Assessment of preterm children's early development

AVALIAÇÃO DO DESENVOLVIMENTO INICIALDE CRIANÇAS NASCIDAS PRÉ-TERMO

EVALUACIÓN DEL DESARROLLO INICIAL DE NIÑOS NACIDOS PREMATURAMENTE

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ABSTRACT

Preterm birth is an event that affects the child's healthy development. Several studies have addressed the evaluation of children born preterm and the influence that multiple risk factors have on the course of their development. This study performed a systematic review of the literature from 2000 to 2005 about the evaluation of the development of children born preterm until the age of 24 months. The biological risk factors were present in every study, with highlights on intraventricular hemorrhage, necrotizing enterocolitis, chronic pulmonary disease, and retardation of intrauterine development as the most studied risks. The child's motor development was the most studied area. In terms of age, the first evaluations focused on the first six months of life. Neonatal risk, low birth weight, baby boys, cerebral injuries, and first-week abnormal spontaneous movements were predicting factors of preterm child development at the age of two years.

KEY WORDS

Child development.
Infant, premature.
Risk factors.

RESUMO

O nascimento prematuro é um evento que traz implicações ao desenvolvimento saudável da criança. Diversos estudos têm sido desenvolvidos sobre a avaliação de crianças nascidas pré-termo e a influência de múltiplos fatores de risco na trajetória de desenvolvimento. Este estudo realizou uma revisão sistemática da literatura de 2000 a 2005 sobre a avaliação do desenvolvimento de crianças pré-termo até 24 meses de idade. Os fatores de risco biológicos estiveram presentes em todos os estudos, destacando-se a hemorragia intraventricular, enterocolite necrotizante, doença pulmonar crônica e retardo do crescimento intra-uterino como os mais estudados. O desenvolvimento motor da criança foi a área mais investigada. Quanto à idade, as primeiras avaliações foram direcionadas aos seis primeiros meses de vida. O risco neonatal, baixo peso ao nascimento, sexo masculino do bebê, lesões cerebrais e movimentos espontâneos anormais nas primeiras semanas foram fatores preditores do desenvolvimento das crianças pré-termo aos dois anos de idade.

DESCRITORES

Desenvolvimento infantil.
Prematuro.
Fatores de risco.

RESUMEN

El nacimiento prematuro es un evento que trae implicaciones en el desarrollo saludable del niño. Diversos estudios han sido efectuados sobre la evaluación de niños nacidos prematuramente y la influencia de múltiples factores de riesgo en la trayectoria de su desarrollo. Este estudio realizó una revisión sistemática de la literatura de 2.000 a 2,005 sobre la evaluación del desarrollo de niños prematuros hasta los 24 meses de edad. Los factores de riesgo biológicos estuvieron presentes en todos los estudios, destacándose la hemorragia interventricular, la enterocolitis necrosante, la enfermedad pulmonar crónica y el retardo del crecimiento intrauterino como los más estudiados. El desarrollo motor del niño fue el área más investigada. En lo que se refiere a la edad, las primeras evaluaciones fueron dirigidas a los seis primeros meses de vida. El riesgo neonatal, bajo peso al nacer, el sexo masculino del bebé, las lesiones cerebrales y los movimientos espontáneos anormales en las primeras semanas, fueron factores indicadores del desarrollo de los niños prematuros a los dos años de edad.

DESCRIPTORES

Desarrollo infantil.
Prematuro.
Factores de riesgo.

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Portuguese / English:
www.scielo.br/reeusp

Received: 07/11/2007
Approved: 09/17/2008

INTRODUCTION

The birth of a preterm child is an event that usually results in implications for healthy development[1]. Progress in neonatology in the last several decades has significantly reduced mortality and morbidity rates of high risk infants. However, preterm infants are at higher risk for development deficits when compared to term birth children[2].

The Neonatal period comprises the first 28 days of life after the infant is born. Term birth infants are those whose gestational age is between 37 to 42 weeks; preterm births include all of those born at less than 37 weeks gestation[3]. Natal morbidity increases as gestational age decreases, and risk factors such as intraventricular bleeding, very low birth weight, low Apgar scores at the fifth minute, male gender, and lack of surfactant therapy[4] increase the risk of morbidity. Due to the significant increase in these infants' survival rates in neonatal ICUs, a great number of studies have been carried out regarding the quality of life of preterm children throughout their development [5-6].

Delivery of care for the health of these infants, performed by multiprofessional teams, has been changing focus from care aimed at survival to a health care perspective of investigating developmental outcomes[7]. These perspectives have been observed in longitudinal studies of preterm children, assessing risk factor prevalence for developmental delay and academic difficulties[8-10]. These children may present a high incidence of development limitations, resulting in an increase of use of therapeutic services and special educational resources in children of school age.

