Executive Function Profiles at Home and at School in 11-Year-Old Very Low Birth Weight or Very Low Gestational Age Children

ABSTRACT

Objective: Executive function (EF) problems of children born at very low birth weight (VLBW; ≤1500 g) or very low gestational age (VLGA; <32 gestational weeks) may present differently at school compared to the home environment. Ecological assessment of EF including parent- and teacher-rated profiles and associated risk factors of 11-year-old children born at VLBW or VLGA were evaluated.

Method: A total of 125 VLBW or VLGA children and 132 controls were assessed using the Behavior Rating Inventory of Executive Function, which includes eight subscales that form the Behavioral Regulation and Metacognition Indexes. For VLBW or VLGA children, full-scale IQ was assessed using the Wechsler Intelligence scale for Children, Fourth Edition. Neonatal data were collected systematically.

Results: VLBW or VLGA children with full-scale IQ ≥70 had clinically significant problems in the Working Memory subscale at school. Although they had clinically significant problems at home in the Behavioral Regulation Index, the difference disappeared when adjusted for paternal education. Lower gestational age, lower birth weight z-score, surgical necrotizing enterocolitis, low paternal and maternal education, and lower full-scale IQ were identified to be risk factors for higher scores in ecological assessment of EF.

Conclusion: VLBW or VLGA in this cohort exhibit less EF problems in ecological assessment of EF compared to previous literature. EF problems of this study population vary by home and school setting and are emphasized in working memory at school. Screening for EF problems in school environment is recommended to target the support.

Key terms: Executive function, behavioral rating scales, cognitive development, very preterm born children, follow-up studies

INTRODUCTION

Children born very preterm are at risk for a range of cognitive and neurobehavioral impairments, including deficits in executive function (EF).[1] EF problems at home are four times more common in adolescents born very preterm than in controls born full-term.[2] EF is an umbrella term encompassing various interrelated, higher-order cognitive skills necessary for the regulation of behavior and metacognitive abilities that support goal-directed activity.[3,4] EF is important for adaptive functioning, such as social interactions and academic performance. EF problems in children with average cognitive development may not be evident in early childhood due to the long maturation process of EF.[5] Inhibition is considered to mature first, after rapid development in pre-school years.[6] Many executive processes mature through adolescence and into adulthood.[6] Therefore, the symptoms are exhibited as a wide range of everyday problems at different ages. Recent studies suggest that EF deficits in preterm children are unlikely to diminish with maturation.[7,8]

EF in daily life is assessed with rating scales. Behavior Rating Inventory of Executive Function (BRIEF) assesses EF in the home and school environments.[4] The BRIEF covers eight abilities needed for behavioral regulation and metacognition.[4] Only few studies have reported complete parent-rated EF profile of preterm born school-age children,[2,9] while some have used shortened versions.[8,10,11] Results concerning the parent-rated behavioral regulation problems of school-age children born preterm are contradictory.[2,8-11] Their EF problems are evidenced more clearly in several metacognitive skills i.e. skills needed in goal-directed activity.[2,9,10]

To date, research has largely focused on the EF of preterm born children in the home environment. There are only few studies concerning teacher-rated EF of children born preterm, and none of these include controls born full-term.[12,13] Parent and teacher ratings of EF are reported to have moderate correlation, reflecting various expectations and vulnerabilities in different environments.[4] In clinical work, the assessment of EF is recommended to include ratings done in at least two environments to enhance diagnostic reliability.[14,15] McCandless reported BRIEF profiles of children with attention deficit/ hyperactivity disorder and found that parents may report their children's behavioral regulation problems more accurately, while teachers may more easily recognize behaviors associated with cognitive deficits.[15] Additionally, teachers' EF ratings have been shown to correlate with academic performance in typically developing children.[16]

Although neonatal and sociodemographic factors are associated with the cognitive profile of preterm children,[17,18] evidence about the relationship between ecologically assessed EF problems and neonatal and sociodemographic risk factors is scarce.[9,19] It has been suggested that birth weight and gestational age may have a weak correlation with parent-rated EF.[9] Teacher ratings may serve as an additional tool in evaluating the risk factors that associate with the EF of preterm born children at school-age.[12]

This study aimed to assess and compare the EF profiles of very low birth weight (VLBW; ≤1500g) or very low gestational age (VLGA; <32 gestational weeks) 11-year-old children and their controls, both at home and at school, and to analyze the effects of neonatal and sociodemographic factors on EF problems in VLBW or VLGA children. We hypothesized that teacher evaluations would provide additional value to the assessment of EF problems in this group, and that ecologically assessed EF cannot be predicted by neonatal and sociodemographic factors.

