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Biological and Environmental Predictors of Behavioral Sequelae in Children Born Preterm

Amy L. Conrad, PhD^a, Lynn Richman, PhD^b, Scott Lindgren, PhD^b, and Peg Nopoulos, MD^a

^aDepartment of Psychiatry Research, University of Iowa College of Medicine, Iowa City, Iowa

^bDepartment of Pediatrics, University of Iowa Children's Hospital, Iowa City, Iowa

Abstract

OBJECTIVE—By using behavioral outcome measures of children who were born preterm, we evaluated differences between children who were born at term and children who were born at extremely low (ELBW; <1000 g) and very low birth weights (VLBW; 1000–1499 g) and assessed the relationship of birth weight, socioeconomic status, and cognitive ability to behavioral outcome.

METHODS—We studied a total of 104 children (aged 7–16 years). Of these, 49 had a preterm birth (31 of ELBW and 18 of VLBW). The remaining 55 were healthy control subjects. Children were administered tests of cognitive ability. Parents and teachers completed behavioral assessments. Multivariate analyses of covariance assessed differences between children who were born at term and those who were born of ELBW and of VLBW on behavioral measures. Hierarchical linear regressions were used to assess relationships among biological (birth weight), environmental (socioeconomic status), intellectual, and behavioral variables.

RESULTS—Children who were born at term had fewer parent reports of hyperactivity/inattention and depression/anxiety symptoms than children of ELBW and VLBW. Teacher ratings were not significant between groups. Birth weight was consistently the strongest predictor of parent ratings of behavioral outcome, and intelligence level did not seem to mediate this relationship.

CONCLUSIONS—Negative behavioral sequelae of preterm birth remain significant in middle childhood and adolescence, although the contribution of multiple factors to neurobehavioral outcome is complex. Research to assess these relationships, integrated with anatomic and functional neuroimaging, is needed to advance knowledge and improve outcomes for children who are born preterm.

Keywords

prematurity; behavior; predictors

The number of children who survive preterm birth has increased, whereas the birth weight and gestational age of surviving children has decreased. Questions have been raised about the longer term sequelae that these children may experience in late childhood and

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Address correspondence to Amy L. Conrad, PhD, University of Iowa Hospitals and Clinics, Department of Psychiatry Research, W 278 GH, 200 Hawkins Dr, Iowa City, IA 52242. amy-l-conrad@uiowa.edu.

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adolescence. Research has found depressed IQ, increased need for special services in school, and higher rates of behavioral problems.^{1–5} Research on behavioral concerns has been inconsistent, with some reporting significant problems across externalizing, internalizing, and hyperactivity/inattention domains^{1,3,4,6,7} and others only in internalizing and inattentive domains.² Regardless of which domains are more affected, these problems are often not identified until school age.⁸

Because children are surviving at lower birth weights and earlier gestational ages, research has also explored the hypothesis that these late effects will be more severe in the smallest and youngest children. Some research has shown a gradient effect, whereby children of extremely low birth weight (ELBW; <1000 g) perform lower than those of very low birth weight (VLBW; 1000–1499 g), who perform lower than term control subjects on measures of intelligence, behavior, and achievement.³ Others have not found differences between groups on the basis of birth weight.⁸

The effect of birth weight on functioning may be inconsistent, because biological factors alone may not dictate long-term effects. There may be a potential interplay of prenatal adversity and social environment.⁶ Several authors have proposed a mediation model.^{5,9–12} In this model, biological and environmental factors are theorized to relate directly to deficits in neuromotor and intellectual functioning. Simultaneously, deficits in neuromotor and intellectual functioning are directly related to lower academic achievement and behavioral problems. Thus, it is through the relationship of biological and environmental factors to neurodevelopmental and intellectual factors that academic and behavioral concerns arise.

This study's purpose was to examine behavioral problems in children who were born at ELBW and VLBW compared with a control sample. Hierarchical multiple regressions assessed the variance in behavior ratings accounted for by biological (birth weight) and environmental (socioeconomic status [SES]) factors and tested the extent to which cognitive ability mediates these effects. It was hypothesized that children who are born preterm would show more behavior problems than healthy control subjects and that children of ELBW would show more behavior problems than children of VLBW. Finally, it was predicted that both biological and environmental factors would significantly contribute to the variation in behavioral ratings but that the influence of biological factors on behavior would be mediated by cognitive ability.

