



## **Learning difficulties in schoolchildren born with very low birth weight**

**Maura C. C. de Rodrigues,<sup>1</sup> Rosane R. Mello,<sup>2</sup> Sandra C. Fonseca<sup>3</sup>**

### **Abstract**

**Objectives:** To investigate the relationship between very low birth weight and learning difficulties at school by means of a systematic review of the literature, identifying patterns of learning difficulties among these schoolchildren, possible cognitive correlations, peculiarities of the lowest birth weight ranges and any interference with outcomes by socioeconomic and/or clinical factors.

**Sources of data:** Bibliographic search (MEDLINE, LILACS, Excerpta Medica, reference lists of original articles, periodicals related to the subject, information from experts in the area and thesis and dissertation databases) on the keywords: prematurity/very low birth weight, learning difficulties/academic achievement/school performance, follow-up/results/cohort.

**Summary of the findings:** The search returned 114 articles and the 18 of these were selected as having investigated learning difficulties in schoolchildren born with very low birth weights using appropriate methodology. The academic performance of these children was observed to be inferior the whole study population was compared with those born full term. The subject most compromised was mathematics. The risk of suffering from learning difficulties increased in inverse proportion to birth weight. An association was identified between very low birth weight and cognitive compromise.

**Conclusions:** The systematic approach corroborated the results obtained by published studies: schoolchildren born with very low birth weights exhibited increased risk of learning difficulties when compared with those born at full term. There was a predominance of children with multiple academic subjects compromised and mathematics was the most affected. Risk was observed to follow an ascending gradient as birth weight reduced. There was an association between very low birth weight and cognitive compromise.

*J Pediatr (Rio J). 2006;82(1):6-14: Learning disorders, very low birth weight, systematic review.*

### **Introduction**

Infant mortality rates reduced significantly over the last decade, particularly in developed countries.<sup>1</sup> A significant part of this reduction is the result of reductions

in neonatal mortality brought about by pharmacological and technical advances, both in delivery rooms and intensive care units.<sup>2-12</sup> Exogenous surfactant treatment has been particularly decisive to the survival of neonates with very low birth weights (below 1,500 g) and extremely low birth weights (below 1,000 g).<sup>13</sup>

According to the literature on this subject, these babies are at increased risk of sequelae such as cerebral palsy, intellectual deterioration and convulsions,<sup>14</sup> in addition to blindness and deafness.<sup>15</sup> Many researchers has emphasized learning and behavioral difficulties among schoolchildren and also reduced social and adaptive functions,<sup>15,16</sup> even when there is no major neurodevelopmental deterioration.

It is estimated that children born prematurely exhibit an up to 50% increased probability of requiring special education, when compared with children born at full

1. Mestre, Instituto Fernandes Figueira (FIOCRUZ). Neonatologista, Programa Núcleo Atenção Interdisciplinar do Recém-Nascido de Risco, Hospital Municipal Raphael de Paula Souza, Secretaria Municipal da Saúde, Rio de Janeiro, RJ, Brasil.

2. Doutora, Instituto Fernandes Figueira (FIOCRUZ). Neonatologista, Seguimento de Recém-Nascido de Risco, IFF, Rio de Janeiro, RJ, Brasil.

3. Doutora, Escola Nacional de Saúde Pública (FIOCRUZ). Epidemiologista, Hospital Municipal Raphael de Paula Souza, Secretaria Municipal da Saúde, Rio de Janeiro, RJ, Brasil.

\* This study is based on the Master's thesis by Maura C. C. de Rodrigues, under supervision by Rosane R. Mello and Sandra C. Fonseca; Pós-graduação em Saúde da Criança, Instituto Fernandes Figueira, February 2005.

Manuscript received Jun 29 2005, accepted for publication Oct 03 2005.

**Suggested citation:** de Rodrigues MC, Mello RR, Fonseca SC. Learning difficulties in schoolchildren born with very low birth weight. *J Pediatr (Rio J)*. 2006;82:6-14.

term. Specific learning difficulties are one of the primary causes of special educational needs.<sup>15,17</sup> This being the case, these results are becoming increasingly important, not just to healthcare teams, but also for schools and educational planners.<sup>4</sup>

Within the school environment learning difficulties are interpreted via their functional aspects, i.e. as a discrepancy between performance and ability as measured by the intelligence quotient.<sup>17</sup> In reality, despite apparently exhibiting intellectual function within normal limits when submitted to standardized tests, children born prematurely are at increased risk of academic performance disabilities.<sup>18-30</sup> This risk appears to increase in line with reductions in birth weight.<sup>16,19</sup> The academic difficulties exhibited by extremely low birth weight children reflect their vulnerabilities in terms of visuospatial, visuomotor and verbal abilities.<sup>19</sup>

Notwithstanding, the magnitude and extent of the influence that premature birth has and the impact of technological innovations on behavioral and cognitive outcomes in this population are still subjects of study.<sup>1</sup> A host of methodological problems, such as inadequate study design, undersized population samples, inadequate demographic data, elevated follow up losses, weak control group selection procedures and other issues result in studies being subject to criticism and make it difficult to estimate the true effect of being born prematurely or with very low weight.<sup>1,11,16,31-33</sup> In this problematic scenario, a systematic review of the literature represents one research strategy, since it dictates increased stringency at all stages, excluding methodologically inadequate articles and reproducing an observational study with an increased sample size.