METHODS

SUBJECTS

This study was part of the prospective, multidisciplinary follow-up study. The present study included VLBW or VLGA infants born at the University Hospital between January 1, 2001 and December 31, 2004. All preterm infants (<37 weeks) with a VLBW criteria (≤1500 g) were included from January 1, 2001 to December 31, 2003. From January 1, 2004, the inclusion criteria were expanded to include all VLGA (<32 weeks) infants, regardless of the birthweight. At least one of the parents had to speak either Finnish or Swedish, the two official languages used in Finland. Children with severe congenital anomalies or diagnosed genetic syndromes affecting their development were excluded from the analysis. The data regarding the prenatal period, delivery, neonatal morbidities, and developmental outcomes were systematically collected as a part of the study protocol. The brain magnetic resonance imaging (MRI) classification (normal, minor, major pathology) has been described earlier.[20]

A total of 193 VLBW or VLGA infants met the inclusion criteria. Of these, 30 died during the neonatal period. We excluded 10 infants of whom four did not fulfill the language criteria, five families lived outside the catchment area of the hospital, and one infant had a genetic syndrome. Of the 153 eligible children, 12 families refused to participate and 13 withdrew during the follow-up. Thus, 128 participated in a cognitive assessment at 11 years of age.[17] The parents of these 128 VLBW or VLGA children received the parent and teacher questionnaires to rate executive function (EF) at school and at home at the 11-year cognitive assessment appointment. Parents filled in the questionnaire during the appointment or at home. If they wanted to fill in the questionnaire at home, they were given a self-addressed envelope. Teachers received the questionnaires and self-addressed envelopes from the parents. Questionnaires assessing EF were returned from 114 (89%) VLBW or VLGA children’s parents and from 122 (95%) VLBW or VLGA children’s teacher.

The control group consisted of healthy full-term born infants born at University Hospital between 2001 and 2004. The control group was recruited by inviting the parents of the first boy and the first girl born each Monday to take part in the study. If they refused, the parents of the next boy and girl were invited. The controls were born at or above 37 weeks of gestation, had at least one parent speaking either Finnish or Swedish and were not admitted to a neonatal care unit during their first week of life. Exclusion criteria were any major congenital anomalies or genetic or chromosomal syndromes, the mother’s use of illicit drugs or alcohol during pregnancy, and a birth weight at least two standard deviations (SD) below the mean for age and gender according to age- and gender-specific Finnish growth charts. A total of 200 infants met the inclusion criteria. Of these, one did not fulfill the language criteria, and one infant did not fulfill the birth weight criteria. Of these 198 eligible children, 10 families refused to participate and 3 withdrew during the follow-up. Parents of these 185 controls were first contacted by phone. If they agreed to participate, they received the parent and teacher questionnaires and self-addressed envelopes by mail. Teachers received the questionnaires and self-addressed envelopes from the parents. Questionnaires assessing EF were returned from 125 (68%) control children’s parents and from 128 (69%) control children’s teacher.

The study protocol was approved by the Ethics Review Committee of the Hospital District of Finland in December 2000 and January 2012. All parents who agreed to participate in the study gave written informed consent after they had received written and oral information in the neonatal intensive care unit. At 11 years of age, the children gave their own written informed consent after receiving written information.

DEVELOPMENTAL ASSESSMENTS

Executive function profiles. We used ecological assessment of EF including parent and teacher forms of the Finnish translation of the Behavior Rating Inventory of Executive Function (BRIEF).[4] BRIEF (86 items, 3-point Likert scale) includes eight subscales that form two indices. The Behavioral Regulation Index is a composite score of Inhibit (ability to resist impulse), Shift (making transitions between tasks and mindsets), and Emotional control (regulation of emotional responses). The Metacognition Index is a composite score of Initiate (starting an activity independently), Working Memory (holding information to complete a task), Plan/Organize (planning and organizing ahead for future events), Organization of Materials (sorting and organizing things), and Monitor (assessing one's own performance for proper goal attainment). The age and gender specific standardized T-scores on the subscales and Index scores were used to measure outcomes. Higher T-scores indicate higher concerns, and pre-established cutoff T-score >64 signal the presence of clinically significant symptoms.