METHODS

Participants

Subjects of preterm birth were identified from a sample of 100 children who participated in a previous research investigation of prematurity and the effects of blood transfusion in infants.¹³ The children in the original study were born at the same Midwestern hospital and treated in the NICU between December 1992 and June 1997. Nearly 90% of these children had received at least 1 red blood cell transfusion in the neonatal period, and children with alloimmune hemolytic disease, congenital heart disease, chromosomal abnormality, or any major birth defect that required surgery were excluded from the original study. Of the 100 children from the original sample, 3 had died and 18 were lost to follow-up. Of the 79 possible participants, 5 were unable to participate because of scheduling issues and 24 declined the study. A total of 50 (63%) agreed to participate. One child did not have complete behavioral information and was excluded. Analyses using multivariate analysis of covariance (MANCOVA) showed no significant differences for gestational age ($F_{1,97} = 0.036$, $P = .849$) or birth weight ($F_{1,97} = 0.747$, $P = .389$) between those who participated with full data ($n = 49$) and those who did not ($n = 49$; missing data for 2 children).

Proportions of boys and girls were also equal between groups ($\chi^2 [1, n = 100] = 0.091, P = .763$).

For the 49 participants with full data, gestational age at birth ranged from 24.00 to 33.00 weeks (mean: 27.70; SD: 2.04), and birth weight ranged from 551.00 to 1300.00 g (mean: 939.00; SD: 199.02). Scores for Neonatal Acute Physiology 14 ranged from 0 to 32 on day of life 1 (mean: 14.60; SD: 8.54); higher scores indicated more severe conditions. There were 26 (53%) boys, and the majority (83%) were of white race, consistent with the geographic location. At the time of testing, ages ranged from 8.50 to 15.30 years (mean: 12.07; SD: 1.66), and family SES on the Hollingshead index was primarily middle class (mean: 2.76; SD: 0.59).¹⁵ Eighteen children were classified as having VLBW (1000–1499 g), and 31 were classified as having ELBW (<1000 g). The current ages, SES levels, and Scores for Neonatal Acute Physiology of these 2 groups were not significantly different (Table 1).

The 55 children in the control group were recruited from advertisements in the local community and surrounding cities within a 70-mi radius and screened to ensure term birth (gestational age: 38–42 weeks) and absence of learning, medical, or psychiatric conditions. Testing was conducted at the same time as the group born preterm. Eighty-nine percent of control subjects lived within 50 mi of the hospital (30% of the children born preterm lived within 50 mi). There were 27 (46%) boys, and the majority (92%) were of white race. At the time of testing, ages ranged from 7.00 to 16.00 years (mean: 10.91; SD: 2.45), and SES was primarily high middle class (mean: 2.3; SD: 0.47). Control subjects were significantly younger ($F_{1,102} = 7.400, P = .008$) and of higher SES ($F_{1,102} = 18.909, P < .001$) than the children who were born preterm; therefore, age and SES were controlled for in analyses (Table 1).

Procedure

This study was approved by the hospital's institutional review board. After parents signed consents and children signed assents, the children participated in cognitive testing while parents completed a behavior rating scale and demographic questionnaire. Parents gave permission for 1 teacher of their choice to be contacted for the study. Teachers were mailed a letter stating that the child was participating in a research study (but providing no details about the study) and asking them to return the behavior scale. Permission was obtained for 97 teacher mailings; of these, 78 were returned (35 for the group born preterm and 43 for the control group).

Measures

Wechsler Intelligence Scale for Children, Fourth Edition—The Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV),¹⁶ assesses intellectual abilities of children aged 6 to 16 years. Scales include verbal comprehension index, perceptual reasoning index, working memory index, processing speed index, full-scale IQ, and general ability index (GAI; a composite of verbal comprehension index and perceptual reasoning index).¹⁷ Children were administered the vocabulary, similarities, block design, and matrix reasoning subtests, and the GAI was used in analyses for this study. The subtests have excellent internal reliability ($r = .79$ to 0.90) and test-retest reliability ($r = 0.76$ to 0.92).¹⁶ Internal reliability for GAI has been estimated at $r = 0.96$, on the basis of reported subtest reliability scores.¹⁸ Concurrent validity for subtests is also high when correlated with the WISC-III ($r = 0.62$ to 0.83).¹⁶

