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The impact of prepregnancy obesity on children's cognitive test scores

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Abstract

Objective—To examine the association between maternal prepregnancy obesity and cognitive test scores of children at early primary school age.

Methods—A descriptive observational design was used. Study subjects consist of 3412 US children aged 60 to 83 months from the National Longitudinal Survey of Youth 1979 Mother and Child Survey. Cognitive test scores using the Peabody Individual Achievement Test reading recognition and mathematics tests were used as the outcomes of interest. Association with maternal prepregnancy obesity was examined using the ordinary least square regression controlling for intrauterine, family background, maternal and child factors.

Results—Children of obese women had 3 points (0.23 SD units) lower PIAT reading recognition score ($p=0.007$), and 2 points (0.16 SD units) lower PIAT mathematics scores ($p<.0001$), holding all other factors constant. As expected, cognitive test score was associated with stimulating home environment (reading: $\beta=0.15$, $p<.0001$, and math: $\beta=0.15$, $p<.0001$), household income (reading: $\beta=0.03$, $p=0.02$ and math: $\beta=0.04$, $p=0.004$), maternal education (reading: $\beta=0.42$, $p=0.0005$, and math: $\beta=0.32$, $p=0.008$), and maternal cognitive skills (reading: $\beta=0.11$, $p<.0001$, and math: $\beta=0.09$, $p<.0001$).

Conclusion—There was a significant association between maternal prepregnancy obesity and child cognitive test scores that could not be explained by other intrauterine, family background, maternal, and child factors. Children who live in disadvantaged postnatal environments may be most affected by the effects of maternal prepregnancy obesity. Replications of the current study using different cohorts are warranted to confirm the association between maternal prepregnancy obesity and child cognitive test scores.

Keywords

maternal obesity; prepregnancy BMI; cognitive skills; life-course; NLSY

INTRODUCTION

There is growing concern about the potential ill effects of maternal obesity on offspring health (1). In the United States, more than 30% of reproductive aged women are obese (body mass index ≥ 30 kg/m^2), and the impact of maternal obesity on fetal brain development is unclear. The brain undergoes rapid development during the fetal period and early childhood. Any insult during this critical period of brain development may be detrimental for individuals' central nervous system development. Animal studies have shown that maternal

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prepregnancy obesity induced by high-fat-diet consumption is associated with alterations in maze performance among the offspring (2, 3, 4). Those studies have also revealed marked elevations in inflammatory markers in the brain (2, 4), and morphological changes in hippocampal neurons with shorter and decreased number of dendrites (3). In humans, influences from post-natal environment and heterogeneity of individual characteristics often complicate the examination of the association between maternal obesity and offspring's cognitive skills. A few studies examining these associations have produced mixed results (5, 6). Brion and colleagues (5) have found inconsistent evidence for the intrauterine effects of maternal prepregnancy overweight/obesity on a child's cognitive skill using two European cohorts. In contrast, Neggers and colleagues (6) have shown the association between maternal prepregnancy obesity and reduction in child IQ scores among low-income African American population.

Numerous studies examined factors associated with children's cognitive development. For example, using mother-child intergenerational data, Batty and colleagues (7) showed a complete attenuation in the association between maternal smoking during pregnancy and a child's cognitive skill after adjusting for maternal Armed Force Qualification Test (AFQT) scores and education using samples from the National Longitudinal Survey of Youth (NLSY). The same authors (8) found no independent association between breast feeding on child cognitive ability. Yang and colleagues (9), comparing within- and between-family associations, found that family characteristics, rather than birth weight, largely accounted for child cognitive test scores. Economic researchers utilized the rich information on postnatal social environment, and demonstrated the robust effects of income, home environment, home structure, and postnatal growth on child cognitive development (10, 11, 12). However, no other studies have examined the association between maternal prepregnancy obesity and a child's cognitive skill.

The aim of this study was to examine the association between maternal prepregnancy weight status and child cognitive skills at primary school age using a life-course approach. There are two major benefits of using the life-course approach for research: 1) the emphasis on early life experiences and cumulative risk exposure, and 2) the ability to examine interaction between experience and risk with biological regulatory mechanisms and environmental context across the lifespan (13). We hypothesized that maternal high BMI prior to conception lowers a child's cognitive test score after controlling for other intrauterine factors, family background, maternal and child factors.

