27344, and K24 HL68041; the Robert Wood Johnson Foundation; Maternal and Child Health Bureau grants 039543, MCJ-060515, and MCJ-360593; Pew Charitable Trust grant 91-01142.

ABBREVIATIONS

BP blood pressure

SBP	systolic BP
IHDP	Infant Health and Development Program
WISC-III	Wechsler Intelligence Scale for Children, Third Edition
GA	gestational age
aOR	adjusted odds ratio

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WHAT'S KNOWN ON THIS SUBJECT

More rapid infant weight gain may have benefits, such as to neurodevelopment, as well as risks, such as higher BP. The balance of risks and benefits of rapid infant weight gain for preterm infants is poorly understood.

WHAT THIS STUDY ADDS

We found that faster weight gain in the first year of life was associated with moderately higher IQ and only slightly higher BP, suggesting that in former preterm infants, promoting faster weight gain might improve neurodevelopment with minimal BP-related effects.

FIGURE 1.

Spline plot of weight z score at age 12 months corrected for prematurity and mean WISC-III score (A) and mean SBP (B), adjusted for weight z score at term and child and maternal factors.

TABLE 1

Characteristics of 911 IHDP Participants and Their Mothers Included in Analyses of Cognition and BP

Characteristic	Included in Cognition Analyses (<i>n</i> = 905)	Included in BP Analyses (<i>n</i> = 666)
Child		
GA, median (range), wk	34 (25–37)	34 (25–37)
Birth weight, median (range), kg	1.86 (0.54–2.50)	1.87 (0.54–2.50)
SBP at 6.5 y, mean $\pm$ SD, mm Hg	104.2 $\pm$ 8.4	104.2 $\pm$ 8.4
WISC-III scores at 8 y, mean $\pm$ SD		
Performance	90 $\pm$ 17	89 $\pm$ 17
Verbal	93 $\pm$ 18	91 $\pm$ 17
Total	91 $\pm$ 18	89 $\pm$ 18
Male gender, <i>n</i> (%)	441 (48.7)	322 (48.4)
GA <32 wk, <i>n</i> (%)	246 (27.2)	177 (26.6)
GA $\geq$ 32 wk, <i>n</i> (%)	659 (72.8)	489 (73.4)
Small for GA, <i>n</i> (%) ^a	339 (37.5)	253 (38.0)
Race/ethnicity, <i>n</i> (%)		
Black	480 (53.0)	389 (58.4)
Hispanic	93 (10.3)	70 (10.5)
White	332 (36.7)	207 (31.1)
Any neonatal morbidity, <i>n</i> (%) ^b	171 (18.9)	120 (18.0)
Mother		
Age, mean $\pm$ SD, y	25.0 $\pm$ 6.0	24.6 $\pm$ 6.0
PPVT-R score, mean $\pm$ SD	81 $\pm$ 21	79 $\pm$ 20
Preeclampsia or eclampsia, <i>n</i> (%)	151 (16.7)	106 (15.9)
Smoked in pregnancy (any), <i>n</i> (%)	292 (32.3)	213 (32.0)
Education attained at study enrollment, <i>n</i> (%)		
12th grade	338 (37.4)	277 (41.6)
High school graduate	262 (29.0)	197 (29.6)
Some college or more	305 (33.7)	192 (28.8)
Income at study enrollment, <i>n</i> (%)		
<\$15 000	239 (26.4)	192 (28.8)
\$15 000 to <\$35 000	281 (31.1)	216 (32.4)
>\$35 000	267 (29.5)	172 (25.8)
Do not know/refused/missing	118 (13.0)	86 (12.9)

PPVT-R indicates Peabody Picture Vocabulary Test–Revised.

^aBirth weight for GA <10th percentile on the basis of a national reference.³¹^bFive-minute Apgar <5, grade 3 or 4 intraventricular hemorrhage, bronchopulmonary dysplasia, or necrotizing enterocolitis.

