



REVIEW ARTICLE

Effect of preterm birth on motor development, behavior, and school performance of school-age children: a systematic review ☆, ☆☆

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KEYWORDS

Premature birth;
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Abstract

Objectives: to examine and synthesize the available knowledge in the literature about the effects of preterm birth on the development of school-age children.

Sources: this was a systematic review of studies published in the past ten years indexed in MEDLINE/Pubmed, MEDLINE/BVS; LILACS/BVS; IBECs/BVS; Cochrane/BVS, CINAHL, Web of Science, Scopus, and PsycNET in three languages (Portuguese, Spanish, and English). Observational and experimental studies that assessed motor development and/or behavior and/or academic performance and whose target-population consisted of preterm children aged 8 to 10 years were included. Article quality was assessed by the Strengthening the reporting of observational studies in epidemiology (STROBE) and Physiotherapy Evidence Database (PEDro) scales; articles that did not achieve a score of 80% or more were excluded.

Summary of findings: the electronic search identified 3,153 articles, of which 33 were included based on the eligibility criteria. Only four studies found no effect of prematurity on the outcomes (two articles on behavior, one on motor performance and one on academic performance). Among the outcomes of interest, behavior was the most searched (20 articles, 61%), followed by academic performance (16 articles, 48%) and motor impairment (11 articles, 33%).

Conclusion: premature infants are more susceptible to motor development, behavior and academic performance impairment when compared to term infants. These types of impairments, whose effects are manifested in the long term, can be prevented through early parental guidance, monitoring by specialized professionals, and interventions.

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PALAVRAS-CHAVE

Nascimento prematuro;
Destreza motora;
Comportamento;
Transtornos de aprendizagem

Efeito do nascimento prematuro no desenvolvimento motor, comportamento e desempenho de crianças em idade escolar: revisão sistemática

Resumo

Objetivos: examinar e sintetizar o conhecimento da literatura sobre os efeitos do nascimento prematuro no desenvolvimento de crianças em idade escolar.

Fontes de dados: revisão sistemática de estudos dos últimos 10 anos indexados nas bases de dados *Medline/Pubmed*; *Medline/BVS*; *Lilacs/BVS*; *IBECs/BVS*; *Cochrane/BVS*; *Cinahl*; *Web of Science*; *Scopus e PsycNET*, em três línguas (português, espanhol e inglês). Foram incluídos estudos observacionais e experimentais que avaliaram o desenvolvimento motor e/ou comportamento e/ou desempenho escolar e que tinham como população-alvo crianças prematuras na faixa etária de oito a 10 anos. A qualidade dos artigos foi avaliada pelas escalas STROBE e PEDro e utilizou-se ainda, como critério de exclusão, artigos que não atingissem uma pontuação correspondente a 80% ou mais nos itens das referidas escalas.

Síntese de dados: a busca eletrônica identificou 3.153 artigos, sendo que 33 foram incluídos a partir dos critérios de elegibilidade. Apenas quatro estudos não encontraram qualquer efeito da prematuridade sobre os desfechos pesquisados (dois artigos sobre o comportamento, um sobre desempenho motor e um sobre desempenho escolar). Dentre os desfechos de interesse, o comportamento foi o mais pesquisado (20 artigos/61%) seguido do desempenho escolar (16/48%) e dos problemas motores (11/33%).

Conclusão: crianças prematuras são mais susceptíveis a prejuízos no desenvolvimento nas áreas motoras, de comportamento e de desempenho escolar em longo prazo quando comparadas a crianças nascidas a termo. Portanto, esses diferentes tipos de agravos, cujos efeitos se manifestam, em longo prazo, podem ser prevenidos precocemente através de orientação dos pais, acompanhamento dos profissionais especializados e intervenção.

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Introduction

Preterm birth has been the subject of concern for families, professionals, and healthcare managers, as early detection of its consequences can facilitate therapeutic interventions and minimize future sequelae. Thus, programs were created to follow premature infants; in most cases, these programs follow the children until the age of 2 years, and are intended primarily for the detection of severe disabilities such as cerebral palsy.¹ This follow-up policy does not appear to be based on evidence, since a small number of premature infants will develop severe sequelae, yet many will have lifelong social limitations and restrictions, as they will have mild motor skill, behavior, school performance, and language impairments, among others, and they often are not specifically diagnosed.²

More extensive follow-up programs require time and imply in additional costs. Hospitalization during the neonatal period has a high cost,³ but the long-term economic and social impact of these children's outcomes in the different sectors of society cannot be underestimated. Although prevention and intervention programs demand a high short-term investment, the costs related to special schools and social services can be significantly reduced in the long run, as well as rates of school failure.⁴

Preterm children have a history of biological vulnerability and a greater risk of developmental problems. Many of these children, considered "apparently normal", have more learning disabilities, as well as a worse motor repertoire and behavioral problems than children born at term.^{5,6} It should

be considered that, in many cases, preterm infants may be exposed to multiple risks, and the context in which they are inserted can be vital for positive or negative effects on their development.⁷

Research worldwide has shown concern for the long-term effects of preterm birth. This concern should also be extended to the developing countries, such as Brazil, as the poor conditions of life can become an aggravating factor for biological vulnerability.⁴ However, there have been few national studies that investigated the development of these children at school age.⁸

In spite of the technological advances in neonatology and increased survival of preterm infants, there are still knowledge gaps in this area. Studies involving preterm children at school age have important limitations, such as different assessment tools; small and heterogeneous samples, which are not representative of the population; little or no detailing of clinical and sociodemographic characteristics; and inadequate comparison groups, among others.^{9,10} Thus, the influence of perinatal variables and the cumulative effects of multiple risk factors during the course of development remain unconfirmed. It is essential to know the association between prematurity and the future performance of preterm infants in order to clarify its possible effects on the different aspects of these children's lives, such as health, education, etc.

Considering the importance of monitoring the development of children in vulnerable situations, the aim of this study was to assess and synthesize the available knowledge in the literature on the effects of premature birth on the development of school-aged children (8 to 10 years).

Methods

The present study is a systematic review of the existing literature, following the recommendations of the Cochrane Library¹¹ and PRISMA.¹² Studies were selected through an electronic search in MEDLINE/Pubmed; MEDLINE/BVS; LILACS/BVS; IBECs/BVS; Cochrane/BVS; CINAHL; Web of Science; Scopus; and PsycNET databases. The search strategy of electronic databases included studies published in the past ten years (January, 2002 to February, 2012) in three languages (Portuguese, Spanish, and English).

Observational studies (cross-sectional, case-control, and cohort) and experimental studies (randomized controlled trials, randomized or quasi-randomized trials) were included. Literature or systematic reviews, letters, editorials, and case reports were excluded. Only studies that assessed motor development and/or behavior and/or school performance and had as target population preterm children that included the age range of 8 to 10 years were considered.

The quality of the articles was assessed by the Strengthening the reporting of observational studies in epidemiology (STROBE) and Physiotherapy Evidence Database (PEDro) scales; due to the great quantity and variability of methodological quality of the identified articles, quality was also used as an exclusion criterion. Articles that did not achieve at least a score of 80% in the requirements established by these scales were not included.¹³ The key words used varied according to database searched, and were chosen after consulting the MeSH terms: "premature, environment, family, child development, psychomotor performance, dexterity, socioeconomic factors, learning disability, child behavior, and child behavior disorder."