Pediatric Behavior Scale–30—The Pediatric Behavior Scale–30 (PBS-30), a 30-item questionnaire, was derived from the full 165-item version of the PBS¹⁹ to create a focused

scale with a clear, well-defined factor structure. The brief form asks the rater to endorse the level at which each behavior describes the child in the past 2 months (0 = almost never/not at all, 1 = sometimes/just a little, 2 = often/pretty much, and 3 = very often/very much). There are 4 factors: aggression/opposition, hyperactivity/inattention, depression/anxiety, and physical health. Internal consistency reliability coefficients for the 4 factors are 0.83, 0.87, 0.80, and 0.73, respectively. For this sample, Pearson correlations between parent and teacher ratings on each scale were 0.403, 0.570, 0.288, and 0.224, respectively ($n = 78$ with both forms). Parent and teacher forms have been used to assess PBS-30 factors in children with diabetes^{20,21} and attention-deficit/hyperactivity disorder.²²

Analyses

Behavioral Comparisons—For determination of differences in behavior ratings, a MANCOVA (controlling for current age, SES, and GAI) included participant type (term versus VLBW versus ELBW) and gender as the independent variable and ratings for the 4 behavioral factors (aggression/opposition, hyperactivity/inattention, depression/anxiety, and physical health) as the dependent variables. Separate MANCOVAs were run for parent and teacher ratings, evaluating participant type-by-gender interaction and main effects. When variables demonstrated significant heterogeneity of variance, Brown-Forsythe analyses were used. Bonferroni corrections were included in the analyses, and adjusted P values are reported.

Effects of Biological and Environmental Factors—For the entire sample, parent total PBS score and teacher total PBS score were used as the outcome variables in 2 hierarchical multiple regressions. For each model, gender and current age were controlled in the first step. Birth weight and SES were entered second to determine how much variance was accounted for after removing the effects of gender and current age. Standardized β values were used to compare amount of variance accounted for by each predictor. This analysis permitted the evaluation of whether birth weight affected behavior when used as a continuous variable rather than the categorical variable method in comparing the children of VLBW versus ELBW.

The test of mediational effects focused on the potential influence of cognitive ability on the relationship between birth weight and parent total PBS score. The 4-step analysis developed by Kenny and colleagues^{23–25} was used. First, a regression equation (controlling for age and gender in the first step) determined the relation between birth weight and parent total PBS score. A second regression equation (again, controlling for age and gender) assessed the relationship between birth weight and GAI. The final regression equation (controlling for age and gender) added birth weight and GAI in the second step to determine their combined relationship with parent total PBS score. This equation provides evidence of the relationship of GAI to parent total PBS score and determines whether variance accounted for by birth weight significantly decreases with the addition of GAI (thus suggesting mediation).

RESULTS

Cognitive Abilities Assessment

Before using the GAI as a covariate in the main analyses, an ANCOVA (controlling for age and SES) was conducted to determine whether there were between-group differences for children of ELBW, VLBW, and term birth. Results indicated significant differences in GAI between groups ($F_{2,99} = 7.680$, $P = .001$). Specifically, children who were born of ELBW had significantly lower GAI scores than those who were born at term (mean difference: 15.212, $P = .001$; Table 2).

Premature Versus Term

The MANCOVA that assessed differences in parental behavior ratings demonstrated no type-by-gender interaction ($F_{8,186} = 1.448, P = .179$) or main effect for gender ($F_{4,92} = 2.127, P = .084$); however, there was a main effect for group ($F_{8,186} = 3.873, P < .001$). Levene's test of equality of error variances showed heterogeneity of variance for all 4 factors; therefore, a Brown-Forsythe Robust Test of Equality of Means was used for follow-up analysis. Tests of group differences were significant for hyperactivity/inattention ($F_{2,35.825} = 7.189, P = .002$) and depression/anxiety ($F_{2,50.624} = 6.512, P = .003$), whereas aggression/opposition approached significance ($F_{2,41.570} = 3.214, P = .050$). Children who were born of ELBW and VLBW were rated with significantly more hyperactivity/inattention and depression/anxiety than those who were born at term (Table 2).