The main objective of this study is to identify the association between very low birth weight and learning difficulties, by means of a systematic review of the literature. Specific objectives were to identify the following in the articles selected: observed patterns of learning difficulties among children born weighing 1,500 g or less; correlations between academic difficulties and memory and cognitive and visuomotor abilities; possible interference by socioeconomic factors and associations between clinical factors and observed educational outcomes.

## Materials and methods

A systematic review of the literature is a summary of medical literature that employs explicit methods for systematic research together with critical evaluation and synthesizes the results of several different studies to a specific question.<sup>34,35</sup>

A bibliographic search was run on the following keywords in varying combinations: prematurity, very low birth weight; learning difficulty/disability, academic

achievement, school performance, follow-up, results, cohort.

Studies were located in computerized and manual databases (MEDLINE, LILACS and *Excerpta Medica*), reference lists of original articles, unindexed periodicals related to the subject, information from experts working in the area and electronic databases of theses and dissertations.

Inclusion criteria were: original research articles published from 1994 to 2004, in Portuguese, English or Spanish, where the outcome (or one of the outcomes) under investigation was learning difficulties at school age in a population of very low birth weight children. A control group was defined as being a prerequisite and it was also decided that this control group could not be a historical cohort. Review articles, meta-analyses, editorials and case histories were all excluded.

An instrument (a questionnaire for assessing the quality of the methodology and analysis of articles) was constructed in order to assess the internal validity of each study, based on criteria adapted from Oxman et al.<sup>36</sup> and Streiner & Norman.<sup>37</sup> The questionnaire was subjected to tests of reliability by experienced neonatology and epidemiology professionals.

The questionnaire was then applied to the articles that met the inclusion criteria, with reviewer anonymity maintained, and those studies that were considered methodologically sound were selected.

## Results

The electronic keyword search returned 114 articles, of which 18 articles were selected. None of the 18 articles was branded as methodologically inadequate and they were all included in this study.

In more than 72% of the studies,<sup>8,16,19,20,28,30,38-44</sup> the study population was selected on a populational basis and all of the articles described cohort studies.

The mean age group varied from 6 years and 7 months to 17 years. Birth weight was the most frequently used cutoff parameter for defining prematurity, to the detriment of gestational age.

Percentage sample losses were reported by all of the articles and varied widely: from 1.4 to 35.5%. Around 60% of the studies exhibited losses of up to 10%<sup>4,8,19,20,28</sup> and in 50% of the articles<sup>4,8,18,19,20,28,39,41,45</sup> there was no information on whether or not these losses were selective.

Specific learning difficulties were often embedded within wider results originating from medium and long-term follow-up studies of schoolchildren who had been born with weights less than or equal to 1,500 g. Thus, the outcomes investigated varied from the generic "school-

age outcomes”<sup>8,42,43</sup> and “educational outcomes”<sup>4,18</sup> to the clearly defined and highly specific outcome: “pattern of learning disabilities”.<sup>19</sup>

Just five articles<sup>4,8,19,27,30</sup> described the criteria employed to define specific learning difficulty (for example, low academic achievement or discrepancy between observed and expected achievement).

The majority of the articles (89%) employed psychometric academic achievement tests for measuring outcomes and this was supplemented in 30% of the studies by information collected by questionnaire from the children’s teachers,<sup>4,18,30,40,42-44</sup> although not all articles described a validation process for their questionnaires.

The psychometric tests employed had had their validity confirmed and were appropriate to the age groups to which they were applied. The most used measures of academic achievement were the Woodcock-Johnson Tests of Achievement-Revised (and sub-tests) and the Wide Range Achievement Test-Revised (and subtests). Often, the WISC scale (Wechsler Intelligence Scale for Children) for cognitive assessment was applied and the relationships established between these results and those from the academic achievement tests.<sup>18,35,41</sup>

More than 60% of studies included children with sensorineural deterioration or disorders. Sensorineural deterioration was defined as the presence of one or more of the following conditions: cerebral palsy, microcephalia, hydrocephalus, blindness, deafness and/or mental retardation.<sup>16</sup> Some authors<sup>16,30,40,41,43,44</sup> compared the results from the entire study population with those from the control population (born to full term or with normal weight) and the results of very low birth weight schoolchildren without sensorineural or intellectual dysfunction with the control group. The definition of “intellectual normality” was not uniform, with children included in the study group (exposed) if their IQs were higher than 70 in some studies,<sup>20,40-43</sup> and in others higher than 85.<sup>4,18,19,25,27,30,38,45</sup>

### **Academic achievement**

All 18 articles under investigation confirmed that the academic performance of schoolchildren born weighing 1,500 g or less was worse than that of the control group (born full term and/or with birth weights above 2,500 g) when the entire study population was assessed, i.e. including those born with weights less than or equal to 1,500 g and apparently normal, those with sensorineural deterioration (DSN) and/or borderline or subnormal intelligence quotient (IQ) (Table 1).