The eligibility assessment and article quality analysis were performed by a single independent reviewer. The assessment of methodological quality of the experimental studies was performed through the PEDro scale,¹⁴ and for observational studies, it was based on the STROBE recommendations.¹³ The PEDro scale is based on the Delphi list, and consists of 11 items, of which only the item "specification of inclusion criteria" is not scored. The scale items are: subject inclusion criteria; random assignment; confidentiality of allocation; similarity of groups at the initial stage; blinding of subjects, therapist and evaluator; measurement of at least one key outcome; intention-to-treat analysis; results of statistical comparisons between groups; and reported measures of variability and precision of at least one outcome. Each criterion is worth one point. Studies scoring less than three points are considered to have low methodological quality.^{15,16}

The STROBE checklist has been recently translated and adapted to Brazilian Portuguese. It contains 22 items with features that should be present in the different sections of an article to increase the quality of observational studies. The items help to focus on the quality of the title and abstract. In the introduction, the focus is the context and objectives; in the methodology, it is the study design, the context, the participants, variables, data sources/measurements, bias, sample size, the quantitative variables, and the statistical methods used. In the results section, the focus is on the quality of participant description, descriptive data, outcomes and key results, whereas

in the discussion, the essential items checked are limitations, generalization, and interpretation. This list was not developed to assess the methodological quality of studies; however, it is commonly used in Brazil for this purpose.^{13,17} Brazilian researchers have established three categories to classify the quality of articles: A, when the study meets 80% or more of the STROBE criteria; B, when it meets 50% to 79% of the STROBE criteria, and C, when less than 50% of the criteria are met.^{18,19}

For data extraction, a form was created, which included the following variables: study identification (title and authors), year of publication, country where the study was conducted, methodological design, objectives, sample size and characteristics (gestational age and birth weight), age of subjects, outcomes, assessment tools, results/conclusions, and STROBE/PEDro scores.

The present study is part of a larger project entitled "Evaluation of the overall development of school-age children born prematurely from 2002 and followed-up in the Outpatient Clinic of Children at Risk (Ambulatório de Crianças de Risco – ACRIAR) of the Hospital das Clínicas of the Universidade Federal de Minas Gerais" which was approved by the Research Ethics Committee of the Universidade Federal de Minas Gerais (UFMG), under No. CAAE 0456.0.203.000-11.

Results

The electronic search retrieved 3,153 articles in different databases, and only 33 were included according to the eligibility criteria. A total of 3,120 articles were excluded for various reasons, such as repetitions in different databases or the fact that they were not available in electronic media or did not meet the eligibility criteria, such as age of the children; additionally, articles with low methodological rigor were excluded.

All selected articles were observational studies (25 cohort, three case-control, four cross-sectional studies, and one was a secondary data analysis from a prospective study) and obtained a score $\geq 80\%$ in the STROBE scale (classification A). No experimental studies with a score $> 80\%$ on the PEDro scale were retrieved. [Figure 1](#) details article selection. The results of the analyzed outcomes (school and motor performance, as well as behavior) were subdivided into topics for ease of understanding.

[Table 1](#) presents the general characteristics of the selected studies, including year and country where it was conducted, study type, population, age of children, and STROBE scores.

All selected articles were conducted in developed countries: United States (12 articles, 36%), Australia (6 articles, 18%), the Netherlands (5 articles, 15%), Denmark and France (3 articles each, 9%), Sweden (2 articles, 6%), and finally England and Canada (one article each, 3%) ([Table 1](#)). Many of the selected studies (14 articles, 42%) originated from large, internationally recognized cohorts.

Most of the studies used (18 articles, 54%) referred to children born at less than 32 weeks of gestation, while 9% had a target population of preterm infants born at 32 to 36 weeks of gestation. Two studies (6%) covered both gestational age groups. The other ten studies (30%) did not

Table 1 General characteristics of identified studies, Belo Horizonte, Brazil, 2012.

Article	Year	Country	Type of study	Population (general characteristics)	Children's age (years)	STROBE score
Roze et al. ³⁸	2009	The Netherlands	Cohort	21 children born prematurely (< 37 weeks), with periventricular hemorrhagic infarction admitted between 1995 and 2003.	4 to 12	93.18%
Svien ¹⁰	2003	USA	Cross-sectional	22 children born prematurely (30 to 35 weeks) adequate for gestational age without congenital anomalies and 22 children born at term.	7 to 10	81.81%
Purdy et al. ³⁷	2008	USA	Historical cohort	44 children born prematurely (24 to 32 weeks). Multiple births or congenital anomalies were excluded.	8	95.45%
Goyen et al. ³⁹	2011	Australia	Case-control	50 children born prematurely (< 29 weeks or birth weight < 1,000 g), with IQ > 85 without neurosensory deficiencies, and 50 children born at term.	8	88.63%
Rademaker et al. ³⁶	2007	The Netherlands	Cohort	226 children born prematurely (\leq 32 weeks and/or body weight \leq 1,500 g) born between 1991 and 1993.	7 to 10	86.36%
Schneider et al. ⁴⁶	2008	Canada	Cross-sectional	Three groups: 1) children born prematurely with mean GA of 26 weeks; 2) children born prematurely with mean GA of 31 weeks and 6 days; and 3) children born at term: born between 1992 and 1993 from a cohort. 14 children born prematurely and nine children born at term.	8	81.81%
Rademaker et al. ²	2004	The Netherlands	Cohort	204 children born prematurely (GA \leq 32 weeks and/or birth weight < 1,500 g) and 21 children born at term.	7 and 8	81.81%
Goyen & Lui ⁴⁰	2009	Australia	Case-control	50 very preterm (< 29 weeks GA) or very low birth weight (< 1,000 g) infants; IQ > 84 and without disabilities at 5 years, and 50 infants born at term matched for gender and age.	8	90.90%
Karemaker et al. ³⁴	2006	The Netherlands	Historical cohort	149 preterm infants (< 32 weeks) born between December of 1993 and July of 1997, and 43 control children.	7 to 10	95.45%
Sherlock et al. ³¹	2005	Australia	Regional cohort	270 very low birth weight (< 1,000 g) or very preterm (< 28 weeks GA) infants born in 1991/1992 from the VICS cohort.	8	84.09%
Kan et al. ³⁰	2008	Australia	Regional cohort	179 very preterm (GA < 28 weeks) born in 1991 and 1992, with no neurosensory disabilities from the VICS cohort.	8	97.72%

Table 1 (Continued)

Article	Year	Country	Type of study	Population (general characteristics)	Children's age (years)	STROBE score
Guellec et al. ²⁴	2011	France	Cohort	2,846 preterm infants between 24 and 32 weeks of gestation selected from nine regions of France in 1997, and 666 born at term from the EPIPAGE cohort.	5 and 8	88.63%
Chyi et al. ³	2008	USA	Cohort	970 moderately preterm infants (32 to 33 weeks) and late preterm infants (34 to 36 weeks), and 13,671 children born at term from the Early Childhood Longitudinal Study Kindergarten	10 and 11	93.18%
D'Angio et al. ³²	2002	USA	Cohort	132 preterm infants (< 29 weeks), born between 1985-1987.	0 to 15	86.36%
Charkaluk et al. ¹	2011	France	Cohort	244 preterm infants born after 22 to 32 weeks gestation in 1997, with no disabilities or developmental impairment from the EPIPAGE cohort.	2 to 8	86.36%
van Baar et al. ²⁹	2006	The Netherlands	Cohort	34 preterm infants (< 32 weeks) and 34 children born at term.	10	81.81%
Msall et al. ³³	2004	USA	Cohort	222 preterm infants with birth weight < 1,251 g and retinopathy of prematurity and no other malformations from a multicentric study (CRYO-ROP)	5, 5 and 8 respectively	90.90%
Casey et al. ⁹	2006	USA	Cohort	221 preterm infants with birth weight ≤ 2,500 g, gestational age ≤ 37 weeks, without severe medical impairments, and 434 controls from the IHDP program.	8	84.09%
Larroque et al. ³⁵	2011	France	Cohort	1,439 preterm infants between 22 and 32 weeks, born in 1997, and 327 infants born at term from the EPIPAGE cohort.	8	84.09%
Kirkegaard et al. ⁶	2006	Denmark	Cohort	211 preterm and 4,897 term children. GA was stratified: 33-36, 37-38, 39-40, and ≥ 41 weeks, and GA from 39 to 40 weeks from the Aarhus Birth Cohort.	9 to 11	90.90%
Mathiasen et al. ²⁸	2010	Denmark	Cohort	All live births in 1988 and 1989: 118,891 preterm or term children. Population-based study.	0 to 15	84.09%
Linnet et al. ²⁰	2006	Denmark	Case-control	All children born between 1980 and 1994 with hyperkinetic disorder; 834 cases (preterm and low birth weight), and 20,100 controls.	2 to 18	88.63%