The BRIEF questionnaires were completed by teachers and parents during the first semester of the school year during which the children turned 11 years of age. Most children had started the fifth grade. Teachers and the parents were all requested to return the questionnaires within two weeks. However, if a pupil was new to the teacher, he or she was encouraged to get acquainted with the pupil for two months before filling in the questionnaire. Only completely and consistently filled-in questionnaires were used in this study.[4] Based on previous literature, Inhibit, Shift and Working Memory are core components of EF.[6,21] Of the BRIEF subscales, parental- and teacher-rated Inhibit, Shift and Working Memory subscales were included in the risk-factor-analyses.

Cognitive development. Cognitive development of VLBW or VLGA children was assessed using the Wechsler Intelligence scale for Children, Fourth Edition.[22,23] Full-scale IQ was used as a measure of general intelligence. Full-scale IQ is a composite score from four index scores that provide information on more specific cognitive domains. It was used to identify VLBW or VLGA children who had a full-scale IQ of <70. In analyses, IQ was used as a continuous variable. It was calculated according to age-appropriate and updated Finnish norms (mean ±SD: 100±15 in the normative population).[23] Three children scored so low that full-scale IQ could not be calculated. Their full-scale IQ was assigned as -4.0 SD.[17] Six bilingual children preferring Swedish instead of Finnish were assessed by a native Swedish speaking psychologist using the Finnish translation of Wechsler Intelligence scale for Children, Fourth Edition[22,23] and translating the instructions and questions into Swedish.[17] A neuropsychologist (AN) assessed all VLBW or VLGA children. To avoid bias, she was blinded to the neonatal data of the study subjects.

Of the 125 VLBW or VLGA children and the 132 controls included in the present study, 117 and 125, respectfully, were successfully assessed at 5 years of age.[24] Full-scale IQ of VLBW or VLGA children and controls were assessed at the 5 years of age using WPPSI-R, Finnish translation.[25] Five of the VLBW or VLGA children's and five of the control's five-year assessment were performed in Swedish using the same translation protocol as in the 11 -year assessments.

DATA ANALYSIS

Continuous variables are shown using means, standard deviations, minimum, and maximum values, or medians, minimum, and maximum values. Categorical variables are shown using frequencies and percentages. Clinically significant BRIEF problems (T-scores >64) of VLBW or VLGA children with full-scale IQ ≥70 and controls were compared using logistic regression. Since there was a statistically significant difference in paternal education between the VLBW or VLGA and the control children, paternal education was added to the logistic regression models and the analysis were repeated. The results are presented with OR and 95% CI.

Associations between parent- and teacher-rated BRIEF T-scores in VLBW or VLGA children were studied using the Spearman correlation. The level of agreement between parent- and teacher-rated T-scores was analyzed using Cohen's kappa. Robust regression analysis was used to study the associations between full-scale IQ and parent- and teacher-rated Inhibition, Shift and, Working Memory of the VLBW or VLGA children with full-scale IQ ≥70. After that, neonatal [gestational weeks, birth weight *z*-score, surgical necrotizing enterocolitis (NEC), and brain MRI findings] and sociodemographic (maternal and paternal education) factors were included in the models. The statistical analyses were carried out using version 9.4 of SAS Institute Inc. (Cary, NC, USA) for Windows. P-values of <0.05 were considered statistically significant.

RESULTS

SUBJECTS

The Behavior Rating Inventory of Executive Function (BRIEF) questionnaire rated by at least parent or teacher was available from 125 VLBW or VLGA children and from 132 controls. Of the 45 (36%) multiples included in the study, 34 (27%) participated with the sibling and 24 (19%) of them had the same reporter at school. The mean (SD) full-scale IQ of the 125 VLBW or VLGA children who participated in the present study was 87.9 (18.1). The mean (SD) full-scale IQ of the six VLBW or VLGA children whose teachers failed to return the questionnaire was 79.8 (12.8) and the mean (SD) full-scale IQ of the 14 VLBW or VLGA children whose parents failed to return the questionnaire was 84.2 (20.1). Of the VLBW or VLGA children, 8 (6%) had cerebral palsy and 2 (2%) had severe hearing impairment. No one had severe visual impairment. Neonatal and social background characteristics of the VLBW or VLGA and control children are shown in Table 1. Mean (SD) full-scale IQ at the age of five years was 99.0 (17.6) in the VLBW or VLGA group (n= 117) and 113.2 (14.3) in the control group (n=125). There were no significant differences in gender or maternal education between the VLBW or VLGA children and controls. The VLBW or VLGA children were less likely to have a father with higher education (>12 years) than the controls (p =.016).

