Self- and Parent-Rated Executive Functioning in Young Adults With Very Low Birth Weight

BACKGROUND AND OBJECTIVE: Adults born preterm score lower on performance-based tests of executive functioning (EF) than their term-born peers. These test scores do not necessarily translate to application of these skills in an everyday environment. The objective of the study was to test differences between very low birth weight (VLBW; <1500 g) adults and their term-born peers in self- and parent-rated EF and examine concordance between self- and parent-rated EF and performance-based tests of EF.

METHODS: A longitudinal study of 90 VLBW adults and 93 term-born controls (aged 21–30 years) was performed. The young adults and their parents filled in the Behavioral Rating Inventory of Executive Functioning—Adult Version, and the adults underwent performance-based tests of EF.

RESULTS: VLBW young adults and especially those born appropriate for gestational age reported fewer problems in behavioral regulation and global EF than term-born controls; however, parents of VLBW adults born small for gestational age reported more problems for their children in all EF scales than parents of the controls. Compared with their parents, VLBW young adults reported fewer problems in behavioral regulation. Adults’ ratings and their parents’ ratings correlated significantly among VLBW and control groups. In the VLBW and VLBW/small-for-gestational-age groups, parent ratings of EF were correlated to performance-based tests, whereas among term-born adults, self-reports correlated.

CONCLUSIONS: These findings reveal that VLBW adults may have learned to compensate in the everyday environment for their EF deficits apparent in performance-based tests. Alternatively, VLBW adults may have positively skewed views of their abilities. Pediatrics 2013;131:1–8
Prematurity and small body size at birth may pose a risk for poorer neurocognitive functioning and academic performance and for emotional, social, and behavioral impairments later in life.1–8 This risk characterizes not only children and adolescents born premature but also appears to carry consequences for their functioning and performance in adulthood as well. These problems may be at least in part due to problems in executive functioning (EF).9–13 EF refers to a set of higher-order neurocognitive processes such as inhibition, set shifting, working memory, and self- or task monitoring necessary for purposeful and goal-directed behavior and emotional regulation.14–16

In line with the scant evidence available on the EF of adults born premature,17–20 we have recently demonstrated that adults born premature with very low birth weight (VLBW; <1500 g) scored lower than their term-born peers on performance tests measuring EF11: the VLBW group performed less well in indices of the Trail-Making Test, Stroop Test, and Verbal Fluency.21 Performance-based tests of EF are, however, subject to some criticism. They are suggested to measure core underlying skills and may not translate to the application of these skills in an everyday environment.22 Performance-based tests of EF are typically administered in an environment with minimal distraction, maximal support, and a high degree of structure. Because the testing environments differ greatly from those in which people actually function, performance-based tasks may fail to engage the same set of skills required in real-life settings.22 In addition, problems evident in performance-based tests may be compensated for by other skills in real-life settings.

Our first study objective was to test differences between VLBW adults and term-born controls in EF manifesting in the everyday environment. Our second objective was to test whether VLBW adults born small for gestational age (SGA) are most vulnerable to impairments based on ratings of EF. In relation to VLBW adults born appropriate for gestational age (AGA), those born SGA have a double burden of prenatal and postnatal adversity. We examined self- and parent ratings of EF, because some studies have indicated differences in results by informant. Parents assign more problems in the functioning of their offspring born VLBW than parents of term-born controls, whereas self-reports of those born VLBW are similar to those of term-born controls.23–25 Availability of two informants allowed us also to examine our third objective, the concordance of self- and parent-rated EF. Our final study objective was to compare self- and parent-rated EF with performance-based EF.

**METHODS**

**Participants**

Study participants came from the Helsinki Study of Very Low Birth Weight Adults, a cohort study composed of adults born prematurely at VLBW (<1500 g) and of controls born at term (gestational age ≥37 weeks) and at AGA, matched for age, gender, and birth hospital. The original study group included 335 VLBW infants born between 1978 and 1985, discharged alive (70.7%) from the NICU and followed up during early childhood and 373 matched controls born at term and AGA. This cohort is described in detail elsewhere.26

Those 255 VLBW and 314 control individuals still living in the greater Helsinki area in young adulthood were invited to a first clinical follow-up in 2004–2005, with 168 (65.1%) former VLBW and 172 (54.8%) control individuals participating. Three years later, 313 (92.6%) of those participating in the first clinical follow-up study were invited to a second clinical visit.27 A total of 218 (69.6% of those invited and eligible) participated at ages 21 to 29 (mean: 25.0; SD, 2.2).27 Each participant signed an informed consent, and the study was approved by the local ethics committee and conducted in accordance with the Helsinki Declaration.