Table 1 (Continued)

Article	Year	Country	Type of study	Population (general characteristics)	Children's age (years)	STROBE score
Gurka et al. ²⁷	2010	USA	Cohort	53 late preterm children (34 to 36 weeks) and 1,245 children born at term (37 to 41 weeks) from the SECCYD cohort.	4 to 15	81.81%
Whiteside-Mansell et al. ²⁶	2009	USA	Longitudinal	728 children < 37 weeks and low birth weight (most had < 2,000 g, but some children had between 2,001 to 2,500 g) from the IHDP program.	8	81.81%
Jeyaseelan et al. ⁵	2006	Australia	Cross-sectional	45 children with extremely low birth weight (< 1,000 g) or preterm (GA < 27 weeks).	7 to 9	84.31%
Conrad et al. ²³	2010	USA	Cross-sectional	49 children with extremely low birth weight (< 1,000 g) or very low birth weight (1,000 to 1,499 g), and 55 children born at term.	7 to 16	81.81%
Purdy et al. ⁴⁴	2013	USA	Cohort	45 preterm children with mean GA of 28 weeks.	8	81.81%
Farooqi et al. ⁴³	2007	Sweden	Cohort	86 preterm children born before 26 weeks of gestation between 1990 and 1992, and 86 controls.	10 to 12	88.63%
Gray et al. ²⁵	2004	USA	Cohort	985 Preterm children (GA < 37 weeks) and birth weight < 2,500 g at birth from the IHDP program.	3.5 and 8	81.81%
Yu et al. ⁴⁵	2006	USA	Data analysis	713 preterm children with < 2,500 g and < 37 weeks GA from the IHDP program.	8	84.09%
Anderson et al. ⁴²	2003	Australia	Regional cohort	298 children with extremely low birth weight (< 1,000 g) or very preterm (< 28 weeks GA). 262 control infants with birth weight > 2,499 g.	0 to 8	93.18%
Crombie et al. ²¹	2011	England	Cross-sectional	196 preterm (< 36 weeks GA) and/or low birth weight (< 2,500 g) children were classified as "at risk", and 1,704 control infants were classified as "no risk".	9 to 10	88.63%
Lindström et al. ²²	2011	Sweden	National cohort	67,543 preterm children with GA between 23 and 36 weeks, and 1,113,163 born at term (> 37 weeks).	6 to 19	81.81%

CRYO-ROP, Cryotherapy for Retinopathy of Prematurity Cooperative Group; EPIPAGE, The Etude Epidemiologique sur les Petits Ages Gestationnels; IHDP, Infant Health and Development Program; GA, Gestational Age; IQ, intelligence quotient; SECCYD, Child Health and Development Study of Early Child Care and Youth Development; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology; VICS, Victorian Infant Collaborative Study.

describe the gestational age at birth, but only mentioned that the selected children were preterm (< 37 weeks of gestation). The sample size of the studies varied greatly, with a minimum of 14 and maximum of 67,543 preterm children evaluated (Table 1).

Tables 2 and 3 present the studies analyzed in this review, the main outcomes evaluated, the tools used, and their main findings/conclusions.

It was established as inclusion criteria that the articles should encompass the age range of 8 to 10 years; 28

Table 2 Studies of motor development in preterm infants and their main findings, Belo Horizonte, 2012.

Article	Outcomes	Tools	Results/Conclusions
Roze et al. ³⁸	1) Motor 2) Cognitive 3) Behavior	1) GMFCS, MACS, and VMI 2) Touwen and WISC III 3) CBCL and BRIEF	Most preterm infants with periventricular hemorrhagic infarction had cerebral palsy with limitations in functional performance at school age. Visual-motor integration was normal in 74%, visual perception in 88%, behavior in 53%, verbal memory in 50%, and normal executive functions in 65%. Characteristics of hemorrhagic infarction were not associated with motor outcome and level of intelligence. Post-hemorrhagic ventricular dilation was considered a risk factor for a worse repertoire of manipulative skills and intelligence performance. The functional outcome at school age of these children was better than previously thought.
Svien ¹⁰	1) Motor: components of health-related fitness	1) BOTMP; Treadmill and Physical activity questionnaire.	No differences were observed between groups in total skinfold thickness measurements, flexibility, O ₂ consumption, or level of physical activity. There were significant differences in all BOTMP test subtests. Despite significant differences in motor performance of infants born preterm, they showed no limitations in activities or participation restrictions at school age.
Purdy et al. ³⁷	1) Behavior 2) Motor 3) Language 4) Daily and social life 5) Clinical life-threatening condition	1, 2, 3, and 4) VABS 5) CRIB	Children who received higher doses of perinatal steroids were more likely to have low scores of overall development, especially lower social skills. Higher doses of perinatal steroids resulted in a more severe condition during the first day of life based on CRIB and a smaller head size at birth, and these were related to worse behavioral outcomes.
Goyen et al. ³⁹	1) Motor 2) Sensory-motor skills	1) MABC-1 2) VMI, MVPT-R, KST, and SIPT	Significantly lower scores were found for visual processing and praxis test, except for verbal command. Preterm children with developmental coordination disorders (DCD) had greater difficulty with visual processing tasks. Motor planning represented a special challenge for these children. Motor dysfunction in extremely preterm children was related to poorer visual processing and motor planning, which may be related to cognitive processing problems.
Rademaker et al. ³⁶	1) Intelligence 2) Motor 3) Memory	1) WISC 2) VMI and MABC-1 3) 15-Word Memory Test	Children treated with hydrocortisone were younger, weighed less, and were sicker when compared to the control group. There were no differences in the occurrence of brain lesions. Neonatal treatment with hydrocortisone for bronchopulmonary dysplasia showed no long-term effects on neurodevelopment and on the motor performance of preterm infants at school age.
Schneider et al. ⁴⁶	1) Visual-motor skills (fine motor skill)	1) Visuo-manual pointing-task and Reaction time test	There were significant differences in fine motor skills between the groups of preterm infants of 26 and 31 weeks. There were no significant differences between the control group and the 31-week preterm children group. The reaction times in the visual-motor task were significantly increased in preterm infants with GA of 26 weeks. Preterm children with GA of 26 weeks showed increased interhemispheric time, suggesting alterations in callosal pathways. Programming time was significantly longer for the dominant hand and unilateral. The existence of failed programming in visual-manual tasks is suspected in preterm infants with GA < 26 weeks.
Rademaker et al. ²	1) Motor 2) Size of corpus callosum	1) MABC and VMI 2) Magnetic resonance	There is a strong association between the size of the corpus callosum (mean total sagittal cross-sectional area, as well as frontal, middle, and posterior regions) and motor function in preterm infants assessed at school age. A worse score on MABC was associated with a smaller size of the corpus callosum. A larger corpus callosum was strongly associated with better scores on the VMI. The authors demonstrated a strong association between motor performance and size of the corpus callosum, which suggests that children who have corpus callosum abnormalities may benefit from early intervention.