EXECUTIVE FUNCTION PROFILE AT HOME

The mean (SD) age of the children when the parent-rated BRIEF was filled in was 11.2 (SD 0.3) years for the VLBW or VLGA children, and 11.4 (SD 0.3) years for the controls. Group comparisons related to parent-rated BRIEF after the 11 VLBW or VLGA children with a full-scale IQ of <70 were excluded are shown in Table 2A. The VLBW or VLGA children showed clinically significant problems in parent-rated Behavioral Regulation Index. After adjusting these comparisons for paternal education, the difference was not statistically significant.

EXECUTIVE FUNCTION PROFILE AT SCHOOL

The mean (SD) age of the children when teacher-rated BRIEF was filled in was 11.2 (SD 0.4) years for the VLBW or VLGA children, and 11.4 (SD 0.3) years for the controls. Group comparisons related to teacher-rated BRIEF after the 12 VLBW or VLGA children with a full-scale IQ of <70 were excluded are shown in Table 2B. The VLBW or VLGA children showed clinically significant problems in teacher-rated Working Memory. After adjusting comparisons for paternal education, difference in Working Memory remained (OR 2.50, 95% CI 1.08–5.79, p=0.033).

COMPARISON BETWEEN EXECUTIVE FUNCTION PROFILES AT HOME AND AT SCHOOL

All VLBW or VLGA children with both parent- and teacher-rated questionnaires returned were included (preterm n= 111/125, 89%, control n= 121/132, 92%) in the analyses (Table 3). All parent-rated BRIEF scores correlated significantly with teacher-rated BRIEF scores. Agreements between the parents' and teachers' ratings were moderate (Kappa= 0.40–0.60) in Behavioral Regulation Index and Metacognition Index, and fair (Kappa= 0.20–0.40) or slight (Kappa= 0–0.20) in subscale ratings.

FACTORS AFFECTING THE EXECUTIVE FUNCTION

All VLBW or VLGA children with a full-scale IQ ≥70 were included in the analyses. Robust regression analysis was used to study the associations between full-scale IQ and parent- and teacher-rated Inhibition, Shift and Working Memory. Lower full-scale IQ associated with higher parent-rated Inhibition scores (estimate -0.09, 95% CI -0.16– -0.009, p=.030) and with higher parent- (estimate -0.22, 95% CI -0.36– -0.07, p=.003) and teacher- (estimate -0.20, 95% CI -0.35– -0.06, p=.006) rated Working Memory scores. Regression analysis was repeated after including neonatal (gestational weeks, birth weight *z*-score, surgical NEC, and brain MRI findings) and sociodemographic (maternal and paternal education) factors in the models. Several significant factors were identified. Surgical NEC (estimate 7.04, 95% CI 1.42–12.65, p=.014) and low paternal education (estimate 4.71, 95% CI 0.39–9.04, p=.033) were associated with higher parent-rated Inhibition scores. Lower gestational age at birth (estimate -0.44, 95% CI -0.78– -0.10, p=.01) and low maternal education (estimate 2.0, 95% CI 0.32–3.67, p=.017) were associated with higher teacher-rated Inhibition scores. Lower birthweight z-score (estimate -1.54, 95% CI -3.03– -0.04, p=.044) was associated with higher parent-rated Shift scores. Lower full-scale IQ was associated with higher parent- (estimate -0.26, 95% CI -0.42– -0.10, p=.001) and teacher- (estimate -0.24, 95% CI -0.38– -0.10, p<.001) rated Working Memory scores.

DISCUSSION

This study reports the complete parent- and teacher-rated Behavior Rating Inventory of Executive Function (BRIEF) profiles of middle school aged VLBW or VLGA children. Parents did not report clinically significant problems in any specific subscales. Teachers most commonly reported clinically significant problems in working memory. Although problems were exhibited differently at home and at school, there was moderate agreement between the ratings. Several associations between risk factors and executive function (EF) were found. Lower gestational age at birth, lower birthweight *z*-score, surgical NEC, and low paternal and maternal education were risk factors for higher behavioral regulation scores (i.e. Inhibition or Shift). Higher scores in Working Memory (indicating problems) were related to lower full-scale IQ.