In conjunction with the second clinical visit, a set of neurocognitive tests was conducted, and participants were asked to fill in questionnaires including assessments of their EF in the everyday environment (Behavior Rating Inventory of Executive Functioning–Adult Version [BRIEF-A]16). Additionally, parents received informant versions of the same EF questionnaire,16 which 95 VLBW and 94 control participants and their mothers or fathers or both completed. Six participants had a neurosensory impairment (deafness, 1; cerebral palsy, 4; and developmental disability, 1) and were excluded. The analytical sample included 90 VLBW and 93 control participants and their parent(s). Age at examination ranged from 21.4 to 29.7 years (mean: 25.0; SD, 2.2). Of the VLBW adults, 31 were born SGA (birth weight less than –2 SD below the mean for gestational age based on Finnish standards).28 Characteristics of the groups are presented in Table 1. The analyzed sample showed no differences from the 132 nonrespondents (individuals invited to the follow-up but not agreeing to participate or those who lacked a parent report) regarding proportion of those born VLBW, gender distribution, gestational age, birth weight, age at hospital discharge, duration of mechanical ventilation (VLBW group), delivery via cesarean section, or maternal preeclampsia or smoking during pregnancy (P-values > .14).

**Measures**

**Ratings of EF in an Everyday Environment**

The BRIEF-A served to measure EF in an everyday environment.16,29 BRIEF-A is
A standardized questionnaire comprising 75 items answered by a 3-point scale. It includes 3 composite scales (Table 2). The Behavioral Regulation Index measures one’s ability to maintain appropriate regulatory control of one’s own behavior and emotional responses. The Metacognition Index measures one’s ability to solve problems via planning and organization in different contexts. The Global Executive Composite combines both indices. Raw scores were used in the analyses, because standardized norms of the BRIEF-A in a Finnish sample are not yet available. Higher scores reflect more problems in EF. Adults filled in the self-report, and their parents filled in the informant form of the BRIEF-A. Mean values of the mothers’ and the fathers’ reports or reports of only 1 parent in BRIEF-A served for analysis (mothers, n = 178; fathers, n = 140). Correlation between mothers’ and fathers’ reports, for r > 0.41, for P < .001, n = 127).

Performance-Based Tasks of EF

For the Trail-Making Test, parts A and B require psychomotor speed, focused attention, and visual-spatial ability. Part B further requires working memory, cognitive flexibility, and shifting alternation. The B — A difference score reflects unique task requirements of B and was used as a measure of EF. The Stroop Test comprises 2 tasks, and to increase test complexity, we used the Bohnen modification. The second part (ie, naming the printing ink for incongruously named color words, or if inside a bordered box, reading the color word) measures selective attention and ability to inhibit a dominant response in favor of an unusual one, as well as cognitive flexibility, working memory, and processing speed. The interference score (the second part — baseline) served as a measure of EF. Verbal fluency was measured using phonetics (words beginning with the letters “S” and “P” and category and semantic categories of vegetables or fruits and animals) subtests (number of words within 60 seconds). This test measures expressive-language abilities, particularly speed and flexibility of verbal thought processes.

Statistical Analyses

First, we examined group differences in self-ratings of EF in the everyday environment (BRIEF-A scales) between (I) VLBW adults and term-born controls, (II) VLBW adults born AGA and term-born controls, (III) VLBW adults born SGA and term-born controls, and (IV) VLBW adults born AGA and SGA. We tested group differences by multiple linear-regression