TABLE 2

Measures of Infant and School-age Size in Z Scores for 911 IHDP Participants

Measure	Z Score for Chronological Age, Median (IQR)	Z Score for Corrected Age, Median (IQR)
Weight		
Term	-2.4 (-3.3 to -1.9)	-0.6 (-1.3 to 0.1)
4 mo	-1.2 (-2.0 to -0.5)	-0.2 (-0.9 to 0.5)
12 mo	-1.1 (-2.0 to -0.4)	-0.7 (-1.5 to -0.0)
6.5 y	-0.2 (-0.9 to 0.5)	-0.1 (-0.8 to 0.6)
8y	-0.0 (-0.8 to 0.7)	0.1 (-0.7 to 0.8)
Length or height		
Term	-3.0 (-4.4 to -2.1)	-0.1 (-1.0 to 0.4)
4 mo	-1.5 (-2.3 to -0.8)	-0.3 (-1.0 to 0.3)
12 mo	-0.8 (-1.5 to -0.2)	-0.3 (-0.8 to 0.4)
6.5 y	-0.3 (-0.9 to 0.3)	-0.1 (-0.8 to 0.5)
8y	-0.3 (-1.0 to 0.3)	-0.2 (-0.8 to 0.5)
Weight-for-length or BMI		
Term	-0.1 (-0.8 to 0.7)	-0.1 (-0.8 to 0.7)
4 mo	0.1 (-0.6 to 0.8)	0.1 (-0.6 to 0.8)
12 mo	-0.2 (-1.0 to 0.5)	-0.2 (-1.0 to 0.5)
6.5 y	-0.0 (-0.8 to 0.7)	-0.0 (-0.8 to 0.7)
8y	0.1 (-0.6 to 0.8)	0.1 (-0.6 to 0.8)
Head circumference		
Term	-2.3 (-3.1 to -1.6)	-0.1 (-0.8 to 0.5)
4 mo	-1.0 (-1.6 to -0.3)	-0.0 (-0.7 to 0.6)
12 mo	-0.1 (-0.9 to 0.6)	0.3 (-0.5 to 0.9)

Z scores were derived from a contemporary national reference²⁹ according to chronological age and age corrected for preterm birth, which is the participant's age in days minus the number of days by which the participant was born before 40 weeks' gestation. IQR indicates interquartile range.

TABLE 3

Associations of Infant Weight Gain From Term to 12 Months With School-age SBP and IQ

Parameter	SBP, mm Hg	WISC-III Score		
		Performance	Verbal	Total
Model 1: child age and gender	0.8 (0.2–1.4)	1.8 (0.8–2.9)	1.9 (0.8–3.0)	2.1 (1.0–3.2)
Model 2: model 1 + maternal and child factors ^a	0.7 (0.1–1.3)	1.7 (0.8–2.6)	1.7 (0.8–2.6)	1.9 (1.0–2.8)

Data are the increment in SBP or WISC-III score per *z* score additional weight gain and 95% CIs. Term represents 40 weeks' postmenstrual age, and age 12 months is adjusted for preterm birth.

^a Child GA, race, IHDP treatment group, BP measurement device (for BP analyses), and IQ (for WISC-III analyses); maternal age, education level, smoking status; and household income.

TABLE 4

Adjusted Associations of Weight Gain and Growth During Various Periods in Infancy With School-age SBP and IQ