In one study,<sup>44</sup> this difference lost significance when children with DSN and/or subnormal IQ (IQ less than or equal to 85). This was a population study performed in Sweden that investigated nine-year olds who had been

born with weights below 1,501 g. At 9 years, the authors confirmed statistically significant differences in the results of all academic achievement tests, with the exception of the vocabulary test. These differences remained significant when very low birth weight children with Scheffzec neurological and functional status scores of 2 or more were excluded. They did not, however, remain significant when children from the control group were compared with very low birth weight children with “normal IQ”. The authors further reported that they had not observed - based on the progress described by parents - any further abnormalities in the school performance of this cohort at 12 years.

The area of academic achievement in which the poorest performance was observed was mathematics (specifically arithmetic, applied problems or numerical abilities), followed by reading in second place. Learning to read was investigated by varying methods with focus on sub-areas with features in common. Reading comprehension was observed to be abnormal in four articles, reading of the word in two articles and letter-word recognition in another two articles. In some of the articles reading disorders were not specified. None of the researchers observed reading disorders in isolation, but, in four articles, arithmetic problems were observed in isolation.<sup>40,46</sup> Seven of the 16 studies that detailed which academic subjects were affected reported problems with writing and spelling (dictation), which, in common with reading disorders, are learning problems related to language.

### **Special education and special academic care**

Special educational needs were described in 61.2% of the articles and were observed to be increased.<sup>4,8,16,20,28,38,41-44</sup> In the study conducted by Taylor et al.,<sup>43</sup> this was only confirmed when the entire study population was assessed; when those with major sensorineural dysfunction were excluded from the study, the difference did not remain significant. Similarly, in one study,<sup>41</sup> special academic educational needs were only increased among very low birth weight schoolchildren who had suffered bronchopulmonary dysplasia. Klebanov et al.<sup>38</sup> confirmed increased special educational needs among extremely low birth weight children, which finding was not observed among those born weighing 1,000 to 1,500 g. Finnström et al.<sup>44</sup> did not observe increased special educational needs among very low birth weight premature children who were intellectually intact, when these were compared with a control group.

Special academic needs can be defined as any requirement for an extra teacher, in or outside of the classroom or for extra teaching hours at the school itself or as the requirement for apparatus or instruments designed to improve or promote learning in the context of

**Table 1** - Results of study groups as to learning difficulties and correlates

Articles	Worst performance in tests of academic achievement	Area of academic performance	Other associations concerning development	Special education need	Special academic assistance need	Higher percentage of repeated years	Higher percentage of attention deficit and hyperactivity disorder	Interference of socio-economic factors	Interference of neonatal clinical factors
Klebanov et al. <sup>38</sup>	Yes	Mathematics Reading	Deficiencies (orthopedic and visual)	Yes (ELBW) No (OVLBW)	Yes (ELBW) No (OVLBW)	Yes	NI	NI	NI
Hack et al. <sup>42</sup>	Yes	NI	Visualmotor Gross motor Adaptative Intelligence	Yes	NI	NI	NI	No	Yes
Hall et al. <sup>20</sup>	Yes	Skills with numbers Word reading	Cognition (intelligence quotient)	Yes	Yes	Yes	NI	Yes	NI
O'Callaghan et al. <sup>27</sup>	Yes	Spelling Reading comprehension Mathematics Writing	NI	NI	NI	NI	No	No	No
Whitfield et al. <sup>30</sup>	Yes	Arithmetic Writing expression Reading	Fine motor Gross motor Visual memory Visualmotor integration Intelligence quotient scale	NI	NI	NI	Yes	Yes	NI
Botting et al. <sup>18</sup>	Yes	Mathematics Reading comprehension	Cognition	NI	Yes	NI	NI	Yes	No
Stjernqvist & Svennings <sup>28</sup>	Yes	Arithmetic Vocabulary and comprehension	Cognition	Yes	Yes	No	Yes	Yes (maternal schooling)	NI
Saigal <sup>25</sup>	Yes	Reading Dictation Arithmetic	Cognition Internalization Adaptative skills	Yes	NI	Yes	NI	Yes	NI
Taylor et al. <sup>43</sup>	Yes	Reading comprehension Letter-word identification Mathematics	Impairment	Yes (with DSN) No (without DSN)	No	Yes	Yes	Yes	NI

ELBW = extremely low birth weight; OVLBW = other very low birth weight; NI = not informed; VLBW = very low birth weight; SND = sensorineural disorder; BPD = bronchopulmonary dysplasia.