Only few studies have reported a comparison of complete parent-rated BRIEF profile between children born preterm and controls,[2,9] while some have reported shortened versions.[8,10,11] Mean scores of the BRIEF in preterm and control groups tend to fall close to the normative mean. Group differences in clinically significant problems are assessed using a pre-established cutoff T score (>64). Ritter et al. reported a shortened version with Inhibit, Shift, and Working Memory in 8-12 year-old children born very preterm with a full-scale IQ above 85.[10] They reported that, compared to controls, children born very preterm only had more clinically significant problems in Working Memory. According to complete parent-rated BRIEF profile, children born preterm showed more clinically significant problems in the Metacognition Index and in Shift, Emotional Control, Initiation, Working Memory, and Monitor subscales at 8 years of age,[9] and in Metacognition Index and in Initiation and Working Memory subscales at 16 years of age[2] than controls. To summarize previous results regarding parents' ratings, clinically significant problems of preterm children in several metacognition subscales have been reported compared to controls.[2,9,10] Previous results concerning parent-rated behavioral regulation are contradictory.[2,9-11] As EF skills have a long developmental trajectory in normal development,[6] diverse findings in these preterm populations can be affected by the wide age range of the children included. Based on our results, VLBW or VLGA children in this study exhibit less ecologically assessed EF problems compared to previous literature.

There are no studies comparing teacher-rated BRIEF profiles of middle school age children born preterm with full-term controls. Our study showed that teachers most commonly reported clinically significant EF problems in Working Memory. Problems in the BRIEF Working Memory subscale are known to relate to inattention.[4] Working memory is essential for multistep activities, mental arithmetic, and following complex instructions.[4,26] The ability to sustain attention is integral to working memory.[4,26] It has been reported that the behavioral phenotypic profiles of children born preterm include social and emotional problems and inattention.[27] Our results are in line with the previous suggestion that teachers may more easily recognize behaviors associated with cognitive deficits.[15]

Previous knowledge suggest that EF problems may vary by settings and demands of the settings.[4,14,15] Our results are in line with this suggesting that optimal EF assessment~~s~~ of VLBW or VLGA children should include ratings from different settings to capture their EF problems and to identify primary targets for intervention to maximize their function. Parent and teacher ratings of EF are reported to correlate only moderately, reflecting differences in child behavior in different environments.[4] In the present study, agreement between the ratings was fair or slight in separate subscale ratings. Our results are in line with previous results suggesting that using only parent-rated EF profile as an assessment tool may underestimate some EF problems. In low risk populations, teacher-ratings of EF are reported to correlate with school achievement.[16] Accordingly, teacher ratings may help identify EF problems important for academic achievement and may serve as an instrument in planning interventions in a school setting.[5,28] Early identification may allow teachers and parents to implement behavioral and academic support services prior to the onset of secondary social or academic problems. Our results suggest that middle school age VLBW or VLGA children are less likely to be disruptive during the school day and accordingly, their EF problems may be overlooked.

Lower gestational age, growth restriction at birth and male gender are known risk factors for lower cognitive development of preterm children.[18,29] We have shown earlier that major brain pathology and intestinal perforation were negatively associated with cognitive development at two years of age in this cohort.[30] Additionally, we have shown that lower paternal education, male gender, and low birth weight z-score associate with cognitive profile at 11 years of age.[17] In the present study, we analyzed the associations between these factors and full-scale IQ and EF, including children born very preterm with a full-scale IQ ≥70. Gender was not included in the EF models as standardized scores of the BRIEF are gender specific. Growth restriction was taken into account by using birth weight z-score as a continuous variable. Lower gestational age at birth, lower birthweight *z*-score, surgical NEC, and low paternal and maternal education were risk factors for higher Inhibition or Shift scores of behavior regulation. In a previous Australian study, a weak correlation between birth weight and gestational age and EF at eight years of age is reported.[9] Roze et al. suggested teacher-rated EF as an additional tool in evaluating the risk factors that associate with ecologically assessed EF of school-age children born preterm.[12] Our results suggest congruent usefulness of parent- and teacher-rated EF in assessing factors affecting VLBW or VLGA children's ecologically assessed EF.

The strength of the present study is that it combined parent and teacher ratings of EF to get a reliable and clinically relevant picture of the EF problems of VLBW or VLGA children. Additionally, we were able to evaluate associated risk factors for EF at home and at school. Other strength of this study was a narrow age-range at the time of assessment of EF. The questionnaires were mailed to the parents of the controls after they were contacted by phone, which may have reduced the return rate. One limitation of this study is that full-scale IQ data on the control group was not available at the age of 11 years, and so selection of controls based on full-scale IQ level was not possible. However, controls were assessed at the age of five years, indicating that they were developing typically.

In conclusion, combined and complete teacher and parent ratings provide valuable information in the assessment of clinically significant EF problems of VLBW or VLGA children at 11 years of age. Ecologically assessed EF problems of the VLBW or VLGA children vary by setting and the demands of the setting. The only clinically significant difference was seen in working memory at school. We recommend using routine evaluations at home and school to screen EF problems in VLBW or VLGA children to attain a comprehensive picture of their multidimensional EF problems and to provide targeted support. Future research may expand current findings by evaluating the developmental trajectory of EF profiles of preterm children during everyday life, both in the home and at school environments.