Table 2 (Continued)

Article	Outcomes	Tools	Results/Conclusions
Goyen & Lui ⁴⁰	1) Motor	1) MABC; Peabody Motor Scales, and Griffith scale (locomotor)	“Apparently normal” children at high-risk in early childhood are also at risk for motor dysfunction in their school years. Most of these children with motor problems at school age could be identified at the age of 3 years. Developmental coordination disorder was independently associated with prolonged rupture of membranes and retinopathy of prematurity, but not with parental education or occupation.
Karemaker et al. ³⁴	1) Motor 2) Behavior 3) School performance	1) MABC 2) CBCL 3) TRF	Children treated with dexamethasone in the neonatal period had lower school performance and presented more behavioral problems than children treated with hydrocortisone. Furthermore, the motor impairment appears to be significantly higher in the group treated with dexamethasone than in the control group. Children who used hydrocortisone did not differ from untreated children, except for ball skills. The results suggest that hydrocortisone is a safe alternative for treatment.
Sherlock et al. ³¹	1) Motor 2) Cognitive 3) School performance	1) MABC-1 2) WISCIII, TOL, RCF 3) WRAT3	Neurodevelopmental dysfunction in school-age children with extremely low birth weight and/or very premature varied in relation to the severity of intraventricular hemorrhage, except for grade 4 intraventricular hemorrhage. The higher the degree of hemorrhage, the higher the motor and school impairment.
Kan et al. ³⁰	1) Motor 2) School performance 3) Cognitive	1) MABC 2) WRAT3 3) WISCIII	Very premature children had lower weight and head circumference at all ages tested. Head circumference at birth was not related to outcomes at school age, but changes in head circumference at ages 2 and 8 years were associated with worse performance on most evaluated measurements, including motor performance. Intrauterine growth restriction was not related to the child’s cognitive skills at age 8 years. Weight at hospital discharge had little influence on neurodevelopment, but head circumference was important in early childhood.

BOTMP, Bruininks-Oseretsky Test of Motor Proficiency; BRIEF, Behavior Rating Inventory of Executive Function; CBCL, Child Behavior Checklist; CRIB, Clinical Risk Index for Babies; GMFCS, Gross Motor Function Classification System; KST, Kinaesthetic Sensitivity Test; MABC-1, Movement Assessment Battery for Children; MACS, Manual Ability Classification System; MVPT-R, Motor-Free Visual Perception Test; RCF, Rey Complex Figure; SIPT, Sensory Integration and Praxis Test; TOL, Tower of London; TRF, Teacher’s Report Form; VABS, Vineland Adaptive Behavioral Scales; VMI, Test of Visual-Motor Integration; WISC, Wechsler Intelligence Scale; WISC III, Wechsler Intelligence Scale III; WRAT-3, Wide Range Achievement Test.

studies (85%) included children aged 8 years, 13 (39%) included children aged 9 years, and 15 (45%) included children aged 10 years. Among the outcomes of interest for this review, behavior was the most often assessed (20 articles, 61%), followed by school performance (16 articles, 48%) and motor impairment (11 articles, 33%) (Tables 2 and 3).

Behavior

In most studies, the outcome “behavior” was comprehensively assessed using tools that identified the presence of components of internalization (depression, anxiety) and/or externalization (aggression, impulsiveness, delinquent behaviors), mental health, temperament, social skills, and presence/absence of psychiatric disorders. The behavior assessment was performed by nine different tools, in addition to government records when the studies were population-based. The Child Behavior Checklist (CBCL) was the most widely used scale (9 articles, 45%), followed by the Strength and Difficulties Questionnaire (SDQ) and the Vineland Adaptive Behavioral Scales (VABS) (3 articles each,

15%), and government records (2 articles, 10%). All other tools were used only once (Tables 2 and 3).

Biological risk factors and their effects on the development of preterm infants has been the subject of studies that analyzed the outcome of behavior. The perinatal factors most often searched for this outcome were gestational age (5 articles, 25%),^{1,9,20–22} birth weight (5 articles, 25%),^{20–25} and classification of birth weight in relation to gestational age (2 articles, 10%).^{9,24} In addition to biological factors, the evaluation of socioeconomic risk factors (socioeconomic status, maternal education, and ethnicity) was significant,^{22,23,25} as well as environmental factors (noise exposure, family conflicts, and psychological distress of the mother),^{21,25,26} and the analysis of the motor and development component in early childhood as a risk factor for behavioral problems at school age.⁵

Some of these studies concluded that the lower the gestational age (4 articles, 20%)^{1,20–22} and birth weight (4 articles, 20%),^{20,21,23,25} the higher the risk of behavioral alterations. Another important finding is that changes in the environmental and socioeconomic risk factors can improve the behavior of preterm children.^{22,25,26}

Table 3 Studies of school performance and behavior of preterm infants and their main conclusions, Belo Horizonte, 2012.

Article	Evaluated outcomes	Tools	Results/Conclusions
Guellec et al. ²⁴	1) Cognitive 2) Behavior 3) School performance	1) KABC 2) SDQ 3) Questionnaire sent by mail to parents.	In preterm children, birth weight was not associated with cognitive, motor, behavioral outcomes, or academic performance. Growth restrictions (small for gestational age) were associated with mortality, cognitive and behavioral outcomes, and learning impairment.
Chyi et al. ³	1) School performance	1) Specific tests were created for the study and included reading and math	Moderately and late preterm infants had lower reading and math scores than control children. Moderately preterm children had twice the risk of needing special education. Due to the concerns of teachers with these children and the test results, the need for educational support was observed for moderately and late preterm children (32-36 weeks gestation) through monitoring, guidance, and school interventions.
D'Angio et al. ³²	1) School performance 2) Cognitive	1) Teacher questionnaire 2) MCSA, CALVT-2, PPVT-R, VMI, and VABS	Intraventricular hemorrhage in the neonatal period and low socioeconomic status were the strongest predictors of adverse outcomes related to school and cognitive performance. Preterm infants in the surfactant era remain at high risk for neurodevelopmental impairment. Although most of these children are well, a significant minority will need special education services until high-school age.
Charkaluk et al. ¹	1) Mental health 2) Quotient of development 3) Schooling 4) Cognitive	1) MPC 2) Brunet-Lezine scale 3) Questionnaire sent by mail to parents. 4) KABC	Schooling was considered adequate if the child was attending a level of education in age-appropriate regular grade, without the need for any additional academic support. Schooling was considered appropriate for 70% of preterm infants assessed. Using only the development quotient level showed not to be the best alternative for predicting adequate schooling at eight years. Other factors should be considered, such as maternal education, gestational age, and head circumference at the age of 2. These factors can be used to individualize the follow-up of these children.
van Baar et al. ²⁹	1) Cognitive 2) School performance 3) Behavior 4) Social-emotional	1) WISC III and MND 2) TRF 3) CBCL 4) Interview with psychologist and SES	The preterm and children born at term differed in all developmental domains (cognitive, academic, behavior, and social-emotional), always to the disadvantage of the preterm group. The subgroup of preterm children without school problems was characterized by less severe neonatal difficulties, better capacity to feed, faster and early growth of the head circumference, and better mental and motor development. Cognitive development differed during the first 2 years of among preterm subgroups and appeared to stabilize after that age.
Msall et al. ³³	At 8 years: 1) School performance	1) Structured questionnaire created for this research	Preterm infants with retinopathy of prematurity showed significant differences in mental development, educational and social skills. Among children who had better visual acuity, 52% were in the appropriate grade for their academic skills, and only about one quarter needed special education services. Most children with poorer visual acuity needed special education; they had lower than expected academic skills and had more social challenges (independence, peer-interaction, and participation in sports).
Casey et al. ⁹	1) Growth 2) Cognitive 3) Behavior 4) Health status 5) School performance	1) Weight (kg), height (cm), head circumference (cm), and body mass index (kg/m ²) 2) WISCIII, VMI, and PPVT-3 3) CBCL 4) Child General Health Survey 5) WJ3	Children who were small for gestational age and had failed to properly develop had lower results in all indicators of growth at 8 years of age, as well as lower cognitive and academic performance scores. There were no differences between the groups regarding behavior or general health. Preterm newborns with low birth weight that developed postnatal growth problems, especially when associated with prenatal growth problems, were shown to have a smaller physical size and lower cognitive and academic performance scores at 8 years.