**TABLE 1** Descriptive Characteristics for VLBW and Control Groups

<table>
<thead>
<tr>
<th></th>
<th>VLBW Group</th>
<th>Control Group</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>All, n = 90</td>
<td>AGA, n = 59</td>
</tr>
<tr>
<td></td>
<td>SGA, n = 31</td>
<td></td>
</tr>
<tr>
<td><strong>Birth characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men, n (%)</td>
<td>42 (46.7)</td>
<td>28 (47.5)</td>
</tr>
<tr>
<td>Birth wt, g</td>
<td>1144 (225)*</td>
<td>1147 (225)*</td>
</tr>
<tr>
<td>Birth wt, SD</td>
<td>−1.2 (1.5)*</td>
<td>−0.3 (0.9)*</td>
</tr>
<tr>
<td>Head circumference at birth, cm</td>
<td>26.3 (2.1)*</td>
<td>25.9 (2.0)*</td>
</tr>
<tr>
<td>Gestational age at birth, wk</td>
<td>29.2 (2.2)*</td>
<td>28.2 (1.6)*</td>
</tr>
<tr>
<td><strong>Adult characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at examination, y</td>
<td>22.1 (2.1)</td>
<td>22.2 (2.2)</td>
</tr>
<tr>
<td>Head circumference at adulthood, cm</td>
<td>55.4 (1.8)*</td>
<td>55.6 (1.8)*</td>
</tr>
<tr>
<td>Parental characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental education, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elementary</td>
<td>7 (8.0)</td>
<td>5 (8.6)*</td>
</tr>
<tr>
<td>High school</td>
<td>22 (25.0)</td>
<td>10 (17.2)</td>
</tr>
<tr>
<td>Intermediate</td>
<td>27 (30.7)</td>
<td>23 (39.7)</td>
</tr>
<tr>
<td>University</td>
<td>32 (36.4)</td>
<td>20 (34.5)</td>
</tr>
<tr>
<td>Parental symptoms of ADHD</td>
<td>21.8 (8.0)</td>
<td>21.3 (8.4)</td>
</tr>
</tbody>
</table>

Data are group means (SD) unless otherwise indicated. Ninetieth percentile cutoffs for clinical impairment in BRIEF-A scales set according to manual and in performance-based tests on the basis of control group data. Missing information: adult head circumference (n = 8), birth head circumference (n = 3), Trail-Making Test (n = 2), and Stroop Test (n = 4). *P < .05 for difference against the control group. **P < .05 for difference between the VLBW-AGA and VLBW-SGA groups. a Results of performance-based tests are for descriptive purposes. Original findings with a larger sample in Pyhälä et al.21 b Difference score (part B — part A). c Interference score (the second part — baseline).
analysis. The BRIEF-A raw scores were logarithmically transformed to attain normality. Group differences are reported in percentages with 95% confidence intervals. Second, group differences were examined in the parent ratings of EF. Third, level of agreement between the adults’ and their parents’ reports of EF was examined via paired sample t tests and intraclass correlation coefficients (ICCs). Fourth, we tested separately in all groups the associations between self- and parent ratings and performance-based tests of EF, and we tested associations by using partial correlations. Logarithmic transformations were made to performance-based tests when needed.21

Adjusted models included: (I) gender and age at assessment; (II) model I and current head circumference and head circumference SD score at birth (head circumference serves as a proxy for brain volume, which is associated with EF35), the highest education level of either parent (higher socioeconomic background is related to better EF skills34,35), and participant’s Wechsler Adult Intelligence Scale–III IQ score21,36 (general cognitive abilities have been shown to be related to EF skills37 and to low birth weight21); and (III) model II and the mean of parent reports of their own attention-deficit/hyperactivity disorder (ADHD) symptoms38 (parental ADHD is related to child’s EF39).

RESULTS

Initial Analyses

We tested the associations between covariates and self- and parent-rated EF after controlling for term-born versus VLBW status. Compared with men, women reported more problems in behavioral regulation and in global EF (P values < .01). According to parent reports, women had more problems in behavioral regulation (P = .02) than men. After controlling for gender, a participant’s lower IQ score was related to problems in parent-reported metacognition and global EF (P values < .01). Parents’ symptoms of ADHD were related to adults’ self-reports of problems in metacognition (P = .05). Parents’ symptoms of ADHD also were related to higher parent-reported problems in all BRIEF-A scales (P values < .01). Finally, higher parental education was related to fewer problems in parent-reported behavioral regulation (P = .01). All other P values > .05.