The MANCOVA that assessed differences in teacher behavior ratings between children who were born of ELBW, of VLBW, and at term was nonsignificant for a type-by-gender interaction ($F_{8,134} = 0.645, P = .739$) and non-significant for group ($F_{8,134} = 1.093, P = .372$) and gender ($F_{4,66} = 0.709, P = .589$) main effects (Table 2). Because the main effect of group type was nonsignificant overall, subscale differences were not interpreted.

Effects of Biological and Environmental Factors

For the hierarchical multiple regressions that assessed the influence of biological and environmental factors on parent and teacher ratings of behavioral problems, only the model for parent ratings was significant (parent: $F_{4,99} = 8.078, P < .001$; teacher: $F_{4,73} = 1.787, P = .141$); therefore, additional interpretation was made only on the parent model. Current age and gender were entered in step 1, explaining a nonsignificant 0.9% of the variance in parental ratings. After entry of birth weight and SES in step 2, the total variance explained significantly increased to 21.6% (R^2 change = 0.218, F change_{2,99} = 14.305, $P < .001$). Birth weight was a statistically significant predictor (standardized $\beta = -.495, P < .001$), uniquely accounting for 20% of the variance. SES did not significantly predict parent ratings of behavior (standardized $\beta = -.046, P = .638$), uniquely accounting for only 0.17% of the variance. These findings confirm an inverse relationship between birth weight and behavior indicating the lower the birth weight, the greater the behavior problems (Table 3).

Next, the potential mediation effect of cognitive ability on the relationship between birth weight and parent ratings was evaluated (Table 4). The analyses focused only on parent ratings, because prediction of teacher scores with birth weight was nonsignificant. By using steps outlined by Kenny and colleagues,^{23–25} the first 2 requirements were met. Specifically, birth weight was a significant predictor of the outcome measure (parental ratings; unstandardized $\beta = -.001, SE = 0.0003, P < .002$) and the mediator measure (cognitive ability; unstandardized $\beta = .005, SE = 0.001, P = .001$); however, the third requirement for a mediation relationship was not met; the mediator (cognitive ability) was not a predictor of the outcome (behavior ratings) in the final equation (unstandardized $\beta = -.065, SE = 0.056, P = .248$). Exploratory analysis evaluated the potential for IQ mediation effects on each of the subscales, but results were similar, with cognitive ability not predicting the subscales. Because of the lack of a mediation effect, no additional analyses were conducted.

DISCUSSION

The purpose of this study was to enhance understanding of behavioral problems that children who are born preterm experience. Parental ratings of (1) hyperactivity/inattention and (2) depression/anxiety were higher for children who were born preterm than for those of term birth and highest in children of ELBW. These differences remained significant even

after controlling for age, gender, SES, and IQ. Findings are consistent with previous research showing higher incidence of behavioral concerns among children who were born preterm.^{1,3,4} This reinforces the recommendation for long-term follow-up and the need for assessment over a broad range of neurobehavioral domains.

The lack of significance among teacher ratings in this study may be attributable to lower power (smaller sample) or children's displaying fewer problem behaviors in the classroom than at home. Teachers typically endorse fewer concerns than parents,⁴ and this was true in this study. Also, because parents observe their children over a longer period of time and in a wider range of environments, it is possible that parents see behaviors that are not displayed in the more limited classroom setting.

No significant differences on parent or teacher ratings were found between children of ELBW and VLBW. It may be that the gradient effect of ELBW < VLBW is stronger for a different outcome variable (eg, cognitive ability). It is also possible that simply being born under a threshold birth weight increases the risk for developmental-behavioral problems.

Despite lack of behavioral differences between birth weight groups for those who were born preterm, when evaluated along with SES to assess its effect on behavior across the entire sample, birth weight was found to have strong and unique predictive power. In fact, SES showed no significant contribution to parent behavioral ratings. This suggests that after accounting for their shared variance, factors that are associated with birth weight (a biological factor) account for more variance in behavioral ratings than factors that are associated with SES (an environmental factor).

Contrary to expectations, cognitive ability showed no significant relationship to behavior in this group, suggesting that cognitive ability was not acting as a significant mediator between birth weight and behavior. It is possible that limitations of the study (eg, coarseness of the outcome variables, small sample size) may have decreased the power to detect a true mediation effect. Also, cognitive ability may have more impact on different aspects of behavioral functioning than others. For example, Samara et al⁷ found that in children who were born preterm, cognitive ability mediated scores on hyperactivity and conduct problems but not attention, peer, or emotional problems.