REFERENCES

1. Aarnoudse-Moens CSH, Weisglas Kuperus N, van Goudoever J, et al. Meta-analysis of neurobehavioral outcomes in very preterm and/or very low birth weight children. *Pediatrics*. 2009;124:717-728.

2. Luu T, Ment L, Allan W, et al. Executive and memory function in adolescents born very preterm. *Pediatrics*. 2011;127:e639-e646.

3. Lezak M. Neuropsychological assessment. 3rd edn. New York, NY: Oxford University Press; 1995.

4. Gioia G, Isquith P, Guy S, et al. Behavior rating inventory of executive function (BRIEF): Professional manual. Lutz, FL: Psychological Assessment Resources; 2000.

5. Brogan E, Cragg L, Gilmore C, et al. Inattention in very preterm children: Implications for screening and detection. *Arch Dis Child*. 2014;99:834-839.

6. Best J, Miller P. A developmental perspective on executive function. *Child Development*. 2010;81:1641-1660.

7. Stålnacke J, Lundequist A, Böhm B, et al. A longitudinal model of executive function development from birth through adolescence in children born very or extremely preterm. *Child Neuropsychol.* 2018;25:318-335.

8. Burnett A, Anderson P, Lee K, et al. Trends in executive functioning in extremely preterm children across 3 birth eras. *Pediatrics*;2018:141:e20171958.

9. Anderson P, Doyle L. Executive functioning in school-aged children who were born very preterm or with extremely low birth weight in the 1990s. *Pediatrics*. 2004;114:50-57.

10. Ritter B, Perring W, Steinlin M, et al. Cognitive and behavioral aspects of executive functions in children born very preterm. *Child Neuropsychol*. 2014;20:129-144.

11. Anderson P, De Luca C, Hutchinson E, et al. Attention problems in a representative sample of extremely preterm/extremely low birth weight children. *Dev Neuropsychol*. 2011;36:57-73.

12. Roze E, Van Braeckel K, van der Veere C, et al. Functional outcome at school age of preterm infants with periventricular hemorrhagic infarction. *Pediatrics*. 2009;123:1493-1500.

13. McCann J, Rider GN, Weiss B, et al. Latent mean comparisons on the BRIEF in preterm children: Parent and teacher differences. *Child Neuropsychol*. 2014;20:737-751.

14. American Psychiatric Association. Diagnostic and statistical manual of mental disorders: DSM-V. Wasington, D.C: American Psychiatric Association; 2013.

15. McCandless S, O' Laughlin L. The clinical utility of the behavior rating inventory of executive function (BRIEF) in the diagnosis of ADHD. *J Atten Disord*. 2007;10:381-389.

16. Dekker M, Ziermans T, Spruijt A, et al. Cognitive, parent and teacher rating measures of executive functioning: Shared and unique influences on school achievement. *Front Psychol*. 2017;8:48.

17. Nyman A, Korhonen T, Munck P, et al. Factors affecting the cognitive profile of 11-year-old children born very preterm. *Pediatr Res*. 2017;82:324-332.

18. Linsell L, Malouf R, Morris J, et al. Prognostic factors for poor cognitive development in children born very preterm or with very low birth weight: A systematic review. *JAMA Pediatr*. 2015;169:1162-1172.

19. Linsell L, Malouf R, Johnson S, et al. Prognostic factors for behavioral problems and psychiatric disorders in children born very preterm or very low birth weight: A systematic review. *J Dev Behav Pediatr*. 2016;37:88-102.

20. Maunu J, Parkkola R, Rikalainen H, et al. Brain and ventricles in very low birth weight infants at term: A comparison among head circumference, ultrasound, and magnetic resonance imaging. *Pediatrics*. 2009;123:617-626.

21. Miyake A, Friedman N, Emerson M, et al. The unity and diversity of executive functios and their contributions to complex “frontal lobe” tasks: a latent variable analysis. *Cogn Psychol.* 2000;41:49-100.

22. Wechsler D. Wechsler intelligence scale for children -IV. Handbook I. (Administration and scoring). Jyväskylä, Finland: Psykologien Kustannus; 2011.

23. Wechsler D. Wechsler intelligence scale for children -IV. Handbook II. (theoretical background, standardization and interpretation). Jyväskylä, Finland: Psykologien Kustannus; 2011.

24. Munck P, Niemi P, Lapinleimu H, et al. Stability of cognitive outcome from 2 to 5 years of age in very low birth weight children. *Pediatrics*. 2012;129:503-508.