Table 3 (Continued)

Article	Evaluated outcomes	Tools	Results/Conclusions
Larroque et al. ³⁵	1) School performance 2) Behavior	1) Structured postal questionnaire created for the study 2) SDQ	Among the very preterm children, 5% were in a special school or class, 18% had repeated a grade in regular school, and 77% were in the appropriate grade. Furthermore, 15% of very preterm children in a conventional class received some support in school <i>versus</i> 5% in the control group. Most very preterm children received special care (55%) when compared with children born at term (38%) between the ages of 5 and 8 years; very preterm children (21%) had more behavioral problems when compared to the reference group (11%). Most very preterm children attended regular schools. However, they had a high risk of difficulty in school, with over half of that population requiring additional support at regular school and/or special school.
Kirkegaard et al. ⁶	1) School performance	1) Structured questionnaires for parents and teachers created for the study	Compared to children born at term, reading and spelling difficulties were more frequent among children with gestational age between 33 and 36 weeks and 37 and 38 weeks, but there was no association between gestational age or birth weight and difficulty in mathematics.
Mathiasen et al. ²⁸	1) School performance	1) Governmental data	Among children born before 37 weeks of gestation, 11.5% had not completed elementary school compared to 7.5% of children born at term. The risk of not completing elementary school increased with decreasing gestational age. The risk was moderate for those born at ≥ 31 weeks of gestation, and increased dramatically for infants born at < 31 weeks of gestation. The increased risk in a gestation < 31 weeks was only partially explained by cerebral palsy.
Linnet et al. ²⁰	1) Behavior (attention deficit hyperactivity disorder)	1) Governmental records	Compared with children born at term, infants with gestational age 34 to 36 weeks had a 70% higher risk of hyperkinetic disorder (e.g., attention deficit hyperactivity disorder). Children with gestational age < 34 weeks had a risk nearly three times higher. Children born at term and low birth weight (1,500 to 2,499 g) had a 90% higher risk of hyperkinetic disorder, and children weighing 2,500 to 2,999 g had a 50% higher risk.
Gurka et al. ²⁷	1) Cognition 2) Social skills 3) Behavior	1) WJ3 2) SSRS 3) CBCL and STRS	No significant difference was observed among late preterm and at-term children at ages 4 to 15 years regarding the assessed skills. Healthy late preterm infants appeared to have no real impact on cognition, achievement, behavior, and social-emotional development throughout childhood.
Whiteside-Mansell et al. ²⁶	1) Family environment 2) Behavior 3) Temperament	1) FES 2) CBCL 3) ICQ	Children exposed to high levels of family conflict had more internalization problems. Underweight/preterm children with a difficult temperament had a higher risk of poor developmental outcomes, such as externalization problems; when exposed to family conflicts, they show less difficult temperament.
Jeyaseelan et al. ⁵	1) Attention 2) Motor	1) CRSR, ADHD Rating Scale, and psychometric measures 2) NSMDA at 12 and 24 months	NSMDA (motor test at 12 months) was only associated with psychometric measures of verbal attention at school age regardless of the presence of social and biological factors. NSMDA at 24 months was strongly associated with specific clinical measures of attention at school age. It was not associated with psychometric measures of attention. The main finding of this study was that the motor difficulties in children with extremely low birth weight at 2 years will be later associated with clinical measures of attention at school age.

Table 3 (Continued)

Article	Evaluated outcomes	Tools	Results/Conclusions
Conrad et al. ²³	1) Cognitive 2) Behavior evaluated by parents and teachers	1) WISC 2) Pediatric Behavior Scale-30	Children born at term had fewer parental reports of hyperactivity/inattention and depression/anxiety when compared to children of extremely low birth weight and very low birth weight. There were no significant differences between the groups in teachers' evaluations. Birth weight was the strongest predictor of behavioral outcomes that appears not to be influenced by the child's intelligence. It was observed that negative behavioral sequelae of preterm birth remain significant in childhood and adolescence.
Purdy et al. ⁴⁴	1) Behavior 2) Stress at birth 3) Perinatal factors	1) CBCL 2) CRIB, SNAPPE-II, and NBRS 3) Review of retrospective records (sepsis, retinopathy, and other neonatal variables)	There were significant associations between CBCL and sepsis, cumulative exposure to steroids in the perinatal period, time from initial exposure to steroids, and height percentile at discharge. There was also a strong association between problems of social and school competence and activities assessed by the CBCL and the variable cumulative exposure to steroids, height percentile of children in the intensive care unit, sepsis, retinopathy, CRIB score, hearing loss, and biological markers. Children in the group with higher exposure to steroids presented more behavioral problems, but it was not possible to detect significant differences. The results are reassuring regarding the long-term effects of cumulative exposure to steroids on the behavioral outcomes of preterm infants.
Farooqi et al. ⁴³	1) Behavioral problems 2) Adaptive behavior at school 3) Family function (environment) 4) Depression	1) CBCL for parents and teachers 2) Structured questionnaire and TRF 3) Nordic Health and Family Questionnaire 4) DSR5	Compared with control children, parents of premature infants reported more internalization behavior, attention, and social problems. Teachers had a similar opinion. Reports from the children showed a trend of increased symptoms of depression compared to the control group. However, the majority of extremely preterm children (85%) were studying in regular schools without major adjustment problems. Although these results appear favorable, teachers report that these children have poorer adjustment to the school environment and are at risk of mental health problems.
Gray et al. ²⁵	1) Maternal psychological problems 2) Behavior	1) GHQ 2) CBCL	The prevalence of behavioral problems was approximately 20% at all ages tested (3, 5, and 8 years). This sample had twice the prevalence of behavioral problems expected in children. The significant predictors of these problems were smoking during pregnancy, maternal psychological distress, maternal age, and Hispanic ethnicity.
Yu et al. ⁴⁵	1) Behavior 2) Learning failure	1) CBCL 2) WISC III and WJ3	Compared with children with verbal and nonverbal learning disability, children with verbal disability were twice as likely to have behavioral problems, and were 89% more likely to have externalization behavior problems. No association was found between learning difficulties in nonverbal disability and behavioral problems. Analysis of specific behavioral subscales showed significant association with behaviors of anxiety/depression, as well as an increased likelihood of attention problems in children with verbal disability. These results provide evidence that there are differences between learning subtypes regarding behavioral outcomes and the effects of early intervention services at 8 years of age.

Table 3 (Continued)

Article	Evaluated outcomes	Tools	Results/Conclusions
Anderson et al. ⁴²	1) Cognitive 2) School performance 3) Behavior	1) WISC III 2) WRAT-3 and CSSA 3) BASC	Extremely preterm or underweight children had lower scores than the control group in IQ, verbal comprehension, perceptual organization, distractibility, and processing speed. Attention difficulties, internalization problems, and adaptive skills were higher in the group of preterm/low birth weight children. In addition, this group showed worse performance on tests of reading, spelling, and arithmetic compared to the control group. School-age children with extremely low birth weight or very preterm infants born in the 1990s continue to have cognitive, educational, and behavioral disabilities.
Crombie et al. ²¹	1) Mental health 2) Early risk assessment	1) SDQ 2) Structured questionnaire completed by parents	Children with early biological risk (preterm or low birth weight) were shown to be more vulnerable to mental health problems when exposed to the effects of noise from aircraft or road traffic noise in the school area. However, these children were more likely to have mental health problems. Children who were "at risk" (i.e., low birth weight or preterm birth) were classified as having more behavioral problems and emotional symptoms and poorer overall mental health than children without these risks.
Lindström et al. ²²	1) Psychiatric disorders 2) Perinatal and social factors	1 and 2) Governmental records	Preterm and early-term birth increases the risk of attention deficit hyperactivity disorder (ADHD). The socioeconomic context modifies the risk of ADHD in moderately preterm births.

BASC, Behavior Assessment System for Children; CALVT-2, Children's Auditory Verbal Learning; CBCL, Child Behavior Checklist; CRIB, Clinical Risk Index for Babies; CRSR, Conners' Rating Scale Revised-Long Form; CSSA, Comprehensive Scales of Student Abilities; DSRS, Depression Self-Rating Scale; FES, Family Environment Scale; GHQ, Maternal General Health Questionnaire; ICQ, Infant Characteristics Questionnaire; KABC, Kaufman Assessment Battery for Children; MCSA, McCarthy Scales of Children's Abilities; MND, minor neurological dysfunctions; MPC, Mental Processing Composite; NBRS, Neurobiological Risk Score; NSMDA, Neurosensory Motor Developmental Assessment; PPVT-3, Peabody Picture Vocabulary Test-3; PPVT-R, Peabody Picture Vocabulary Test-Revised; SDQ, Strength and Difficulties Questionnaire; SES, socio-economic status score; SNAPPE-II, Score for Neonatal Acute Physiology Perinatal. Extension II; SSRS, Social Skills Rating System-Teacher Form; STRS, Student-Teacher Relationship Scale; TRF, Teacher report form; VABS, Vineland Adaptive Behavior Scale; VMI, Test of Visual-Motor Integration; WISC III, Wechsler Intelligence Scale for Children; WJ3, Woodcock Johnson Test of Academic Achievement; WRAT-3, Wide Range Achievement test.