Alternatively, cognitive ability may play less of a mediational role in behavioral outcomes than it has shown in academic outcomes.^{5,9-12} Other aspects of being born preterm may have a relationship to behavioral outcome. For example, Lozoff et al²⁶ recently found that socioemotional outcomes in infancy (9 and 12 months) were related to level of iron status (iron deficient to iron sufficient). Although nearly 90% of the children in our study had received at least 1 blood transfusion, it is unclear whether transfusions in infants who are born preterm have effects that are uniformly neuroprotective or instead place the child at risk for specific neurodevelopmental problems.

Preterm birth is associated with higher risks for damage or abnormal development in the brain. Ventricular dilation/thinning, atrophy of the corpus callosum,²⁷ and white matter disruption² have been found. Furthermore, cognitive dysfunction in prematurity has been correlated to specific abnormalities of brain structure.²⁸ This study found that behavioral abnormalities that are associated with prematurity were not fully explained by cognitive deficits. These behavioral problems may be related to unique structural brain abnormalities. Additional research that incorporates both structural and functional analysis of the brain is needed for better understanding of the relationship of neuropsychological, behavioral, and academic variables to important life outcomes. Through greater understanding of these relationships, interventions and accommodations can be developed to improve outcomes for preterm children who are at risk.

WHAT'S KNOWN ON THIS SUBJECT

Research has demonstrated increased academic concerns, diminished cognitive functioning, and increased reports of behavioral concerns among children born preterm. These late effects of preterm birth have been linked to various environmental and biological factors.

WHAT THIS STUDY ADDS

This study evaluated the relationship of environmental, biological, and intellectual factors on the severity of behavioral ratings for a group of children born preterm. Birth weight was the strongest predictor of behavioral outcome; this relationship was not mediated by IQ.

ABBREVIATIONS

ELBW	extremely low birth weight
VLBW	very low birth weight
SES	socioeconomic status
MANCOVA	multivariate analysis of covariance
GAI	General Ability Index
WISC	Wechsler Intelligence Scale for Children
PBS-30	Pediatric Behavior Scale–30

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REFERENCES

1. Anderson P, Doyle LW. Neurobehavioral outcomes of school-age children born extremely low birth weight or very preterm in the 1990s. *JAMA* 2003;289(24):3264–3272. [PubMed: 12824207]
2. Farooqi A, Hagglof B, Sedin G, Gothefors L, Serenius F. Mental health and social competencies of 10- to 12-year-old children born at 23 to 25 weeks of gestation in the 1990s: a Swedish national prospective follow-up study. *Pediatrics* 2007;120(1):118–133. [PubMed: 17606569]
3. Horwood LJ, Mogridge N, Darlow BA. Cognitive, educational, and behavioural outcomes at 7 to 8 years in a national very low birthweight cohort. *Arch Dis Child Fetal Neonatal Ed* 1998;79(1):F12–F20. [PubMed: 9797619]
4. Pharoah PO, Stevenson CJ, Cooke RW, Stevenson RC. Prevalence of behaviour disorders in low birthweight infants. *Arch Dis Child* 1994;70(4):271–274. [PubMed: 8185358]
5. Taylor HG, Klein N, Drotar D, Schluchter M, Hack M. Consequences and risks of < 1000-g birth weight for neuropsychological skills, achievement, and adaptive functioning. *J Dev Behav Pediatr* 2006;27(6):459–469. [PubMed: 17164618]
6. Bohnert KM, Breslau N. Stability of psychiatric outcomes of low birth weight: a longitudinal investigation. *Arch Gen Psychiatry* 2008;65(9):1080–1086. [PubMed: 18762594]
7. Samara M, Marlow N, Wolke D. EPICure Study Group. Pervasive behavior problems at 6 years of age in a total-population sample of children born at ≤25 weeks of gestation. *Pediatrics* 2008;122(3):562–573. [PubMed: 18762527]
8. Escobar GJ, Littenberg B, Petitti DB. Outcome among surviving very low birthweight infants: a meta-analysis. *Arch Dis Child* 1991;66(2):204–211. [PubMed: 1825773]