25. Wechsler D, ed. Wechsler preschool and primary scale of intelligence -reviced. Handbook. Helsinki, Finland: Psykologien Kustannus; 1995.

26. Retzler J, Johnson S, Groom M et al. Cognitive predictors of parent-rated inattention in very preterm children: the role of working memory and processing speed. *Child Neuropsychol.* 2018;Sep 19 [Epub ahead of print].

27. Johnson S, Marlow N. Preterm birth and childhood psychiatric disorders. *Pediatr Res*. 2011;69:11R-18R.

28. Isquith P, Roth R, Kenworthy L, et al. Contribution of rating scales to intervention for executive dysfunction. *Appl Neuropsychol Child*. 2014;3:197-204.

29. Kerr-Wilson C, Mackay D, Smith G, et al. Meta-analysis of the association between preterm delivery and intelligence. *J Public Health.* 2012;24:209-216.

30. Munck P, Haataja L, Maunu J, et al. Cognitive outcome at 2 years of age in Finnish infants with very low birth weight born between 2001 and 2006. *Acta Paediatr.* 2010;99:359-366.

Table 1 Characteristics of the VLBW or VLGA children and controls.

	VLBW or VLGA children		Controls
Characteristics	All (n=125)[a]	IQ ≥70 (n=112)[a]	(n=132)[a]
Antenatal corticosteroids, n(%)	120(96%)	108(96%)	
Gestational age (weeks) Mean (SD) [min, max]	28.9(2.7)[23.0, 35.9]	28.9(2.6)[24.0, 35.9]	40.0(1.2)[37.1, 42.3]
Birthweight (g) Mean (SD) [min, max]	1087(292)[400, 2025]	1097(280)[565, 2025]	3676(426)[2570, 4810]
Birthweight z-score	-1.5(1.6)	-1.4(1.5)	
Small for gestational age[b], n(%)	44(35%)	38(34%)	
<28 weeks/ ≥28 weeks	44(35%)/ 81(65%)	39(35%)/ 73(65%)	
<32 weeks/ ≥32 weeks	109(87%)/ 16(13%)	97(87%)/ 15(13%)	
≤1500g/ >1500g	120 (96%)/ 5(4%)	107(96%)/ 5(4%)	
Male, n(%)	65(52%)	56 (50%)	62(47%)
Apgar <6 at 5 min, n(%)	30(24%)	24 (21%)	
Multiple birth, n(%)	45(36%)	40 (36%)	
Postnatal corticosteroids, n(%)	19(15%)	15 (13%)	
Treated retinopathy of prematurity, n(%)	2(2%)	2(2%)	
Surgical necrotizing enterocolitis, n(%)	6(5%)	4(4%)	
Chronic lung disease[c], n(%)	17(14%)	14(13%)	
Brain MRI[d], n(%) Normal findings Minor pathologies Major pathologies	 69(56%) 22(18%) 32(26%)	 67(61%) 21(19%) 22(20%)	
Maternal education, n(%) ≤9 years Over 9-12 years >12 years	 12(10%) 34(28%) 77(62%)	 8(7%) 29(26%) 73(66%)	 4(3%) 46(39%) 69(58%)
Paternal education, n(%) ≤9 years Over 9-12 years >12 years	 13(11%) 70(57%) 40(32%)	 10(9%) 61(55%) 39(35%)	 9(8%) 47(41%) 58(51%)
5 year full-scale IQ <70, n(%)	5/117(4%)		0/125(0%)

[a] Behavior Rating Inventory of Executive Function questionnaire rated by at least the parent and/or by the teacher; [b] Defined as a birth weight of <-2.0 SD according to the age and gender specific Finnish growth charts; [c]Defined as a need for supplementary oxygen at the corrected age of 36 gestational weeks; [d]Magnetic resonance imaging.

Table 2 Proportion of very low birth weight or very low gestational age children with full-scale IQ ≥70 and controls that had clinically significant problems (Scores above 64) in executive function at home (A) and at school (B).

A.