**Table 1** - Results of study groups as to learning difficulties and correlates (continuation)

Articles	Worst performance in tests of academic achievement	Area of academic performance	Other associations concerning development	Special education need	Special academic assistance need	Higher percentage of repeated years	Higher percentage of attention deficit and hyperactivity disorder	Interference of socio-economic factors	Interference of neonatal clinical factors
Rickards et al. <sup>46</sup>	Yes	Arithmetic	Information of visual processing and visual memory Social withdrawn and low self-esteem	No	No	Yes	No	NI (academic accomplishment) Yes (cognition)	NI (academic accomplishment) Yes (cognition)
Bowen et al. <sup>4</sup>	Yes	Mathematics Spelling Reading (basic skills)	Retinopathy, Intracranial hemorrhage, sepsis, muscle relaxants associated to disability	Yes	Yes	No	NI	Yes	Yes
Grunau et al. <sup>19</sup>	Yes	Reading Writing Arithmetic	NI	NI	NI	NI	NI	NI	NI
McGrath & Sullivan <sup>8</sup>	Yes	Mathematics	Cognitive deterioration	Yes	Yes	Yes	Yes	NI	Yes
Weindrich et al. <sup>39</sup>	Yes	Arithmetic German	Motor skills Non-verbal intelligence	NI	NI	Yes	NI	NI	Yes
Finnström et al. <sup>44</sup>	Yes (all VLBW) No (VLBW Intellectual/normal)	Mathematics Reading comprehension Spelling/ dictation	Weight, height and head circumference Neurofunctional classification and neurologic examination	Yes (all VLBW) No (VLBW intellectually intact)	NI	NI	Yes	Yes	Yes
Anderson et al. <sup>40</sup>	Yes	Arithmetic Spelling Reading	Cognition Internalization Adaptative skills	NI	Yes	Yes	Yes	Yes	NI
Short et al. <sup>41</sup>	Yes	Mathematics Reading (BPD)	Motor results Cognitive results	Yes (with DBP) No (without DBP)	Yes	No	Yes	NI	Yes
Chaudhari et al. <sup>45</sup>	Yes	Mathematics Writing	NI	NI	NI	NI	NI	NI	NI

ELBW = extremely low birth weight; OVLBW = other very low birth weight; NI = not informed; VLBW = very low birth weight; SND = sensorineural disorder; BPD = bronchopulmonary dysplasia.

inclusive education. In 80% of cases, those articles that analyzed special educational support found it to be necessary, while in one of these<sup>38</sup> special educational needs were only investigated among those born with weights less than or equal to 1,000 g.

### **Repetition of school years**

Premature children exhibited statistically higher rates of repeat years than those born full term.<sup>4,28,41</sup>

### **Attention Deficit/Hyperactivity Disorders (ADHD)**

Attention deficit/hyperactivity disorder (ADHD) can be defined as the persistent presence of progressive and inappropriate characteristics of inattention and/or hyperactivity/impulsivity, according to the Diagnostic and Statistical Manual for Mental Disorders (DSM-IV) published by the American Academy of Psychiatry.<sup>47</sup>

Around 78% of the articles that investigated ADHD found a significantly greater incidence among the premature group than among the control group; while in one study this was not true when very low birth weight schoolchildren scored normally in the Raven Progressive Matrices nonverbal intellectual ability measures.<sup>44</sup>

### **Other associations related to development**

According to many authors, schoolchildren born with weights less than or equal to 1,500 g are at increased risk of disabilities or deterioration in general, as was demonstrated by Bowen et al.<sup>4</sup> and Taylor et al.<sup>43</sup> The authors of the first of these studies believe that this is related to neonatal factors (retinopathy, intracranial hemorrhage, sepsis and muscle relaxants).

Many authors<sup>8,16,18,20,28,39-41,46</sup> reported associations between very low birth weight and cognitive deterioration, gauged by intelligence quotient. Weindrich et al.<sup>39</sup> specified non-verbal intellectual compromise in eleven-year old schoolchildren, with significantly lower mean scores compared to those born weighing less than 2,500 g.

Associations between prematurity and both visual processing and visual memory were observed by Rickards et al.,<sup>46</sup> in addition to increased rates of social rejection and low self-esteem.

Abnormal gross and/or fine motor control performance was shown to be associated with birth weights less than or equal to 1,500 g.<sup>30,39,41,42,44</sup>

Klebanov et al.<sup>38</sup> confirmed that the lower the birth weight, the greater the risk of being classified as disabled. Schoolchildren born with extremely low birth weights exhibited a fivefold increase in the chance of being classed as disabled when compared with children born weighing more than 2,500 g, with particular

emphasis on orthopedic disorders, visual deterioration and diagnoses of visual problems.