Self- and Parent Ratings of EF in an Everyday Environment: Group Comparisons

VLBW adults born AGA reported fewer problems in behavioral regulation and in global EF than term-born controls (model I) (Table 3). These differences showed no change after additional adjustments (models II and III). After additional adjustments (models II and III), however, the combined VLBW group adults (including both VLBW-AGA and VLBW-SGA groups) also reported fewer problems in behavioral regulation than those born at term (Table 3). Parents of VLBW adults born SGA reported more problems in their children’s behavioral regulation, metacognition, and global EF than parents of term-born controls (model I) (Table 3). Results remained the same even after further adjustments (models II and III).

Agreement Between Self- and Parent Ratings

The paired mean score comparisons showed that, compared with their parents, term-born control-group adults reported more problems in all BRIEF-A scales (t > 2.14, P < .04), and the combined VLBW group adults reported fewer problems in behavioral regulation (t = 2.23, P = .03). In addition, all ICCs between self- and parent ratings were statistically significant in the term-born control group, in the combined VLBW group, and in the VLBW-AGA group (all ICCs > 0.53, P values < .001). In the VLBW-SGA group, however, none of the ICCs were statistically significant (ICCs < 0.44, P values > .06).

Associations Between Ratings and Performance-Based Tasks of EF

In the term-born control group, better self-reported EF (all BRIEF-A scales) was related to better performance in the Verbal Fluency Test. In the combined VLBW group, better parent-rated EF (all BRIEF-A scales) was related to better

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Table 2: Description of the BRIEF-A Composite Indices and Their Clinical Subscales

<table>
<thead>
<tr>
<th>Composite Index/Clinical Subscales</th>
<th>Descriptions of the Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral Regulation Index</td>
<td>Ability to maintain appropriate regulatory control of one’s own behavior and emotional responses</td>
</tr>
<tr>
<td>Inhibit</td>
<td>Inhibitory control (ie, to inhibit, resist, or not act on impulse) and the ability to stop one’s own behavior</td>
</tr>
<tr>
<td>Shift</td>
<td>Ability to shift between behavioral or cognitive tasks</td>
</tr>
<tr>
<td>Emotional Control</td>
<td>Ability to modulate emotional responses</td>
</tr>
<tr>
<td>Self-Monitor Scale</td>
<td>Ability to track one’s own behavior and its effects on others</td>
</tr>
<tr>
<td>Metacognition Index</td>
<td>Ability to solve problems via planning and organization in variety of contexts</td>
</tr>
<tr>
<td>Initiate</td>
<td>Ability to start task or activity and independently generate ideas, responses, or problem-solving strategies</td>
</tr>
<tr>
<td>Working Memory</td>
<td>Capacity to actively hold information in mind to complete task or generate a response</td>
</tr>
<tr>
<td>Plan/Organize</td>
<td>Ability to manage current- and future-oriented task demands within situational context</td>
</tr>
<tr>
<td>Task Monitor</td>
<td>The extent to which one keeps track of one’s own problem-solving success or failure</td>
</tr>
<tr>
<td>Organization of Materials</td>
<td>Organization of everyday environment, orderliness of work, living, and storage spaces</td>
</tr>
</tbody>
</table>

Global Executive Composite Incorporates all of the clinical scales of BRIEF-A.
performance in trail making and verbal fluency. In the VLBW-AGA group, better parent-rated behavioral regulation and global EF were related to better performance in the Trail-Making Test (model I, Table 4).

In fully controlled models (model III, Table 4), better self- and parent-rated EF was related significantly to better performance in EF tests in the following way: in the term-born control group, self-reported metacognitive abilities and global EF were related to verbal fluency; in the combined VLBW group, parent-rated metacognitive abilities and global EF were related to verbal fluency; in the VLBW-AGA group, parent-rated behavioral regulation and global EF were related to the Trail-Making Test; and in the VLBW-SGA group, parent-reported metacognition and global EF were related to the Trail-Making and Verbal Fluency Tests, and behavioral regulation was related to the Trail-Making Test.