The general concept of behavior was the most often assessed outcome (11 articles, 55%), followed by more specific components, such as mental health (4 articles, 20%) and attention deficit hyperactivity disorder (3 articles, 15%). Moreover, temperament, family conflicts, depression, anxiety, and emotional development were also assessed (one article each, 5%). Only two of these studies found no effect of preterm birth on the school-age child's behavior.^{9,27}

School performance

School performance was also a recurring theme, with most of the studies comparing the performance of preterm infants and those born at term using six different scales. Half of the articles (50%) investigated schooling through structured questionnaires or tests created by the researchers themselves, which were applied to the children or their parents and teachers. The Wide Range Achievement Test (WRAT-3) was the most commonly used standardized tool (3 articles, 19%), followed by the Woodcock Johnson Test of Academic Achievement (WJIII) (2 articles, 12%)(Table 3).

Considering school performance, the most often assessed birth conditions were gestational age at birth (4 articles, 25%),^{1,6,9,28} followed by birth weight^{6,24,29} and head circumference (3 articles, 19%),^{1,29,30} periventricular hemorrhage (2 articles, 12%) and classification of birth weight in relation to gestational age (2 articles, 12%).^{31,32} Other variables investigated were perinatal retinopathy,³³ use of corticosteroids,³⁴ and use of surfactants³⁵ (one article each, 6%).

All articles that investigated gestational age, head circumference, intraventricular hemorrhage, classification of birth weight in relation to gestational age, retinopathy, use of surfactants and corticosteroids demonstrated an association with school performance. Most studies that investigated birth weight also found an association with school performance (2 articles, 12%).^{6,29} Four articles (25%) assessed socioeconomic risk factors;^{29,32,33,35} the majority (three articles, 19%) observed an association between school performance and socioeconomic markers.^{32,33,35}

Approximately half of the articles (7 articles, 44%) that analyzed school performance in preterm infants used tests or questionnaires that evaluated the learning domains (arithmetic, reading, and writing). Eight articles (50%)

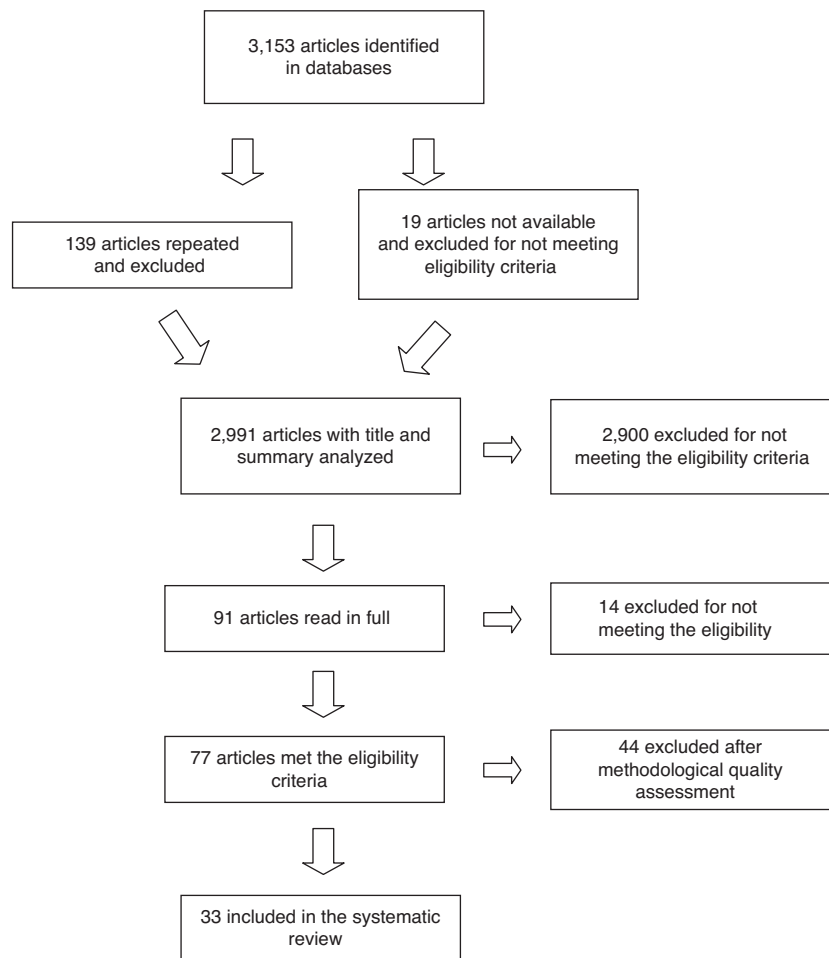


Figure 1 Flow chart for selection of articles at the different phases of the systematic review, Belo Horizonte, Brazil, 2012.

considered the viewpoints of parents and/or teachers regarding the children's academic skills, and only one article was based on government data to evaluate the academic success of preterm children. It was also observed that most studies aimed to assess whether the preterm children attended a grade appropriate for their age and whether they studied in special schools or needed any school aid (6 articles, 37%). Only one study did not find an association between preterm birth and school performance.³²

Motor performance

Articles that investigated the motor component focused on the drugs used in the neonatal period and their influence on the development, identification of risk factors for motor impairment, and concerns about social limitations and restrictions of preterm children compared to children born at term. To assess the motor skills of preterm children, five different tools were used (Movement Assessment Battery for Children [MABC-1], Developmental Test of Visual Motor Integration [VMI], Bruininks-Oseretsky Test of Motor Proficiency [BOTMP], Vineland Adaptive Behavioral Scales [VABS], and Griffiths scale), as well as two classification systems (one to assess gross motor function, the Gross Motor Function Classification System [GMFCS], and the other to

assess fine motor skills, the manual Ability Classification System [MACS]). The MABC-1 was the most commonly used tool to detect motor abnormalities (7 articles, 64%), followed by VMI (4 articles, 36%). The remainder tools were used only once (Table 2).

Most articles that investigated motor performance sought to examine perinatal risk factors and their impact on school age (7 articles, 64%), while other articles focused on analyzing only the consequences of preterm birth (4 articles, 36%).

The risk factors most often studied were the use of corticosteroids in the neonatal period (3 articles, 27%),^{34,36,37} followed by periventricular hemorrhage (2 articles, 18%),^{31,38} head circumference (one article, 9%),³⁰ and size of the corpus callosum (one article, 9%).² Of the three articles that analyzed the effects of different drugs on the development of preterm children, two found an association between the use of dexamethasone and motor disorders.^{34,37} Two articles found no effects of hydrocortisone use on motor development, suggesting that this is a safer alternative for use in cases of lung problems.^{34,36}

Of the two articles that investigated intraventricular hemorrhage, only one observed an association with poorer motor performance.³¹ All articles that investigated the size of the corpus callosum and head circumference found an

association with motor disorders. The authors of these studies evaluated different aspects of motor performance, and the most often assessed areas were gross/fine motor skills and visual-motor integration. Only one study, among the seven that analyzed risk factors, did not observe long-term effects of preterm birth on motor performance.³⁶

The four remaining articles that assessed motor performance analyzed, from different perspectives, the impact of preterm birth on school age. Two articles assessed sensorimotor skills,^{36,39} such as visual-motor integration; one article assessed the fine/gross motor development;⁴⁰ and the last article measured physical activity and cardiorespiratory performance.¹⁰ All four articles found motor impairments related to preterm birth. Considering all the articles that assessed motor behavior, it was observed that most researchers were concerned with assessing fine and gross motor development of preterm children (7 articles, 64%). Some articles also assessed aspects related to the visual-motor integration (5 articles, 45%) and the functionality of preterm children (3 articles, 27%).