METHODS AND PROCEDURES

Data Source

We used data from the National Longitudinal Survey of Youth (NLSY) Mother and Child Survey. The NLSY has been widely used for social and health research. The NLSY original cohort (NLSY79) included a nationally representative sample of 12,686 men and women who were 14 to 21 years of age on December 31, 1978. Annual interviews have been completed with these respondents from 1979 until 1994, and biennial interviews thereafter. In 1986, the U.S. Bureau of Labor Statistics established a biennial survey to assess all biological children (NLSY-Children) born to female respondents of NLSY79 cohort on a variety of subjects.

Study Samples

Our study sample consisted of NLSY-Children who were term birth (37≤gestational age≤42 weeks), aged between 60 and 83 months at the time of their biennial interview, and whose Peabody Picture Vocabulary Test (PPVT) age was greater than 60 months. All age-eligible children from survey years between 1986 and 2008 (n=6638) were pooled. The analysis was limited to full-term birth children (n=5236) to avoid any influence from prematurity or post-maturity on brain development. Exclusion criteria included: (1) mother-reported health conditions such as seizure disorder (n=12), mental retardation (n=12), and “heart problem” (n=9); (2) implausible birth weight (<500 grams; n=221); (3) missing information on Peabody individual Achievement Test (PIAT) reading recognition and mathematics scores (n=604 missing reading scores, n=378 missing mathematics scores, n=6 missing both due to missed interviews), Home Observation for the Measurement of the Environment-short form (HOME-SF) cognitive stimulation subset scores (n=148), per-capita income (n=50), mother’s AFQT scores (n=179), maternal prepregnancy BMI (n=79), maternal pregnancy weight gain (n=106), child BMI z-score at testing (n=717); or (4) invalid BMI percentile for age and gender using the Center for Disease Control and Prevention (CDC) growth charts program (n=123). The final study sample consisted of 3412 (65.2%) children who had complete data on cognitive test scores, maternal prenatal information, family background, and maternal and child’s information.

Measures

All variables used in the analysis are presented in Table 1. We reviewed children’s cognitive development studies to guide covariate selection. We organized variables into four broad areas of influence using Halfon and Hochstein’s Life Course Health Development framework (13). These areas are intrauterine factors, family background, prenatal and postnatal maternal factors, and child factors. Selected variables are described below.

The PIAT mathematics and reading recognition scores were used to assess children’s cognitive skills. The PIAT has been widely used in research, and has shown relatively high validity and reliability (KR-20 >0.90) (14). In addition, the PIAT demonstrates a moderate to high correlation with the Wechsler Intelligent Scale for Children-Revised (WISC-R; e.g. PIAT mathematics and WISC-R performance IQ, r=0.76 and PIAT reading recognition and WISC-R verbal IQ, r=0.71) (15). The NLSY provided standardized scores were used, with a mean of 100 and a standard deviation (SD) of 15.

Mother’s prepregnancy body mass index (BMI) was calculated from reported height and prepregnancy weight. Subsequently, mothers’ BMI was categorized into four groups according to the World Health Organization classification: underweight (BMI<18.5), normal weight (18.5≤BMI<25), overweight (25≤BMI<30), and obese (30≤BMI). Mother-reported weight changes for each pregnancy was used to categorize gestational weight gain according to the 2009 Institute of Medicine (IOM) recommendation (16). Child’s birth weight and gestational age were obtained from the mother’s report.

HOME-SF is a shorter version of the HOME inventory developed by Caldwell and Bradley (17), and a unique observational measure of the quality of the cognitive stimulation and emotional support by a child’s family (18). The NLSY provided age-based standardized HOME-SF cognitive stimulation scores were used, which has a mean of 100 and an SD of 15. An average HOME-SF cognitive stimulation score for a child’s entire observation window was calculated and used as a permanent measure of cognitive stimulation at home. For household income, an average per-capita income deflated to 2008 US dollars for a child’s entire observation window was used. For maternal genetic endowment or maternal cognitive skills, the NLSY provided age-adjusted AFQT percentile scores were used.

Child height z-score was derived from mother-reported and interviewer-measured height using the CDC growth charts program. Child BMI z-score and BMI percentile were derived from mother-reported and interviewer-measured height and weight. Of the study sample’s height and weight data, 71.6% of height and 65.2% of weight were interviewer-measured.