BRIEF[a] Clinically significant problems at home	VLBW or VLGA children with IQ ≥70 (n=103) n (%)	Controls (n=125) n (%)	P	OR (CI 95%)
Inhibit	9 (9%)	4 (3%)	.08	2.90 (0.87–9.70)
Shift	5 (5%)	2 (2%)	.18	3.14 (0.60–16.52)
Emotional Control	7 (7%)	4 (3%)	.22	2.21 (0.63–7.76)
Behavioral Regulation Index	9 (9%)	2 (2%)	**.03**	5.89 (1.24–27.90)
Initiate	10 (10%)	8 (6%)	.36	1.57 (0.60–4.14)
Working Memory	11 (11%)	8 (6%)	.25	1.75 (0.68–4.53)
Plan/Organize	9 (9%)	5 (4%)	.15	2.30 (0.75–7.09)
Organization of Materials	12 (12%)	8 (6%)	.17	1.93 (0.76–4.92)
Monitor	7 (7%)	3 (2%)	.12	2.97 (0.75–11.77)
Metacognition Index	12 (12%)	6 (5%)	.06	2.62 (0.95–7.23)

[a]Behavior Rating Inventory of Executive Function.

B.

BRIEF[a] Clinically significant problems at school	VLBW or VLGA children with IQ ≥70 (n=110) n (%)	Controls (n=128) n (%)	P	OR (CI 95%)
Inhibit	14 (13%)	12 (9%)	.41	1.41 (0.62–3.19)
Shift	12 (11%)	9 (7%)	.30	1.62 (0.66–4.00)
Emotional Control	9 (8%)	13 (10%)	.60	0.79 (0.32–1.92)
Behavioral Regulation Index	9 (8%)	10 (8%)	.92	1.05 (0.41–2.69)
Initiate	16 (15%)	10 (8%)	.10	2.01 (0.87–4.63)
Working Memory	21 (19%)	11 (9%)	**.02**	2.51 (1.15–5.47)
Plan/Organize	9 (8%)	5 (4%)	.17	2.19 (0.71–6.75)
Organization of Materials	12 (11%)	8 (6%)	.20	1.84 (0.72–4.67)
Monitor	15 (14%)	9 (7%)	.10	2.09 (0.88–4.98)
Metacognition Index	13 (12%)	8 (6%)	.14	2.01 (0.80–5.05)

[a]Behavior Rating Inventory of Executive Function.

Table 3 Correlation between executive function profiles and an additional value of executive function profile at school.

	VLBW or VLGA children (n=111)				
	Scores	Clinically significant problems (Scores >64)			
BRIEF[a] Profile at home and at school	r Median (Min, Max)	n (%)	Agree[b]	Kappa[c] (CI 95%)	Problems only at school[b]
Inhibit	.47***		6/20 (30%)	.39 (0.14–0.65)	10/20 (50%)
parent	44 (40, 94)	10 (9%)			
teacher	46 (44, 108)	16 (14%)			
Shift	.30**		2/21 (10%)	.09 (-0.13–0.31)	13/21 (62%)
parent	45 (38, 91)	8 (7%)			
teacher	47 (44, 93)	15 (14%)			
Emotional Control	.36***		5/17 (29%)	.39 (0.12–0.67)	6/17 (35%)
parent	44 (37, 85)	11 (10%)			
teacher	46 (45, 105)	11 (10%)			
Behavioral Regulation Index	.41***		6/18 (33%)	.44 (0.18–0.70)	5/18 (28%)
parent	44 (36, 94)	13 (12%)			
teacher	48 (43, 109)	11 (10%)			
Initiate	.42***		4/27 (15%)	.15 (-0.07–0.37)	16/27 (59%)
parent	47 (35, 86)	11 (10%)			
teacher	51 (42, 73)	20 (18%)			
Working Memory	.49***		9/32 (28%)	.32 (0.11–0.53)	16/32 (50%)
parent	51 (38, 89)	16 (14%)			
teacher	51 (43, 92)	25 (23%)			
Plan/Organize	.50***		5/18 (28%)	.37 (0.10–0.64)	6/18 (33%)
parent	49 (37, 86)	12 (11%)			
teacher	47 (43, 86)	11 (10%)			
Organization of Materials	.23*		5/25 (20%)	.23 (-0.01–0.47)	11/25 (44%)
parent	49 (34, 99)	14 (13%)			
teacher	46 (44, 99)	16 (14%)			
Monitor	.45***		7/25 (28%)	.35 (0.11–0.58)	12/25 (48%)
parent	49 (33, 86)	13 (12%)			
teacher	49 (41, 102)	19 (17%)			
Metacognition Index	.50***		10/22(46%)	.56 (0.34–0.78)	7/22 (32%)
parent	49 (35, 89)	15 (14%)			
teacher	50 (42, 91)	17 (15%)			

[a]Behavior Rating Inventory of Executive Function; [b]Referred to clinically significant problems at least in one environment; [c]Moderate agreement = 0.40 to 0.60, fair agreement= 0.20 to 0.40, and slight agreement = 0 to 0.2; *p <.05, ** p <.01, ***p < .001.