The assessment of methodological quality of the selected studies demonstrated that 24 articles (73%) met 80% to 90% of the STROBE scale criteria, and 9 articles (27%) met over 90% of the items of this scale. All articles met all the items of the following categories: "data sources/measurements" (to provide the source of data and details used for the measurement), "outcome" (to present the outcomes and their summary measures), and "main findings" in the discussion (to summarize the main findings, correlating them to the study objectives). The lowest-scoring item was "study size" (to explain how sample size was determined) (23 articles, 70%).

The findings/conclusions of the selected studies showed that the association between preterm birth and poor motor development, behavior, and school performance abnormalities was demonstrated by most of the studies. Of the 47 different development outcomes evaluated, 32 (68%) found an association of preterm birth with the studied outcomes (7 articles on motor development, 13 on behavior, and 12 on school performance). Twelve studies failed to achieve all the desired goals (3 articles on motor development, 5 on behavior, and 3 on school performance), and only 4 studies failed to show an association between preterm birth and long-term outcomes (one article on motor development, 2 on behavior, and one on school performance) (Tables 2 and 3).

Discussion/Conclusion

The main finding of this review was the confirmation of the long-term vulnerability of preterm infants regarding all developmental indicators assessed (motor, behavior, and school performance). Thus, expansion of the follow-up of preterm children is needed, as the school stage is a key moment for the child's development, because it requires skills that have not been previously demanded, which might be impaired.¹ It is important to consider that follow-up only until to 2 years of age is insufficient for the detection of development problems such as bimanual skills, behavior, and visual-motor integration abnormalities.

Another extremely important finding concerns the gestational age studied. Most articles focused on studying

extreme prematurity, and only a small part investigated the development of moderate to late preterm infants.⁴¹ It is necessary to expand the studies in order to properly assess the development of all preterm infants born at different gestational ages. Moderate to late preterm infants are also susceptible to developmental impairment, and are more prevalent than extremely preterm infants.⁴¹

Regarding the methodological design of the evaluated studies, it was expected that cohorts would be the most frequent model, as they allow for the follow-up of preterm infants. It was also to be expected that these studies would be conducted in developed countries, as they have the financial resources required for studies with long follow-up periods. However, these are troubling data, as they suggest that, in the last ten years, no studies were conducted in developing countries such as Brazil using the quality parameters used in this study. To illustrate the situation, is noteworthy to observe that among the 77 studies initially selected for this systematic review, only two had been performed in Brazil; however, they presented a B score in the STROBE scale, and were thus removed from this review.

The behavior of preterm infants is one of the outcomes of greatest interest among researchers in the development area. There is a growing effort by researchers in an attempt to assess the consequences of preterm birth on the children's mental health.²⁵ This is another important result, since most of the studies demonstrated an association between preterm birth and behavioral problems.⁴²⁻⁴⁵ However, it is worth mentioning that the great number of tools used to assess this area makes result comparison difficult.

Another outcome that deserved the attention of researchers was school performance; most articles that assessed this subject confirmed that there are some school-related problems among preterm children.^{6,28} This finding is of great relevance to government agencies, as it supports the creation of public policies aimed at this population, such as early diagnosis and intervention programs. However, it is noteworthy that half of the studies used non-standardized tools (questionnaires created by the researchers themselves), and that, in many cases, the viewpoints of parents about the children's educational process were assessed rather than the children's performance. This fact brings subjectivity to the research, and should be further explored in future studies.

Mild motor impairments, often imperceptible to family and friends, were also targeted by the analyzed studies. There is an agreement between the analyzed studies that preterm birth has an effect on motor performance.⁴⁶ Although there is also a reasonable variability among the tools used for detecting motor impairment, all scales used were standardized; most studies used the MABC-1 in the evaluation of these children. MABC-1 is one of the most often used tools to detect disorders of motor coordination, as it has adequate psychometric properties and its use is simple and enjoyable for children.^{47,48}

Despite the methodological rigor of all reviewed articles, considerations must be made in order to guide future research. Only 30% of the articles described how sample size calculation was determined, even though 5 of the 33 articles selected were population-based studies. This fact is noteworthy, as this is a key item to assess the consistency of results. There is also the need to improve the descriptions

of the research context and characteristics of the study population. Although they efficiently described the location and the time of recruitment of the children, most studies failed to report items such as the period of data collection and follow-up.

Even though they disclosed descriptive data of the clinical variables, most of the selected studies failed to provide the description of sociodemographic variables, which can directly interfere with the development of these children. The results section lacked a more detailed description of the findings (confidence intervals, for example).

The main limitation of this study was that only one reviewer selected and analyzed the methodological quality of the studies. Nevertheless, this study attempted to provide well-established, high-quality evidence. The importance of the methodological analysis of observational studies and not only of experimental ones is noteworthy, an unusual fact in the Brazilian literature.

It can be concluded, considering the evidence of the last ten years that preterm infants are more susceptible to motor development, behavior, and school performance abnormalities when compared to children born at term. These abnormalities are modulated by biological and environmental factors that determine their intensity. Therefore, a greater investment by managers of long-term monitoring programs and early intervention is necessary in order to minimize future sequelae. With these results, health-care professionals and family members should remain alert to any changes in the development of preterm infants, in addition to demanding from the government the establishment of public policies aimed to promote positive early experiences for this population, such as the creation of higher-quality public daycare centers. Further studies that meet the international quality standards in this area, including randomized controlled trials, are required in order to compare the effects of different early interventions on the development of children born prematurely.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Charkaluk ML, Truffert P, Marchand-Martin L, Mur S, Kaminski M, Ancel PY, et al. Very preterm children free of disability or delay at age 2: predictors of schooling at age 8: a population-based longitudinal study. *Early Hum Dev.* 2011;87:297–302.
2. Rademaker KJ, Lam JN, Van Haastert IC, Uiterwaal CS, Liefink AF, Groenendaal F, et al. Larger corpus callosum size with better motor performance in prematurely born children. *Semin Perinatol.* 2004;28:279–87.
3. Chyi LJ, Lee HC, Hintz SR, Gould JB, Sutcliffe TL. School outcomes of late preterm infants: special needs and challenges for infants born at 32 to 36 weeks gestation. *J Pediatr.* 2008;153:25–31.
4. National Scientific Council on the Developing Child. In: timing and quality of early experiences combine to shape brain architecture: Working Paper 5. Cambridge, MA: Center on the Developing Child, Harvard University; 2007. p. 1–9.
5. Jeyaseelan D, O'Callaghan M, Neulinger K, Shum D, Burns Y. The association between early minor motor difficulties in extreme low birth weight infants and school age attentional difficulties. *Early Hum Dev.* 2006;82:249–55.
6. Kirkegaard I, Obel C, Hedegaard M, Henriksen TB. Gestational age and birth weight in relation to school performance of 10-year-old children: a follow-up study of children born after 32 completed weeks. *Pediatrics.* 2006;118:1600–6.
7. Vieira ME, Linhares MB. Developmental outcomes and quality of life in children born preterm at preschool- and school-age. *J Pediatr (Rio J).* 2011;87:281–91.
8. Linhares MB, Chimello JT, Bordin MB, Carvalho AE, Martinez FE. Psychological development of school-aged children born preterm in comparison with children born full-term. *Psicol Reflex Crit.* 2005;18:109–17.
9. Casey PH, Whiteside-Mansell L, Barrett K, Bradley RH, Gargus R. Impact of prenatal and/or postnatal growth problems in low birth weight preterm infants on school-age outcomes: an 8-year longitudinal evaluation. *Pediatrics.* 2006;118:1078–86.
10. Svien LR. Health-related fitness of seven- to 10-year-old children with histories of preterm birth. *Pediatr Phys Ther.* 2003;15:74–83.
11. The Cochrane Library. John Wiley & Sons, Inc. [cited 2012 Aug 5]. Available from: www.thecochranelibrary.com
12. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med.* 2009;6:e1000100.
13. Malta M, Cardoso LO, Bastos FI, Magnanini MM, Silva CM. STROBE initiative: guidelines on reporting observational studies. *Rev Saude Publica.* 2010;44:559–65.
14. Physiotherapy Evidence Database. Sydney: The George Institute for Global Health; 2013 [cited 2012 May 4]. Available from: <http://www.pedro.org.au/portuguese/>
15. Dodd KJ, Taylor NF, Damiano DL. A systematic review of the effectiveness of strength-training programs for people with cerebral palsy. *Arch Phys Med Rehabil.* 2002;83:1157–64.
16. Sampaio RF, Mancini MC. Systematic review studies: a guide for careful synthesis of the scientific evidence. *Rev Bras Fisioter.* 2007;11:77–82.
17. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ.* 2007;335:806–8.
18. Mataratzis PS, Accioly E, Padilha PC. Micronutrient deficiency in children and adolescents with sickle cell anemia: a systematic review. *Rev Bras Hematol Hemoter.* 2010;32:247–56.
19. Stocco JG, Crozeta K, Taminato M, Danski MT, Meier MJ. Evaluation of the mortality of neonates and children related to the use of central venous catheters: a systematic review. *Acta Paul Enferm.* 2012;25:90–5.
20. Linnet KM, Wisborg K, Agerbo E, Secher NJ, Thomsen PH, Henriksen TB. Gestational age, birth weight, and the risk of hyperkinetic disorder. *Arch Dis Child.* 2006;91:655–60.
21. Crombie R, Clark C, Stansfeld SA. Environmental noise exposure, early biological risk and mental health in nine to ten year old children: a cross-sectional field study. *Environ Health.* 2011;10:39.
22. Lindström K, Lindblad F, Hjern A. Preterm birth and attention-deficit/hyperactivity disorder in schoolchildren. *Pediatrics.* 2011;127:858–65.
23. Conrad AL, Richman L, Lindgren S, Nopoulos P. Biological and environmental predictors of behavioral sequelae in children born preterm. *Pediatrics.* 2010;125:e83–9.
24. Guellec I, Lapillonne A, Renolleau S, Charlaluk ML, Roze JC, Marret S, et al. Neurologic outcomes at school age in very preterm infants born with severe or mild growth restriction. *Pediatrics.* 2011;127:e883–91.