Statistical Analysis

Dependent variables were PIAT reading recognition and mathematics scores. The primary independent variable was maternal prepregnancy obesity. Ordinary least squares (OLS) regression was used to estimate the association between PIAT scores and maternal prepregnancy BMI categories, adjusting for intrauterine factors, family background, maternal and child factors. We adjusted for PIAT assessment year due to a secular trend in increasing test scores over time. Because siblings were present in the sample, standard errors were corrected for clustering by family level using the Huber-White sandwich method. We assessed for multicollinearity in the OLS regressions. A variance inflation of greater than 10 indicates serious multicollinearity (19); however, our diagnostics did not indicate serious multicollinearity in our models. All analyses were performed using SAS (SAS Institute Inc., Cary, NC) version 9.2.

RESULTS

Table 2 shows characteristics of the study sample. The mean PIAT reading recognition score was 106.1 (SD=13.5), and the mean PIAT mathematics score was 99.9 (SD=13.6). More than half of children were of Hispanic (20.4%) or African American (30.2%) origins. Children were equal in gender ratio, and 42% were first born. The mean real per-capita income was $15,840 (SD= 20,510) measured in constant 2008 US dollars. A majority of mothers (75.7%) had 12 – 15 years of education, 4.9% with less than high school, and 19.4% with at least 16 years of education. More than half (65.6%) of mothers had normal BMI before pregnancy, and only 9.6% were obese. Nearly half (44.6%) of mothers gained above the 2009 IOM recommended weight gain during pregnancy. The mean weight gains among overweight and obese women were 14.0kg (SD=6.8) and 12.4kg (SD=7.7) respectively. Of mothers who gained above the IOM recommendation, 12.3% were obese, 25.4% overweight, 57.9% normal BMI, and 4.4% underweight.

Children in the study sample were not different from those who were excluded in birth weight, gender, birth order, mothers' pregnancy weight gain and prepregnancy BMI categories. However, excluded children were more likely to be older in PPVT-age, but younger in chronological age, have lower PIAT reading and mathematics scores, and more likely to be of Hispanic origins. Compared to those included, mothers of excluded children were more likely to be older and less educated, have lower AFQT scores, and provide less stimulating home environment.

Table 3 shows the results of OLS regression for PIAT reading and mathematics score. One specification included child height z-score; another specification included child BMI z-score. Overall, our models explained 21–25% of variance for cognitive test scores. Maternal prepregnancy obesity, but not overweight, was negatively associated with cognitive test scores in both specifications. Using height z-score (Table 3 Columns 1 & 3) and holding all other factors constant, children of obese women was associated with 0.23 SD units lower PIAT reading recognition score and 0.16 SD units lower PIAT mathematics score compared to those of normal weight women. Maternal gestational weight gain was not an independent factor for cognitive test scores. A linear term for birth weight was not a significant predictor for PIAT reading score (β=0.67, p=0.13), but a quadratic relation between birth weight and PIAT mathematics score was present. Using height z-score as a covariate, PIAT mathematics score increased with increasing birth weight until approximately 3.58kg, and then decreased with increasing birth weight. For example, an increase in birth weight from 3.75kg to 4kg resulted in 0.2 points (or 0.01 SD units) lower PIAT mathematics score, holding all other factors constant. An increase in birth weight further from 4kg to 4.5kg resulted in 1.0 point (or 0.07 SD units) lower PIAT mathematics score.

Both HOME-SF score and income were positively associated with cognitive test scores after adjusting for all other factors. Maternal education and AFQT scores were also positively associated with cognitive test scores. Maternal age at childbirth was positively associated with mathematics scores only. Female gender and first-born were positively associated with higher test scores. Child height z-score was positively associated with cognitive test scores. Race/ethnicity was also associated with cognitive test score. There was no significant interaction among any of the variables used.

Of note, as shown in Table 3 columns 2 and 4, child BMI z-score was not an independent predictor for PIAT reading recognition scores (β=0.19, p=0.17), and the association between BMI z-score and PIAT mathematics score was significant only at the 5% level (β=0.34, p=0.02). When child BMI percentile was categorized and entered in the model, an association between cognitive test scores and child BMI categories did not emerge. Inclusion of child BMI z-score or BMI categories did not affect the magnitude of the effect of maternal prepregnancy obesity.