Natal morbidity increases as gestational age decreases, and risk factors such as intraventricular bleeding, very low birth weight, low Apgar scores at the fifth minute, male gender, and lack of surfactant therapy increase the risk of morbidity.

Among problems found in the neonatal period, brain damage, especially periventricular bleeding, stands out, which is the disorder that most commonly affects preterm infants' central nervous system (CNS)[11]. They may also develop respiratory complications such as chronic pulmonary disease, which may compromise the organization and functioning of the CNS, increasing the occurrence of neurological sequelae and, as a result, school performance difficulties[12].

Taking into consideration preterm infants' high risk of complications, preventive measures have been adopted through the Newborn Individualized Developmental Care and Assessment Program (NIDCAP)[13] approach to care delivery by doctors, nurses and other professionals dealing directly with these children.

Longitudinal follow-up studies on infants at risk that investigate medium and long term developmental effects stress the need for initial interventions within the neonatal ICU by the multiprofessional team to neutralize the adverse effects of preterm children' vulnerability[14-15].

Regarding the early detection of developmental delay in these infants, many researchers have emphasized the use of standardized assessment devices in high risk child follow-up studies[15-16]. Some researchers stress the need to assess these children while they are still admitted to the hospital, along with the data collection that can support risk predictions based on preterm features and neonatal clinical progress[17-18].

There are many techniques to determine low birth weight[19] preterm infants' normal developmental progress, such as observing spontaneous movements during the first weeks of life[20], neurologic exams, questionnaires to the parents[21], and assessment and selection devices to observe development[22] that can be applied by doctors, nurses, psychologists, physiotherapists, and others.

As we analyzed the methodology used in longitudinal studies on the development of high-risk infants, a few issues were identified, such as the use of the gestational age versus the weight at birth; changes in test instruments from one study to another; and the use of low sensitivity or specific measures to evaluate the infant's development. In order to avoid research based on excessive confusing variables, measures that demonstrate reliability and legitimacy and that include measures of the quality of life of children[23] were used. In addition, there is a need to compare preterm groups among themselves, in order to use the infants' weight or neonatal morbidity as an exclusion variable of the group[18,24-25].

Since the importance of preterm infants initial assessment is acknowledged based on evidence presented in literature, it is important to check the empirical studies with a view to identifying the lineation used in research investigating preterm birth and its consequences due to prematurity for the future development of these children.

This study's aim was to systematically review the published literature in indexed publications, spanning the period from 2000 to 2005, focusing on the study's characteristics regarding research lineation, children's variables and ages, results found and critical analysis of the methodology employed in these studies on the initial assessment of the preterm birth infants' development. This study adopted The Cochrane Library definition that considers the studies that digest results from different investigations as systematic review, using limiting strategies on random error and bias. Review criteria were adjusted from Cochrane and included: target population definition, research databases, time limit, keywords definition, inclusion and exclusion criteria for the selection of studies, quality assessment of the studies, and results interpretation and summary.

METHOD

A systematic review of the literature was performed on Medline, Lilacs and PsycInfo databases, using the following combined keywords: assessment/early assessment, preterm, development/motor/mental/behavior/cognitive, and their corresponding keywords in Portuguese: *avaliação/avaliação precoce, pré-termo, desenvolvimento motor / mental / comportamental / cognitivo*, found in Lilacs. 153 articles were identified at this stage.

Inclusion criteria for the review were: empirical studies on preterm infants' development up to 24 months old; English or Portuguese language; and studies from 2000 to 2005. After the application of the inclusion criteria, 120 articles were excluded from the review, totaling 33 articles for the review. The study was performed in 2005; for this reason, the chosen period of study was the last five years.

Exclusion criteria for the 120 articles were: review articles (17), intervention studies (25), samples composed of a higher age bracket than the one established for this article (44), and studies where only biological and/or maternal variable analysis were included (34).

RESULTS AND DISCUSSION

Study characteristics

The research comprised international articles from many countries, including the USA[26-30], Holland [31-35], England[36-39], Taiwan[40-42], Germany[43-44], Scotland[45], Sweden[46], Australia[47], Slovenia[48], India[49] and Israel[50]. Eight Brazilian articles were found[51-58].

From the articles that were analyzed, 25 presented longitudinal lineation (75%), where 23 were prospective and two were retrospective[40,44]. Transverse lineation was observed in eight studies[28,30-32,37,39,49,55]. As for the analysis format used in the studies, in 16 studies[28,30-32,37,39,49,55], comparisons among groups were performed, involving infants' categorization due to weight, gestational age, and score in the image results assessment. Fourteen studies[26,29,31-32,34,36,38-39,41,46-48,50,53] used predicting biological variables for prediction analysis on the posterior development of preterm birth infants. Four studies[37,51-52,57] performed descriptive analysis on preterm infants' developmental indicators. The investigation of instruments' psychometric parameters were verified in three studies[26,41,47].