9. Hack M, Taylor HG, Drotar D, et al. Chronic conditions, functional limitations, and special health care needs of school-aged children born with extremely low-birth-weight in the 1990s. *JAMA* 2005;294(3):318–325. [PubMed: 16030276]
10. Hack M, Youngstrom EA, Cartar L, et al. Behavioral outcomes and evidence of psychopathology among very low birth weight infants at age 20 years. *Pediatrics* 2004;114(4):932–940. [PubMed: 15466087]
11. Nadeau L, Boivin M, Tessier R, Lefebvre F, Robaey P. Mediators of behavioral problems in 7-year-old children born after 24 to 28 weeks of gestation. *J Dev Behav Pediatr* 2001;22(1):1–10. [PubMed: 11265917]
12. Taylor HG, Burant CJ, Holding PA, Klein N, Hack M. Sources of variability in sequelae of very low birth weight. *Child Neuropsychol* 2002;8(3):163–178. [PubMed: 12759832]
13. Bell EF, Strauss RG, Widness JA, et al. Randomized trial of liberal versus restrictive guidelines for red blood cell transfusion in preterm infants. *Pediatrics* 2005;115(6):1685–1691. [PubMed: 15930233]
14. Richardson DK, Gray JE, McCormick MC, Workman K, Goldmann DA. Score for Neonatal Acute Physiology: a physiologic severity index for neonatal intensive care. *Pediatrics* 1993;91(3):617–623. [PubMed: 8441569]
15. Hollingshead, AB., editor. New Haven, CT: Department of Sociology, Yale University; 1975. Four Factor Index of Social Status.
16. Wechsler, D. Wechsler Intelligence Scale for Children, 4th Edition—Integrated: Technical and Interpretive Manual. San Antonio TX: PsychCorp; 2004.
17. Raiford, SE.; Weiss, LG.; Rolfhus, E.; Coalson, D., editors. Wechsler Intelligence Scale for Children: 4th Edition—General Ability Index. San Antonio, TX: Pearson Education, Inc; 2009. Report no 4.
18. Prifitera, A.; Saklofske, D.; Weiss, L., editors. WISC-IV Clinical Use and Interpretation: Scientist-Practitioner Perspectives. San Diego, CA: Academic Press; 2005.
19. Lindgren, S.; Koeppl, G. Assessing child behavior problems in a medical setting: development of the Pediatric Behavior Scale. In: Prinz, E., editor. *Advances in Behavioral Assessment of Children and Families*. Greenwich, CT: JAI; 1987. p. 57-90.
20. McCarthy AM, Lindgren S, Mengeling MA, Tsalikian E, Engvall J. Factors associated with academic achievement in children with type 1 diabetes. *Diabetes Care* 2003;26(1):112–117. [PubMed: 12502666]
21. McCarthy AM, Lindgren S, Mengeling MA, Tsalikian E, Engvall JC. Effects of diabetes on learning in children. *Pediatrics* 2002;109(1) Available at: www.pediatrics.org/cgi/content/full/109/1/e9.
22. Wolraich ML, Lambert W, Doffing MA, Bickman L, Simmons T, Worley K. Psychometric properties of the Vanderbilt ADHD diagnostic parent rating scale in a referred population. *J Pediatr Psychol* 2003;28(8):559–567. [PubMed: 14602846]
23. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol* 1986;51(6):1173–1182. [PubMed: 3806354]
24. Judd CM, Kenny DA. Process analysis: estimating mediation in treatment evaluations. *Evaluation Review* 1981;5(5):602–619.
25. Kenny, DA.; Kashy, DA.; Bolger, N. Data analysis in social psychology. In: Gilbert, DT.; Fiske, ST.; Lindzey, G., editors. *The Handbook of Social Psychology*. 4th ed.. New York, NY: Oxford University Press; 1998. p. 233-265.
26. Lozoff B, Clark KM, Jing Y, Armony-Sivan R, Angelilli ML, Jacobson SW. Dose-response relationships between iron deficiency with or without anemia and infant social-emotional behavior. *J Pediatr* 2008;152(5):696–702. 702.31–702.33. [PubMed: 18410777]
27. Stewart AL, Rifkin L, Amess PN, et al. Brain structure and neurocognitive and behavioural function in adolescents who were born very preterm. *Lancet* 1999;353(9165):1653–1657. [PubMed: 10335784]
28. Reiss AL, Kesler SR, Vohr B, et al. Sex differences in cerebral volumes of 8-year-olds born preterm. *J Pediatr* 2004;145(2):242–249. [PubMed: 15289777]