DISCUSSION

Results indicate that among generally healthy primary school aged children of term birth, maternal prepregnancy obesity is associated with reductions in cognitive test scores after adjusting for other intrauterine factors, family background, and maternal and child factors. The association is consistent in both PIAT reading recognition and mathematics scores. We repeated our analyses excluding all children who had any health conditions that limited school attendance, schoolwork, or physical activities, yet found similar estimates. Adjustment for maternal smoking during pregnancy, breastfeeding, gestational age, and maternal marital status did not change the estimates substantially. Although test scores reductions of 2–3 points sound small, our results indicate that the effect of maternal prepregnancy obesity is equivalent to a decrease of seven years of education for both reading and math scores. The effect on reading (math) scores of a 1-point increase in HOME-SF score was equivalent to a $5,000 ($3,750) increase in income.

Maternal prepregnancy obesity is associated with various congenital anomalies, such as neural tube defects (20) and congenital heart defects (21). The alarming increasing prevalence in obesity among women of reproductive age may affect cognition and health of future generations. For example, a recent Finnish study showed an increased incidence of mild intellectual disability among children of obese mothers (22). However, studies examining the association between maternal prepregnancy obesity and cognitive test scores among generally healthy children have produced inconsistent results due to differences in socioeconomic characteristics and prevalence of obesity in study cohorts, as well as methodological differences (5, 6).

The results on the effects of maternal prepregnancy obesity were consistent with those by Neggers and colleagues (6), who first documented a negative association between IQ and maternal prepregnancy obesity among a low-income African American population. Since maternal prepregnancy obesity did not interact with any of race/ethnicity groups, this indicates that effects of maternal obesity were not confined to African American populations but remain equally applicable to other racial/ethnic groups. Our results differ from Brion and colleagues (5), who found no consistent association between cognitive test scores and maternal overweight and obesity in two European cohorts. Brion and colleagues (5) combined obesity and overweight categories, which may have masked the effect of maternal prepregnancy obesity on children’s cognitive development. Both Neggers’ and the current study did not find an independent effect of maternal overweight on children’s cognition. We recommend confirmatory studies with different cohorts using similar analytical methodologies.

Pregnancy and birth complications are more common with excessive gestational weight gain (23), and therefore, weight gain during pregnancy is a significant health concern for both mother and child. Excessive gestational weight gain alone is an independent factor for a number of adverse neonatal outcomes (24), which may lead to delayed child cognitive development. However, results of the current study did not demonstrate an association between maternal gestational weight gain above the IOM recommendation and cognitive test scores in our sample.

Studies examining the relationship between birth weight and children's cognitive test scores have produced mixed results. A few studies have found a quadratic relation (25) and other studies have found a linear relation (9, 26), or no relation at all (27). Direct comparison of each study is difficult due to the methodological differences, but a systematic review of the studies examining the association between birth weight and cognitive skills has shown a linear relation with inconsistent results at a higher end of birth weight (28). In the current study, we found a linear association between birth weight and reading scores, whereas math scores followed a quadratic association. It is possible that certain biological characteristics unique to obese women influence fetal brain development, but do not necessarily alter fetal growth. If true, the obstetrical standard of early delivery to avoid large birth size would not change the outcome of children's cognitive skills.

Mechanisms for the association between maternal obesity and reduction in children's cognitive skills are not clear. However, it has been speculated that insulin receptors in the brain bind with neurotrophic factors (29); hence, restricting neuronal cell growths and synapse formations. Fetal insulin resistance as well as altered metabolic regulations, often found among neonates of obese as well as diabetic women (30, 31), may work to impede neuronal growth of the fetal brain.

As shown in results of the current study as well as those from many other previous studies, genetic endowment and the postnatal environment have strong influences on development of children's cognitive skills. The postnatal home environment is a powerful factor of child cognitive development in early age (12). In particular, poverty limits parental ability to provide a stimulating early home environment (10). While income and parental genetic endowment are nonetheless important for child cognitive development, these effects are mediated by home environment (12). In addition, racial differences found in scholastic test scores are largely accounted for by disadvantaged early home environment (32). While maternal age at childbirth *per se* may not be a causal factor, children born to young mothers are more likely to have disadvantaged family background (33), thus are more likely to have lower cognitive skills.

The extent of recovery from an insult by maternal obesity undoubtedly depends on postnatal environment. These insults may have the greatest impact on children who live in disadvantaged home environments. With risk factors accumulated in childhood, a chance of recovery will likely decrease among children living in disadvantaged environment. In other words, early investment in the health of children before they are born could result in amplifying differences in the cognitive outcomes between children of advantaged and disadvantaged parents.