**DISCUSSION**

We examined the ratings of EF of VLBW adults in an everyday environment from the perspective of the young adults themselves and their parents, and in relation to performance-based tests of EF. Our results revealed that VLBW adults, on average, rate their EF as similar to that of those born at term; average ratings among the VLBW-AGA group were even more positive than among controls; however, parents of VLBW adults born SGA reported more EF problems in their children than parents of those born at term. Our results also reveal that parents of VLBW young adults seemed to report more problems in their offspring than the young adults themselves, whereas the reverse was true for the term-born controls. Finally, we found that among VLBW adults the performance-based test scores associated with parent reports of EF, whereas among term-born controls, associations were found with self-reports.

To our knowledge, this report is the first to focus on VLBW adults’ EF in an everyday environment. Earlier studies on parental ratings of EF extend up to adolescence.\textsuperscript{40,41} Studies are also lacking on agreement between parents’ and VLBW subjects’ self-reports on EF and between VLBW adults’ self-reports and performance-based tasks of EF. VLBW and term-born adults’ self-reports of EF generally resembled each other; which is in line with other studies on behavioral and emotional adjustment.\textsuperscript{4,25,42} However, we also found that, compared with those born at term, VLBW adults evaluated more positively their ability to regulate and modulate their behavior and emotions (combined VLBW group and VLBW-AGA group) and their global EF (VLBW-AGA group). Current results of VLBW adults views of themselves are in line with our other results showing that compared with term-born individuals, VLBW young adults reported less impulsiveness, that is, better ability to control their emotions\textsuperscript{6} and fewer depressive symptoms (VLBW and VLBW-AGA groups).\textsuperscript{8} Evidence also exists on fewer self-reported behavioral problems and less risk-taking behavior among extremely low birth weight/VLBW participants compared with controls,\textsuperscript{1,43–45} yet contrasting findings exist.

Instead, we found that parents of VLBW-SGA adults report their children’s EF skills as poorer than parents of term-born children. In line with earlier findings on parental reports of EF among extremely low birth weight/ VLBW children and adolescents, we found that VLBW-SGA adults received lower scores on the Metacognition Index and Global Executive Composite scale.\textsuperscript{40,41,47,48} In contrast to earlier findings,\textsuperscript{40,41} we also found associations with the Behavioral Regulation Index. Earlier studies, however, used younger participants born with lower birth weights,\textsuperscript{40,41} limiting direct comparisons to our results.

Studies on agreement (mean level) between parents’ and VLBW participants’ perceptions are relatively few and mixed,\textsuperscript{25,46,43} with none regarding EF. Instead, we found that parents of VLBW-SGA adults report their children’s EF skills as poorer than parents of term-born children. In line with earlier findings on parental reports of EF among extremely low birth weight/ VLBW children and adolescents, we found that VLBW-SGA adults received lower scores on the Metacognition Index and Global Executive Composite scale.\textsuperscript{40,41,47,48} In contrast to earlier findings,\textsuperscript{40,41} we also found associations with the Behavioral Regulation Index. Earlier studies, however, used younger participants born with lower birth weights,\textsuperscript{40,41} limiting direct comparisons to our results.

Studies on agreement (mean level) between parents’ and VLBW participants’ perceptions are relatively few and mixed,\textsuperscript{25,46,43} with none regarding EF.
VLBW adults tended to report less problems, but term-born controls tended to report more problems in EF than their parents. It seems that VLBW adults’ self-perceptions of their EF are very similar to those of term-born individuals, but parents more easily evaluate VLBW adults more negatively and term-born ones more positively than the adults themselves. Earlier studies have shown that mothers perceive premature children as cognitively less competent and behaviorally less mature even in the absence of objective indicators of suboptimal postnatal development. Our results suggest that a child’s premature birth impacts the parents’ views of that child even in adulthood. In addition, the findings may suggest that parents of VLBW children are more aware of their children’s abilities than parents of term-born controls. We have previously shown that premature VLBW adults leave the parental home later, their parents have had longer to observe their children, up to the age of full EF development. ICCs of parents’ and VLBW children’s reports have ranged from low to high. In the current study we found that the correlations between self- and parent ratings of EF were relatively high, yet the association was weakest in the VLBW-SGA group. Studies have reported nonsignificant and significant correlations between performance-based tests and parent ratings of EF. We found that among VLBW adults, performance-based measures of EF were associated with parental reports, whereas among term-born individuals, associations were found with self-reports. The findings were not systematic across different measurements and were relatively modest, which may indicate that BRIEF scales and performance-based tests measure different aspects of EF or that performance-based tests have low validity in an everyday environment. Yet BRIEF scales also may measure a broader range of concerns than performance-based tests of EF.