### **Interference by socioeconomic factors**

Around 80% of the studies reported that socioeconomic factors impacted on specific learning difficulties.<sup>4,16,18,20,28,30,40,43,44</sup>

Low maternal educational levels were related to retarded reading abilities and special educational needs,<sup>44</sup> and were significantly lower among extremely low weight preterms in relation to those born full term;<sup>28</sup> while having separated parents was related to the quantity of special education required.<sup>44</sup>

### **Associations with clinical neonatal factors**

Seventy-five percent of those articles that mentioned this possibility concluded that clinical neonatal factors did impact on results.<sup>4,8,39,41,42,44</sup>

Factors related to unfavorable educational outcomes were bronchopulmonary dysplasia,<sup>8</sup> length of time on oxygen,<sup>41</sup> intraventricular hemorrhage<sup>8,44</sup> and sepsis.<sup>8</sup> Those children who suffered these conditions during the neonatal period exhibited significantly lower mean scores in all areas of academic achievement<sup>8</sup> or specifically in mathematics,<sup>44</sup> and also in cognition,<sup>41</sup> especially visuoperception.<sup>8</sup> First minute Apgar scores were demonstrated to be related to Raven scores (Raven progressive Matrices for measurement of nonverbal intellectual ability) and reading ability.<sup>44</sup> Mechanical ventilation was associated with mathematics and reading abilities and also with Raven scores,<sup>44</sup> and the duration of ventilation was inversely proportional to intelligence quotient.<sup>18</sup>

Indomethacin used to close patent ductus arteriosus was associated with reduced school performance.<sup>4</sup>

### **Assessment of development broken down by birth weight strata**

Klebanov et al.<sup>38</sup> found that extremely low birth weight schoolchildren exhibited a fivefold (OR 5.56) risk of being classed as disabled than those born at normal weight, that very low birth weight children had a threefold risk, and that those born with weights from 1,500 g to 2,500 g had a risk of 1.53. When they investigated years repeated at school, this risk gradient was reproduced, (with reduced intensity) for the extremely low birth weight and very low birth weight groups compared with the greater than 2,500 g group (OR 3.35 and 2.05, respectively). Extremely low birth weight schoolchildren exhibited significantly lower academic achievement scores than all other birth weight strata; the differences between groups were reduced

when the analysis was restricted to children with IQs above 85, but those born weighing less than 1,000 g still had worse performance scores.

Hack et al.<sup>42</sup> compared the intelligence, academic abilities, special educational needs and adaptive functions of a group of children with birth weights below 750 g and another group with birth weights from 750 to 1,499 g with children born full term. Academic abilities were shown to be three times (RR 3.7; CI 1.3-10.0) more limited among schoolchildren born weighing 750 to 1,499 g and twenty-two times (RR 22.7; CI 2.9-176.7) among the less than 750 g group, when compared with full term children. With respect of intelligence, the risk that a child born at less than 750 g would have a mental processing composite (MPC) score lower than 70 was five times greater than for birth weights between 750 g and 1,499 g, when compared with full term children.

Hall et al.<sup>20</sup> found that groups of children weighing less than 1,000 g at birth and 1,000 to 1,499 g at birth scored significantly lower on reading assessment tests when compared with control groups.

Saigal et al.<sup>16</sup> observed that the lower the birth weight, the lower the scores were for psychometric tests, dictation and arithmetic. No statistically significant differences in reading were observed between subsets (less than 750 g and 750-1,000 g), but the difference between extremely low birth weight and full term children was significant. They also identified an increased proportion of children with special educational needs among those born at less than 750 g compared with those from 750 to 1,000 g at birth (65 against 43%;  $p = 0.02$ ; OR: 2.5; CI: 1.2-5.3).

Taylor et al.<sup>43</sup> reported that children weighing less than 750 g at birth had a greater chance of having special educational needs, repeat years, ADHD and specific learning difficulties than those born between 750 and 1,499, when compared with a full term control group.

McGrath & Sullivan<sup>8</sup> used analysis of variance to demonstrate that only mathematics exhibited significantly different mean values for each group (full term, low birth weight, very low birth weight and extremely low birth weight).

Chaudhari et al.<sup>45</sup> described differences in mean scores for mathematics between schoolchildren born with weights from 1,500 g to 1,999 g and a full term control group that did not attain statistical significance, although significantly lower means were observed among very low birth weight (less than 1,500 g).

Weindrach et al.,<sup>39</sup> in contrast with what was reported by Chaudhari et al., observed that the differences between low birth weight subsets (less than 2,500 g and less than 1,500 g) were very slight for all of the aspects of development that they analyzed: academic achievement,

nonverbal intelligence, motor abilities and attention problems. Nevertheless, it is important to point out that children with neurological deterioration had been excluded from the sample, and such patients notoriously occur with greater frequency among very low birth weight populations than among low weight populations.