Strength of our study was that we were able to control for a number of confounding factors shown to have strong influence on development of cognitive skills in children: intrauterine, family background, maternal, and child factors. We also used permanent measures of family functions, which has been demonstrated to be a better predictor for child cognitive outcomes than point-in-time measures (10). Our study also has some limitations. First, we did not have information on paternal cognitive skills and maternal gestational diabetes. We do not know how much gestational diabetes accounts for the association between maternal obesity and children's cognitive test scores. It is possible that there may be other omitted variables. Second, our results are limited to cognitive skills in reading and mathematics; therefore, generalization to other domains of cognition may be limited. Finally, we may have introduced sampling bias because missing data did not appear to occur at random.

In summary, we found that maternal prepregnancy obesity was associated with a reduction in cognitive test scores among generally healthy children from term birth. The magnitude of the reduction due to prepregnancy obesity is large compared to magnitude of the changes in income or education that would be required to produce a comparable effect. Compounded with an adverse childhood environment, a large and long-term impact on child's future may result. Thus, it is imperative for practitioners and policy makers to encourage young women to maintain a healthy weight prior to conception, promote weight reduction after each child, and provide easy access to an early supportive postnatal environment for children. We recommend study replication with different cohorts using analytic methodologies prior to translating findings into practice.

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Table 1

Measures

MEASURES	**Description**
Children’s cognitive skills	
PIAT mathematics score	84 multiple-choice items. Standardized to have mean of 100 and standard deviation of 15
PIAT reading recognition score	84 words for a child to read silently, then say it aloud. Standardized to have a mean of 100 and standard deviation of 15.
Intrauterine factors	
Maternal prepregnancy BMI	Calculated from self-reported adult height and weight just before each pregnancy. Categorized to underweight, normal weight, overweight, and obese according to the World Health Organization BMI categories.
Maternal gestational weight gain	Reported weight changes of mother during each pregnancy: categorized into below, within, and above recommendation using the 2009 IOM Guideline according to prepregnancy BMI categories.
Birth weight	Mother reported birth weight in kilograms.
Family background	
HOME-SF cognitive stimulation score	A permanent measure constructed from HOME-SF cognitive stimulation subscale by averaging all scores of a child over entire observation window. Questions and raw scores differ by age groups (less than 3 years, ages 3 – 5, ages 6 – 9, and ages 10 – 14). Some items of the HOME-SF included: numbers of books or toys child has, how many times child gets out of house, how many times child eats meals with both parents, and if the play environment is safe.
Household income in 2008 US dollars	A permanent measure constructed from household income and number of persons in the household deflated to 2008 US dollars. It is an average of per-capita income from birth of a child to the age of his/her PIAT assessment.
Maternal factors	
Education	Expressed as maximum years of education completed
Cognitive skills	Age adjusted percentile score of Armed Force Qualification Test (AFQT). Developed by the Department of Defense, and a measure of trainability and a primary criterion of enlistment eligibility for the Armed Forces. Four areas of ASVAB, arithmetic reasoning, word knowledge, paragraph comprehension, and mathematics knowledge, make up AFQT scores.
Age of mother at birth of child	Reported in years.
Child factors	
Gender	Male vs. female (female=1)
Height at PIAT assessment	Height percentile for age and gender, calculated from mother reported or measured height using the CDC growth chart program.
PPVT age of child at PIAT assessment	Reported in months. Determined by the Peabody Picture Vocabulary Test score. PPVT> 60mon is the eligibility for the PIAT assessment.
Birth order	Dichotomous measure: first child =1
Race/ethnicity	Mother reported race/ethnicity: Hispanic, African American, White, and Asian.

Table 2

Characteristics of Study Sample (n=3412)