Our findings that VLBW-SGA adults’ self-evaluations did not differ from those of adults born at term and were not significantly related to performance-based tests, together with our previous finding showing that VLBW adults perform more poorly than term-born controls in tests measuring neurocognitive abilities, may suggest that VLBW-SGA adults have learned to compensate for some of their EF shortages in everyday life. Yet the finding that VLBW adults’ self-reports of their EF skills were more positive than their parents’ reports also may reflect positive bias among VLBW adults.

Finally, we found that on several occasions, VLBW adults born SGA differed from the rest of the groups. Whereas VLBW infants born SGA share similar experiences after birth as those born AGA, the period before birth differs; among SGA the period before birth is often characterized by placental dysfunction and hypoxia severe enough to prompt immediate delivery. The SGA birth may have long-term effects through many mechanisms: being born SGA may challenge parent-child

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**TABLE 4. Partial Correlations Between Behavioral Ratings of EF (BRIEF-A) and Performance-Based Tasks of EF**

<table>
<thead>
<tr>
<th>Behavioral Ratings of EF</th>
<th>Parent Reports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Behavioral Regulation Index, Model I</td>
</tr>
<tr>
<td>Control</td>
<td>Metacognition Index, Model I</td>
</tr>
<tr>
<td>VLBW</td>
<td>Metacognition Index, Model I</td>
</tr>
<tr>
<td>VLBW-AGA</td>
<td>Metacognition Index, Model I</td>
</tr>
</tbody>
</table>

| Control | Trail-Making Test | 0.11 | 0.05 | 0.09 | 0.14 | 0.13 | 0.15 |
|         | Verbal Fluency   | -0.26* | -0.23* | -0.27* | -0.14 | -0.13 | -0.14 |
| VLBW    | Trail-Making Test | 0.03 | 0.08 | 0.05 | 0.23* | 0.25* | 0.25* |
|         | Verbal Fluency   | -0.01 | -0.10 | -0.05 | -0.23* | -0.25* | -0.25* |
| VLBW-AGA| Trail-Making Test | 0.04 | 0.09 | 0.06 | 0.21 | 0.31* | 0.27* |
|         | Verbal Fluency   | 0.00 | -0.04 | -0.02 | -0.20 | -0.19 | -0.21 |
| VLBW - SGA| Trail-Making Test | 0.09 | 0.13 | 0.12 | 0.28* | 0.35* | 0.34* |
|          | Verbal Fluency   | -0.07 | -0.12 | -0.01 | -0.23 | -0.27 | -0.26|

* P < .05 after controlling for gender and age.
* P < .05 after controlling for gender, age, parental education, current head circumference, head circumference SD at birth, and current IQ scores (model II).
* P < .05 after further controlling for parental symptoms of ADHD (model III). In BRIEF scales and in the Trail-Making and Stroop Tests, higher scores reflect poorer performance/more problems in EF, whereas in verbal fluency, higher scores reflect better performance/fewer problems in EF.
interaction, and evidence exists that preterm-SGA infants’ brain anatomy differs from that of those born preterm-AGA.

We have reported on the limitations of the Helsinki Study of Very Low Birth Weight Adults. In addition, EF is shown to be heritable, but we had no data on EF of the parents and could not eliminate the role of genetic factors.

Parental ADHD symptoms and their educational levels served as a proxy for parental neurocognitive abilities.

CONCLUSIONS

Deficits in EF have been linked to poor academic performance and to many disorders, including ADHD, autism-spectrum disorder, and conduct disorder. We found that the VLBW adults’ EF in an everyday environment is less optimal than that of the control adults, at least from the perspective of their parents. Given that VLBW adults have been shown to have deficits in several areas related to EF, these findings may suggest an important intervention area in promoting VLBW adults’ well-being.

REFERENCES


(Continued from first page)

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