TABLE 1
Demographics Characteristics for Preterm and Control Children in the Study

Characteristic	ELBW (<i>n</i> = 31)		VLBW (<i>n</i> = 18)		Control (<i>n</i> = 55)	
	Mean	SD	Mean	SD	Mean	SD
Birth weight, g	810.0	125.5	1149.0	79.5	3640.0	474.0
Gestational age, wk	27.2	1.8	28.5	2.2	—	—
Current age, y	12.04	1.63	12.12	1.74	10.91	2.45
SES ^a	2.77	0.59	2.72	0.60	2.31	0.46
SNAP	15.31	9.08	13.44	7.71	—	—

SNAP indicates Score for Neonatal Acute Physiology.

^a1 = Professional to 5 = unskilled.

TABLE 2
Comparisons Between ELBW, VLBW, and Term-born Groups on Cognitive and Behavioral Measures

Measures	ELBW		VLBW		Control		MANCOVA	
	Mean	SD	Mean	SD	Mean	SD	η_p^2	P
GAI	91.4	20.4	104.0	15.4	110.4	15.1	.134	.001
Parent ratings							.143	.001
Aggression/opposition ^a	4.97	4.0	4.56	5.1	2.73	2.7	—	.050
Hyperactivity/inattention ^a	7.07	5.6	7.33	7.6	2.67	2.8	—	.002
Depression/anxiety ^a	4.74	3.8	4.33	3.6	2.20	2.1	—	.003
Physical health ^a	1.94	2.4	1.22	1.8	1.20	1.5	—	.232
Teacher ratings							.061	.372
Aggression/opposition	2.35	3.8	2.20	3.1	1.37	2.9	.004	.859
Hyperactivity/inattention	6.10	5.4	5.33	7.1	3.12	4.3	.017	.551
Depression/anxiety ^a	3.65	3.2	2.20	2.9	1.33	1.8	—	.014
Physical health	1.10	1.5	1.00	1.9	0.72	2.1	.001	.965

η_p^2 indicates partial eta squared.

^a Posthoc analyses used Brown-Forsythe test of equality of means; no η_p^2 available.

Hierarchical Multiple Regression of the Contribution of Birth Weight and SES to Parental and Teacher Behavior Ratings

TABLE 3

Parameter	R ²	β	β	P	sr ²
Parent PBS ^a	0.246				
Age		-.854	-.171	.070	0.026
Gender		2.404	.111	.212	0.012
Birth weight		-.004	-.495	<.001	0.203
SES		-.887	-.046	.638	0.002
Teacher PBS ^a	0.089				
Age		-.355	-.079	.497	0.006
Gender		-2.241	-.115	.315	0.013
Birth weight		-.002	-.237	.059	0.046
SES		1.411	.081	.522	0.005

β indicates unstandardized β; β, standardized β; sr², squared semipartial correlation.

^aFinal model: outcome (total PBS); covariates (age and gender); predictors (birth weight and SES).

TABLE 4
Hierarchical Multiple Regressions of Possible Mediation of Behavior by Cognitive Status

Parameter	R ²	β	SE β	β	P	sr ²
Model 1 ^a	0.132					
Age		-.267	.166	-.156	.110	0.0230
Gender		1.128	.700	.152	.110	0.0230
Birth weight		-.001	.0003	-.311	.002	0.0910
Model 2 ^b	0.168					
Age		.145	.812	.017	.859	0.0003
Gender		-6.107	3.419	-.165	.077	0.0260
Birth weight		.005	.001	.374	<.001	0.1310
Model 3 ^c	0.255					
Age		-.901	.451	-.181	.048	0.0300
Gender		2.011	1.929	.093	.300	0.0080
Birth weight		-.003	.001	-.437	<.001	0.1540
GAI		-.065	.056	-.111	.248	0.0100

β indicates unstandardized β; β, standardized β; sr², squared semipartial correlation.

^a Outcome (parental total PBS); covariates (age and gender); predictor (birth weight).

^b Outcome (GAI); covariates (age and gender); predictor (birth weight).

^c Outcome (parental total PBS); covariates (age and gender); predictor (birth weight and GAI).