25. Gray RF, Indurkha A, McCormick MC. Prevalence, stability, and predictors of clinically significant behavior problems in low birth weight children at 3, 5, and 8 years of age. *Pediatrics*. 2004;114:736–43.
26. Whiteside-Mansell L, Bradley RH, Casey PH, Fussell JJ, Conners-Burrow NA. Triple risk: do difficult temperament and family conflict increase the likelihood of behavioral maladjustment in children born low birth weight and preterm? *J Pediatr Psychol*. 2009;34:396–405.
27. Gurka MJ, LoCasale-Crouch J, Blackman JA. Long-term cognition, achievement, socioemotional, and behavioral development of healthy late-preterm infants. *Arch Pediatr Adolesc Med*. 2010;164:525–32.
28. Mathiasen R, Hansen BM, Andersen AM, Forman JL, Greisen G. Gestational age and basic school achievements: a national follow-up study in Denmark. *Pediatrics*. 2010;126:1553–61.
29. van Baar AL, Ultee K, Gunning WB, Soepatmi S, Leeuw R. Developmental course of very preterm children in relation to school outcome. *J Dev Phys Disabil*. 2006;18:273–93.
30. Kan E, Roberts G, Anderson PJ, Doyle LW, Victorian Infant Collaborative Study Group. The association of growth impairment with neurodevelopmental outcome at eight years of age in very preterm children. *Early Hum Dev*. 2008;84:409–16.
31. Sherlock RL, Anderson PJ, Doyle LW, Victorian Infant Collaborative Study Group. Neurodevelopmental sequelae of intraventricular haemorrhage at 8 years of age in a regional cohort of ELBW/very preterm infants. *Early Hum Dev*. 2005;81:909–16.
32. D'Angio CT, Sinkin RA, Stevens TP, Landfish NK, Merzbach JL, Ryan RM, et al. Longitudinal, 15-year follow-up of children born at less than 29 weeks' gestation after introduction of surfactant therapy into a region: neurologic, cognitive, and educational outcomes. *Pediatrics*. 2002;110:1094–102.
33. Msall ME, Phelps DL, Hardy RJ, Dobson V, Quinn GE, Summers CG, et al. Educational and social competencies at 8 years in children with threshold retinopathy of prematurity in the CRYO-ROP multicenter study. *Pediatrics*. 2004;113:790–9.
34. Karemaker R, Heijnen CJ, Veen S, Baerts W, Samsom J, Visser GH, et al. Differences in behavioral outcome and motor development at school age after neonatal treatment for chronic lung disease with dexamethasone versus hydrocortisone. *Pediatr Res*. 2006;60:745–50.
35. Larroque B, Ancel PY, Marchand-Martin L, Cambonie G, Fresson J, Pierrat V, et al. Special care and school difficulties in 8-year-old very preterm children: the Epipage cohort study. *PLoS One*. 2011;6:e21361.
36. Rademaker KJ, Uiterwaal CS, Groenendaal F, Venema MM, van Bel F, Beek FJ, et al. Neonatal hydrocortisone treatment: neurodevelopmental outcome and MRI at school age in preterm-born children. *J Pediatr*. 2007;150:351–7.
37. Purdy IB, Wiley DJ, Smith LM, Howes C, Gawlinski A, Robbins W, et al. Cumulative perinatal steroids: child development of preterm infants. *J Pediatr Nurs*. 2008;23:201–14.
38. Roze E, Van Braeckel KN, van der Veere CN, Maathuis CG, Martijn A, Bos AF. Functional outcome at school age of preterm infants with periventricular hemorrhagic infarction. *Pediatrics*. 2009;123:1493–500.
39. Goyen TA, Lui K, Hummell J. Sensorimotor skills associated with motor dysfunction in children born extremely preterm. *Early Hum Dev*. 2011;87:489–93.
40. Goyen TA, Lui K. Developmental coordination disorder in "apparently normal" schoolchildren born extremely preterm. *Arch Dis Child*. 2009;94:298–302.
41. van Baar AL, Vermaas J, Knots E, de Kleine MJ, Soons P. Functioning at school age of moderately preterm children born at 32 to 36 weeks' gestational age. *Pediatrics*. 2009;124:251–7.
42. Anderson P, Doyle LW, 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.
43. Farooqi A, Hägglöf B, Sedin G, Gothefors L, Serenius F. Mental health and social competencies of 10- to 12-year-old children born at 23 to 25 weeks of gestation in the 1990s: a Swedish national prospective follow-up study. *Pediatrics*. 2007;120:118–33.
44. Purdy IB, Smith L, Wiley D, Badr L. A psychoneuroimmunologic examination of cumulative perinatal steroid exposures and preterm infant behavioral follow-up. *Biol Res Nurs*. 2013;15:86–95.
45. Yu JW, Buka SL, McCormick MC, Fitzmaurice GM, Indurkha A. Behavioral problems and the effects of early intervention on eight-year-old children with learning disabilities. *Matern Child Health J*. 2006;10:329–38.
46. Schneider C, Nadeau L, Bard C, Lambert J, Majnemer A, Malouin F, et al. Visuo-motor coordination in 8-year-old children born pre-term before and after 28 weeks of gestation. *Dev Neurorehabil*. 2008;11:215–24.
47. Schulz J, Henderson SE, Sugden DA, Barnett AL. Structural validity of the Movement ABC-2 test: factor structure comparisons across three age groups. *Res Dev Disabil*. 2011;32:1361–9.
48. Wagner MO, Kastner J, Petermann F, Bös K. Factorial validity of the Movement Assessment Battery for Children-2 (age band 2). *Res Dev Disabil*. 2011;32:674–80.