Parameter	SBP, mm Hg	WISC-III Score		
		Performance	Verbal	Total
Weight gain				
Term-12 mo	0.7 (0.1 to 1.3)	1.7 (0.8 to 2.6)	1.7 (0.8 to 2.6)	1.9 (1.0 to 2.8)
Term-4 mo	1.0 (0.2 to 1.7)	2.1 (1.0 to 3.1)	1.8 (0.8 to 2.8)	2.1 (1.1 to 3.1)
4-12 mo	0.1 (-0.8 to 1.1)	0.8 (-0.5 to 2.1)	1.0 (-0.3 to 2.3)	1.0 (-0.2 to 2.3)
Head circumference				
Term-12 mo	0.3 (-0.4 to 1.0)	2.0 (1.1 to 3.0)	2.1 (1.1 to 3.0)	2.3 (1.3 to 3.2)
Term-4 mo	-0.6 (-1.2 to 0.0)	1.0 (0.0 to 1.9)	0.8 (-0.1 to 1.7)	0.9 (0.0 to 1.9)
4-12 mo	0.9 (0.2 to 1.7)	2.4 (1.3 to 3.5)	2.8 (1.7 to 3.9)	2.9 (1.8 to 4.0)
Length				
Term-12 mo	0.4 (-0.4 to 1.2)	1.0 (-0.1 to 2.1)	1.5 (0.4 to 2.6)	1.4 (0.3 to 2.4)
Term-4 mo	1.2 (0.4 to 1.9)	2.0 (0.8 to 3.1)	2.4 (1.3 to 3.5)	2.4 (1.3 to 3.5)
4-12 mo	-0.4 (-1.3 to 0.5)	-0.0 (-1.3 to 1.3)	0.3 (-1.0 to 1.6)	0.2 (-1.1 to 1.4)
Weight-for-length				
Term-12 mo	0.6 (-0.0 to 1.1)	1.4 (0.5 to 2.3)	1.3 (0.5 to 2.2)	1.5 (0.6 to 2.3)
Term-4 mo	0.1 (-0.5 to 0.7)	0.8 (-0.1 to 1.7)	0.5 (-0.3 to 1.4)	0.7 (-0.1 to 1.6)
4-12 mo	0.8 (0.1 to 1.4)	1.7 (0.8 to 2.7)	1.9 (0.9 to 2.8)	2.0 (1.1 to 2.9)

Data are the increment in SBP or WISC-III score per *z* score additional growth in the given time interval and 95% CIs. Term represents 40 weeks' postmenstrual age, and other ages are adjusted for preterm birth. Estimates are adjusted for child and maternal factors.

TABLE 5

Adjusted Associations of Infant Weight Gain From Term to 12 Months With School-age SBP and Cognition According to GA, Fetal Growth, and Neonatal Complications

Parameter	SBP, mmHg	WISC-III Score		
		Performance	Verbal	Total
GA category, wk ^a				
<32	−0.5 (−1.7 to 0.7)	1.4 (−0.7 to 3.5)	1.2 (−0.9 to 3.4)	1.4 (−0.7 to 3.5)
32	1.1 (0.3 to 1.9)	1.0 (−0.0 to 2.1)	1.3 (0.2 to 2.3)	1.3 (0.2 to 2.3)
Fetal growth category ^b				
SGA, <10th percentile	1.0 (−0.1 to 2.0)	1.5 (0.0 to 3.0)	1.6 (0.1 to 3.1)	1.7 (0.3 to 3.2)
AGA/LGA, 10th percentile	0.6 (−0.3 to 1.4)	1.0 (−0.3 to 2.2)	0.9 (−0.3 to 2.2)	1.0 (−0.2 to 2.2)
Neonatal complications ^c				
Yes	0.5 (−1.3 to 2.3)	2.2 (−0.5 to 4.9)	2.8 (0.2 to 5.5)	2.8 (0.2 to 5.5)
No	0.7 (−0.0 to 1.4)	0.8 (−0.2 to 1.8)	0.8 (−0.2 to 1.8)	0.8 (−0.1 to 1.8)

Data are the increment in SBP or WISC-III score per *z* score additional weight gain from term to 12 months and 95% CIs. Estimates are adjusted for child and maternal factors, for GA and fetal growth categories, and for presence or absence of neonatal complications. SGA indicates small for GA; AGA, appropriate for GA; LGA, large for GA.

^a*P* = .049 for interaction.

^bBirth weight for GA percentile on the basis of a contemporary national reference.³¹

^cNeonatal complications include grade 3 or 4 intraventricular hemorrhage, necrotizing enterocolitis, bronchopulmonary dysplasia, and 5-minute Apgar <5.