Characteristic	Mean	(SD)	Median	Range	n	(%)
Child						
PIAT mathematics score	99.9	(13.6)	101	65 – 135		
PIAT reading recognition score	106.1	(13.5)	105	65 – 135		
Birth weight, kg	3.42	(0. 51)	3.4	0.9 – 6.5		
Height z-score at testing	0.24	(1.3)	0.3	−6.4 – 6.4		
Height, cm	116.1	(7.6)	116.8	88.9 – 152.4		
BMI z-score at testing	−0.06	(1.5)	0.09	−5.9 – 3.4		
Age at testing, month	71.5	(6.7)	72	60 – 83		
PPVT age at testing, month	71.8	(7.7)	72	60 – 108		
Female					1688	(49.5)
First born					1416	(41.5)
Race/ethnicity						
Hispanic					697	(20.4)
African American					1030	(30.2)
White					1658	(48.6)
Asian					27	(0.8)
Family Background						
Average Home-SF score	97.6	(13.7)	100	22 – 129		
Average per-capita income (in 2008 US $1000)	15.8	(20.5)	11.2	0 – 293		
Mother						
Education, year	13.3	(2.4)	12	0 – 20		
AFQT percentile score	39.4	(27.9)	35	0 – 100		
Age at child birth, year	25.4	(5.0)	25	15 – 41		
Prepregnancy BMI (kg/m^2)						
BMI<18.5, underweight					247	(7.2)
18.5≤BMI<25, normal weight					2239	(65.6)
25≤ BMI<30, overweight					599	(17.6)
30≤ BMI, obese					327	(9.6)
Gestational Weight Gain						

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Characteristic	Mean	(SD)	Median	Range	n	(%)
below IOM recommendation					843	(24.7)
within IOM recommendation					1046	(30.7)
above IOM recommendation					1523	(44.6)

PIAT mathematics, reading recognition, HOME-SF scores are standardized to a mean of 100 and an SD of 15. Pregnancy weight gain categories were determined by amount of weight gain for each prepregnancy BMI category.

Table 3

Associations between Cognitive Test Scores and Maternal Prepregnancy Weight Status and Gestational Weight Gain among Children ages 60–83 months of the NLSY79-C cohort

	PIAT Reading Recognition		PIAT Mathematics	
	(1) Included height	(2) Included BMI	(3) Included height	(4) Included BMI
Variable	**β(se)**	**β (se)**	**β(se)**	**β(se)**
Intrauterine Factors				
Prepregnancy BMI				
Underweight	−0.36(0.80)	−0.34 (0.80)	−0.75(0.87)	−0.70(0.87)
Overweight	−0.73(0.59)	−0.81 (0.59)	−0.68(0.57)	−0.81(0.57)
Obese	−3.05(0.79) ***	−3.14 (0.80) ***	−2.22(0.82) **	−2.37(0.83) **
Gestational Weight Gain				
Above recommendation	−0.54(0.49)	−0.53 (0.49)	−0.49(0.50)	−0.48(0.50)
Birth weight in kg	6.47(3.21) *	6.62 (3.18) *	11.11(2.91) ***	11.33(2.87) ***
Birth weight squared	−0.85(0.46)	−0.86 (0.46)	−1.55(0.42) ***	−1.56(0.42) ***
Family Background				
HOME-SF score	0.15(0.02) ***	0.15 (0.02) ***	0.15(0.02) ***	0.15(0.02) ***
Per-capita income in $1K	0.03(0.01) *	0.03 (0.01) *	0.04(0.01) *	0.04(0.01) **
Maternal Factors				
Education in years	0.42(0.12) ***	0.42 (0.12) ***	0.32(0.12) **	0.33(0.12) **
AFQT score	0.11(0.01) ***	0.11 (0.01) ***	0.09(0.01) ***	0.09(0.01) ***
Age at child birth	0.07(0.10)	0.07 (0.10)	0.22(0.11) *	0.23(0.11) *
Child Factors				
Female gender	3.07(0.40) ***	3.01 (0.41) ***	1.41(0.42) *	1.31(0.42) **
Height z-score	0.32(0.16) *	--	0.41(0.16) ***	--
BMI z-score	--	0.19 (0.14)	--	0.34(0.14) *
First-born child	2.70(0.47) ***	2.72 (0.47) ***	0.70(0.48) *	0.71(0.48)
Race/ethnicity				
Hispanic	0.07(0.61)	0.01 (0.61)	−2.21(0.63) ***	−2.29(0.63) ***
African American	3.34(0.60) ***	3.40 (0.60) ***	−2.42(0.63) ***	−2.37(0.63) ***
Asian	4.12(1.90) *	4.10 (1.90) *	1.95(1.84)	1.89(1.87)
R^2	0.25	0.25	0.21	0.21
N	3412	3412	3412	3412

Significant at

* α=0.05,

** α=0.01,

*** α=0.001 levels.

All standard errors were calculated correcting sibling clustering.

Estimates were also adjusted for maternal weight gain below IOM recommendation, child's PPVT age in months at cognitive testing, and year of cognitive testing.

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