As for the variables studied, preterm infants' developmental risk factors were present in most cases, pointing out biologic factors such as periventricular leukomalacia[36,40,47], necrotizing enterocolitis[42-43], intrauterine development and retardation[27,30,49,50], and chronic pulmonary disease[46] as those conditions that most commonly compromise preterm infants' health. Psychosocial variables, such as maternal education and socioeconomic level were included in only four of the studies[28-29,35,41].

As for the children's age at the first assessment, 10 studies[28,30,38,45,47-51,55] led investigations into the first weeks of the infant's life, 12 studies[29,33,37-38,40-42,46,52-53,57-58] assessed infants between one and six months old, and eight studies[26,31-22,36,43,44,54,56] assessed infants between six and twelve months old. Only three studies[27,34,38] performed the first assessment of infants between 13 and 24 months of age. As for the infants' age at the time of the follow-up assessment, eight studies[26,35,45-46,51-53,58] assessed infants between two and 12 months, nine studies[36,39-40,42,48,50,54,56-57] assessed between 13 and 24 months and eight studies[27,31,34,38,41,43,44,47] investigated the infants' development after two years of age. The maximum age of the researched children in the studies was 14 years old [38].

As for the investigated development areas, 12 studies assessed only motor development aspects[31,33,36,45,47,50-51,53-55,57-58], 11 studies assessed motor, cognitive and social behavior development[26-27,29-30,34,38,40-41,43,46,56] and 10 studies assessed motor and cognitive development[28,32,35,37,39,42,44,48-49,52].

From the 33 studies analyzed, the use of a variety of assessment instruments was verified, including neurobehavioral scales to evaluate the first weeks of the child's life, non-standard development assessments, neurologic exams and scales that evaluate the child's development at school age. About 30 instruments were reported used in different studies, where 10 studies (30%) used the Bayley Scales of Infant Development, considered to be the *gold standard* in assessing the development of infants[26-27,29,31,35,39-42,44]. Six studies (18%) used neurologic exams[31,33,36,44,47-48] and four studies (12%) used unsystematic assessments[32,36,48,57].

Studies' main results

Results obtained from the analysis of the 33 studies included in the literature review are organized into three topics, according to the themes addressed in the articles: a) risk factor prediction in preterm infant development; b) preterm infant development compared to term infants; c) preterm infant groups' development comparison.

a) Risk factor prediction in preterm infant development

Thirteen articles were included in this topic that investigated preterm infants' development, focusing on risk factors prediction studies. Risk factors, such as very young mothers, male infants, and larger number of perinatal recurrences have presented a negative influence on preterm infants' development on cerebral palsy detection tests[53].

Studies have shown that children with lower gestational age[34,39], small for the gestational age (SGA)[50], with neurologic abnormalities (intraventricular bleeding degrees II, III and IV)[41], low socio-economic level of the mother and using dexamethasone in post-natal treatment presented more development problems compared to healthy infants[34]. Motion retardation (gross and fine), and expressive and comprehensive language difficulties were related to very low weight at birth (<1,500 g), chronic pulmonary

disease, male infants and low maternal education level[41]. Regression analysis revealed that risk factors such as an Apgar at the fifth minute lower than four, multiple pregnancy, mother's cocaine abuse, and newborn bronco pulmonary dysplasia were associated with poor outcomes in preterm infants' neuromotor development[31].

Among the recurrences presented by infants while admitted to the hospital, chronic pulmonary disease[46] (CPD) and intrauterine growth retardation[50] were considered as aggravating morbidities to preterm infants' clinical status and, consequently, in the manual psychomotor activities and in general movements assessed in the first months of life.

Children with abnormal or absent generalized movements in the first weeks of life present a high incidence of abnormal neurologic exams at the age of two. The legitimacy of generalized movements was 92%, with a sensitivity of 94%, specificity of 92%, predicting positive value of 81%, and a predicting negative value of 92%[48].

From the articles analyzed in this review, the use of the Bayley Scales of Infant Development was mentioned in ten studies (30%), which assesses cognitive and motor development of premature birth infants. This instrument shows high legitimacy as it predicts developmental motor and cognitive outcomes of infants at 12 and 24 months of age[26,39].

Children with abnormal or absent generalized movements in the first weeks of life present a high incidence of abnormal neurologic exams at the age of two.