### Final considerations

The results obtained in this study, by means of evidence-based methodology were comparable with those described in the literature published on the subject and with what we usually observe in our day-to-day clinical practice. Schoolchildren who were born weighing less than or equal to 1,500 g exhibit increased risk of learning difficulties when compared with those born full term or with weights above 2,500 g. The most common pattern of learning difficulties observed was of compromise to multiple academic areas, with mathematics being the one area of academic achievement that was affected in all articles that detailed this breakdown.

It was also confirmed that there is a risk of learning difficulties gradient across birth weight strata, with the greatest risk observed in the lowest birth weight stratum.

In psychometric tests of academic achievement, the majority of articles demonstrated significant differences between intellectually normal or sensorineural dysfunction-free very low birth weight children and adolescents and control groups. Just one study<sup>44</sup> failed to confirm significant differences in psychometric academic achievement test results when just the intellectually normal very low birth weight population was compared with the normal weight one.

Methodological problems with the study articles limited the extent to which this review was able to fulfill its objectives. Weak control group selection processes, a lack of consensus on the criteria for the diagnosis of learning difficulties, the use of a variety of psychometric tests to investigate outcomes and the varied means of contemplating environmental factors (when contemplated at all), make summary of the results complex. The possibility of interference by clinical factors in the progress of these children and adolescents was not studied by all of the researchers and those that did used different parameters. Even though mathematics was the academic area most affected in all of the studies that provided this information, it was impossible to establish the prevalence of each subtype of verbal and nonverbal learning difficulties among very low birth weight schoolchildren because of the scant descriptions of signs and symptoms that make up the syndrome and due to the fact that a majority of the schoolchildren exhibited difficulties in multiple academic areas simultaneously.

It was possible to confirm an association between birth weights less than or equal to 1,500 g and compromised cognitive, visuomotor and memory faculties.

Unfortunately, the majority (94%) of the study articles, all published during the last ten years, did not include the population of very low weight children born since 1990, making it impossible to assess the impact of technological innovations on this population with respect of specific learning difficulties. New drugs and technology could have the capacity to influence the development of babies born prematurely and at very low weights. One of these new drugs is surfactant, which, by controlling the severity of neonatal respiratory disease, has contributed to a significant decline in severe deterioration of very premature babies.<sup>48</sup> In this review, chronic lung disease was demonstrated to be directly or indirectly (in the form of the parameter “necessity of mechanical ventilation”) associated with worse academic performance. Meta-analyses of randomized clinical trials have shown that antenatal glucocorticoid can reduce the incidence of respiratory distress syndrome and potentialize the effects of exogenous surfactant.<sup>41</sup>

The majority of the very low birth weight population is comprised of those born prematurely. It is beyond the scope of this study to attempt to establish a causality relationship between prematurity *per se* and learning difficulties, and, in the literature consulted on the subject, and also in the study articles, it was impossible to isolate the clinical and social morbid conditions commonly associated with prematurity or very low birth weight. Many different factors can influence the later development of very low birth weight infants. Researchers have found associations with both perinatal and sociodemographic factors and mental deficiencies and specific learning difficulties; although sociodemographic factors appear to be primarily associated with emotional disturbances and specific learning difficulties.<sup>49</sup> Other authors<sup>50</sup> concluded that, for children with very low birth weights, the factors that act on them during fetal and early neonatal life compromise their performance at General Certificate of Secondary Education (GCSE) than do social environmental factors at school during their childhood. In the current study, clinical neonatal factors associated with poor educational achievement were bronchopulmonary dysplasia, time on oxygen, intraventricular hemorrhage and sepsis.

The medium and long term developmental evolution of these children is an area in which concerns and doubts still abound. A contemporary perspective on the many cerebral injuries to which this high-risk group is more susceptible has made it possible to establish links between periventricular brain damage/reduced cerebral volume and cognitive deficits/behavioral disorders/learning disabilities.

Interventions to benefit this very low and extremely low birth weight population will only become possible in the presence of a better understanding of the physiopathogenic mechanisms involved in the brain damage suffered by extremely low birth weight populations, of its causes and of the influence that biological, genetic and environmental factors may have on these children, improving or worsening their development. Long-term, prospective, follow-up studies are required, into populations that have benefited from the new technologies like surfactant. National and international multicenter studies that strictly adhere to the precepts of evidence-based medicine are probably the most trustworthy path to helping very low birth weight schoolchildren, their families and society.

## References

1. Bhutta AT, Cleves MA, Casey PH, Cradock MM, Anand KJ. Cognitive and behavioral outcomes of school-aged children who were born preterm – A meta-analysis. *JAMA*. 2002;288:728-37.
2. Abernethy LJ, Palaniappan M, Cooke RW. Quantitative magnetic resonance imaging of the brain in survivors of very low birth weight. *Arch Dis Child*. 2002;87:279-83.
3. Avchen RN, Scott KG, Mason CA. Birth weight and school-age disabilities: a population-based study. *Am J Epidemiol*. 2001;154:895-901.
4. Bowen JR, Gibson FL, Hand PJ. Educational outcome at 8 years for children who were born extremely prematurely: A controlled study. *J Paediatr Child Health*. 2002;38:438-44.
5. Gabrielson J, Hard A-L, Ek U, Svensson E, Carlsson G, Hellström A. Large variability in performance iq associated with postnatal morbidity, and reduced verbal IQ among school-aged children born preterm. *Acta Paediatr*. 2002;91:1371-8.
6. Hack M, Taylor HG, Klein N, Mercuri-Minich N. Functional limitations and special health care needs of 10- to 14-year-old children weighing less than 750 grams at birth. *Pediatrics*. 2000;106:554-60.
7. Agarwal P, Lim SB. Long-term follow-up and outcome of extremely-low-birth-weight (ELBW) infants. *Ann Acad Med Singapore*. 2003;32:346-53.
8. McGrath M, Sullivan M. Birth weight, neonatal morbidities, and school age outcomes in full-term and preterm infants. *Issues Compr Pediatric Nurs*. 2002;25:231-54.
9. Perlman JM. Neurobehavioral deficits in premature graduates of intensive care – potential medical and neonatal environmental risk factors. *Pediatrics*. 2001;108:1339-48.
10. Póo-Argüelles P, Campistol-Plana J, Iriundo-Sanz M. Recién nacido de riesgo neurológico em el año 2000. Recomendaciones para el seguimiento, incorporación de nuevos instrumentos. *Revista de Neurologia*. 2000;31:645-52.
11. Taylor HG, Klein N, Hack M. School-age consequences of birth weight less than 750g: a review and update. *J Dev Neuropsychol*. 2000;17:289-321.
12. Yu VY. Developmental outcome of extremely preterm infants. *Am J Perinatol*. 2000;17:57-61.
13. Jones HP, Guildea ZE, Stewart JH, Cartlidge PH. The Health Status Questionnaire: achieving concordance with published disability criteria. *Arch Dis Child*. 2002;86:15-20.
14. Stathis SL, O’Callaghan M, Harvey J, Rogers Y. Head circumference in ELBW babies is associated with learning difficulties and cognition but not ADHD in the school-aged child. *Dev Med Child Neurol*. 1999;41:375-80.
15. Hack M, Taylor HG. Perinatal brain injury in preterm infants and later neurobehavior function. *JAMA*. 2000;284:1973-4.
16. Saigal S, Hoult LA, Streiner DL, Stoskopf BL, Rosenbaum PL. School difficulties at adolescence in a regional cohort of children who were extremely low birth weight. *Pediatrics*. 2000;105:325-31.

17. Leonard CH, Piecuch RE. School age outcome in low birth weight preterm infants. *Semin Perinatol.* 1997;21:240-53.
18. Botting N, Powlis A, Cooke RW, Marlow N. Cognitive and educational outcome of very-low-birthweight children in early adolescence. *Dev Med Child Neurol.* 1998;40:652-60.
19. Grunau RE, Whitfield MD, Davis C. Pattern of learning disabilities in children with extremely low birth weight and broadly average intelligence. *Arch Pediatr Adolesc Med.* 2002;156:615-20.
20. Hall A, McLeod A, Counsell C, Thomson L, Mutch L. School attainment, cognitive ability and motor function in a total Scottish very-low-birthweight population at eight years: a controlled study. *Dev Med Child Neurol.* 1995;37:1037-50.
21. Harvey JM, O'Callaghan MJ, Mohay H. Executive function of children with extremely low birth weight: a case control study. *Dev Med Child Neurol.* 1999;41:292-7.
22. Hille ET, Ouden AL, Bauer L, Oudenrijn C, Brand R, Verloove-Vanhorick SP. School performance at nine years of age in very premature and very low birth weight infants: perinatal risk factors and predictors at five years of age. *J Pediatr.* 1994;125:426-34.
23. Jacobs SE, Sokol J, Oblsson A. The newborn individualized developmental care and assessment program is not supported by meta-analyses of the data. *J Pediatr.* 2002;140:699-706.
24. Keller H, Ayub BV, Saigal S, Bar-Or O. Neuromotor ability in 5- to 7-year-old children with very low or extremely low birthweight. *Dev Med Child Neurol.* 1998;40:661-6.
25. Saigal S. Follow-up of very low birthweight babies to adolescence. *Semin Neonatol.* 2000;5:107-18.
26. Sauve RS, Robertson C, Etches P, Byrne PJ, Dayer-Zamora V. Before viability: a geographically based outcome study of infants weighing 500 grams or less at birth. *Pediatrics.* 1998;101:438-45.
27. O'Callaghan MJ, Burns YR, Gray PH, Harvey JM, Mohay H, Rogers YM, et al. School performance of ELBW children: a controlled study. *Dev Med Child Neurol.* 1996;38:917-26.
28. Stjernqvist K, Svenningsen NW. Ten-year follow up of children before 29 gestational weeks: healthier, cognitive development, behavior and school achievement. *Acta Paediatr.* 1999;88:557-62.
29. Walther FJ, Lya den Ouden A, Verloove-Vanhorick SP. Looking back in time: outcome of a national cohort of very preterm infants born in The Netherlands in 1983. *Early Hum Dev.* 2000;50:175-91.
30. Whitfield MF, Grunau RV, Holsti L. Extremely premature ( $\leq$  800g) schoolchildren: multiple areas of hidden disability. *Arch Dis Child.* 1997;77:85-90.
31. Agarwal P, Lim SB. Long-term follow-up and outcome of extremely-low-birth-weight (ELBW) infants. *Ann Acad Med Singapore.* 2003;32:346-53.
32. Aylward GP, Pfeiffer SI, Wright A, Verhulst SJ. Outcome studies of low birth weight infants published in the last decade: A metaanalysis. *Pediatrics.* 1989;115:515-20.
33. Orstein M, Ohlsson A, Edmonds J, Asztalos E. Neonatal follow-up of very low birthweight/extremely low birthweight infants to school age: a critical overview. *Acta Paediatr Scand.* 1991;80:741-8.
34. Oxman AD. Science of reading. *Pediatrics.* 1989;83:617-9.
35. Allen MC. Preterm outcomes research: a critical component of neonatal intensive care. *Ment Retard Dev Disabil Res Rev.* 2002;8:221-33.
36. Oxman AD, Guyatt GH, Singer J. Agreement among reviewers of review articles. *J Clin Epidemiol.* 1991;44:91-8.
37. Streiner DL, Norman GR. Health measurement scales: a practical guide to their development and use. Oxford: Oxford University Press; 1995.
38. Klebanov PK, Brooks-Gunn J, McCormick MC. Achievement and failure in very low birth weight children. *J Dev Behav Pediatr.* 1994;15:248-56.
39. Weindrich D, Jennen-Steinmetz C, Laucht M, Schmidt MH. Late sequelae of low birthweight: mediators of poor school performance at 11 years. *Dev Med Child Neurol.* 2003;45:463-9.
40. Anderson P, Doyle LW, the Victorian Infant Collaborative Study Group. Neurobehavioral outcomes of school-age children born extremely low birth weight or very preterm in the 1990s. *JAMA.* 2003;289:3264-72.
41. Short EJ, Klein NK, Lewis BA, Fulton S, Eisengart S, Kerckmar C, et al. Cognitive and academic consequences of bronchopulmonary dysplasia and very low birth weight: 8-year-old outcomes. *Pediatrics.* 2003;112:359-66.
42. Hack M, Taylor HG, Klein N, Eiben R, Schatschneider C, Mercuri-Minich N. School-age outcomes in children with birth weights under 750g. *N Engl J Med.* 1994;331:753-9.
43. Taylor HG, Klein N, Minich NM, Hack M. Middle-school-age outcomes in children with very low birthweight. *Child Devel.* 2000;71:1495-511.
44. Finnström O, Gäddlin PO, Leijon I, Samuelsson S, Wadsby M. Very-low-birth-weight children at school age: academic achievement, behavior and self-esteem and relation to risk to risk factors. *J Matern-Fetal Neonatal Med.* 2003;14:75-84.
45. Chaudhari S, Otiv M, Chitale A, Pandit A, Hoge M. Pune Low Birth Weight Study – cognitive abilities and educational performance at twelve years. *Indian Pediatrics.* 2004;41:121-8.
46. Rickards AL, Kelly EA, Doyle LW, Callanan C. Cognition, academic progress, behavior and self-concept at 14 years of very low birth weight children. *J Dev Behav Pediatr.* 2001;22:11-8.
47. American Psychiatric Association (APA): Diagnostic and statistical manual of mental disorders. 4th ed. Washington, DC: American Psychiatric Press; 1994.
48. Hallman M, Vainionpää L. Infants born very premature – more prospective studies needed. *Acta Paediatr.* 2000;89:1149-54.
49. Resnick MB, Shanti VG, Carter RL, Ariel M, Roth J, Kilgore KL, et al. Educational disabilities of neonatal intensive care graduates. *Pediatrics.* 1998;102:308-14.
50. Pharoah PO, Stevenson CJ, West CR. General Certificate of Secondary Education performance in very low birthweight infants. *Arch Dis Child.* 2003;88:295-8.

## Correspondence:

Maura C. C. de Rodrigues  
 Rua Cândido Gaffrée, 169, Urca  
 CEP 22291-080 – Rio de Janeiro, RJ – Brazil  
 E-mail: mauraricardo@terra.com.br