It is well known that preterm birth is not an isolated event; it is often followed by many complications and adverse risks to the health of infants due to organic system immaturity and the neonatal ICU environment. Researchers have investigated the influence of higher and lower neonatal risks on motor and cognitive outcomes in these newborns. Risk indicators, such as the Neurobiologic Risk Score (NRS)[29] and the Neonatal Medical Index (NMI)[31], have been associated with neonatal risk factors and results from the development assessments in the first months of life. Among these risk indicators, an NRS>8 was associated with an increase in abnormal motor and mental development risks including cerebral palsy[29]. An NMI>3 assessed in the neonatal period, especially on males, was associated with higher motor delay of the child at seven years of age[31].

Preterm infants' assessment in the first year of life has been a target for many prediction studies[38-39,41] proposed by researchers in the area. In one of these studies[38], researchers verified that preterm infants' developmental state by one year of life was predictive for results at the ages of 14 and 15 for the following variables: neuromotor abilities, cognitive function, and educational, behavioral and psychiatric indicators. In this study, the controlling variables throughout the years to minimize the effects of confounding variables were not mentioned. The assessment at the age of 14 was performed by a psychologist, pediatrician, neurologist and a psychiatrist, and all of them were *blind* to the results obtained in the first year.

In addition to the tools that assessed health compromises in newborns, studies have investigated the influence of cerebral alterations in these infants based on neuroimaging exam techniques, such as transfontanellar ultrasonography[36,47], computed tomography (CT) and magnetic resonance imaging (MRI). The presence of cerebral alterations in the first months of life constitute a reliable predictive factor for the presence of retarded motor development[36] and detection of cerebral palsy[47] at the age of two or three. This result is of great importance for professionals thatdeal with infants in the intensive care units on a daily basis, with a view to adopting preventive care measures and medium and long term follow up.

b) Preterm infant development in comparison to term infants

This topic includes nine studies aimed at comparing preterm birth infants' development to term infants. The authors point to preterm and term infants' development regarding behavior aspects[28,35,49], non-nutritional suction pressure control[45], posture control[51], and gross[54,56,58] and fine[55] motor abilities acquisition throughout the two first years of life.

In the neonatal period, preterm infants' development demonstrated that they were distinctively different in comparison to term babies in regards to autonomic response, motor responses, behavioral states, attention/interaction and self-regulating systems[28,35]. In addition, preterm infants that were appropriate for gestational age (AGA) present lower motor skills than infants described as small for gestational age (SGA) and preterm infants that have suffered from perinatal anoxia[49].

The healthy preterm infant with a gestational age >32 weeks presented similar postural control when compared to term infants up until 12 months old[51]. On the other hand, extreme preterm infants (<29 weeks) and with very low weight (<1,500g) displayed developmental delay when compared to term infants regarding temporal control of non-nutritional suction[47] in the first weeks, and in postural control in the first year[58]. A weak suction control was predictive of motor retardation at the age of nine months[47].

When comparing motor performance between preterm and term infants, there were no differences among groups in movement abilities at 8 months and mobility at 12 months[54]. However, regarding gross and fine movements, preterm infants presented more delay[56] when comparing Denver test regulated samples and similar performance[55] of the Brazilian samples at the age of two. These results show that researchers must be careful when analyzing development results in infants when comparing with regulated data from standard tests.

It is important to note that these results are over Brazilian samples using the same instrument.

c) Development comparison among preterm groups

This topic includes seven studies[27,30,33,40,42-44] aimed at comparing preterm birth infants' development to term infants' development, extracted from different groups. Three of these studies[30,23,40] assessed the association through imaging exams and the assessment of preterm infants' development. In these studies, infants were extracted in groups according to weight at birth[27,30], neonatal clinical risk index[33], cerebral alterations on neuroimaging exams[40] and by the presence of necrotizing enterocolitis[42-43] and prematurityassociated comorbidities[44].

Findings in these studies reveal that premature infants with neurologic abnormality during the neonatal period had worse neurologic and cognitive results at eight years old[27]. When associated to intrauterine growth retardation, preterm infants showed significant reduction in intracranial volume and gray matter when measured in the first two weeks of life through magnetic resonance imaging (MRI). Brain gray matter volume presented a positive correlation with the infants' attention-interaction abilities during neurobehavioral assessment performed in the neonatal period[30].

Preterm infants with brain alterations detected by cerebral ultrasonography were associated with a higher clinical risk of presenting higher levels of delay compared to muscle strength and motor performance at 12 months of age [33].

The presence of necrotizing enterocolitis associated with low weight at birth was related to a high rate of neonatal death (29%) and delay in mental and psychomotor development at 6 and 18 months, and at 12 and 20 months corrected age[43]. In addition, another study verified that preterm infants presenting umbilical artery flow speed reversion associated with other neonatal comorbidities, such as intestinal problems, chronic pulmonary disease and prematurity retinopathy higher than degree III, present permanent neurologic sequelae compared infants presenting with only the first condition[44].

Based on these results, the need to study preterm birth infant's development within a guided context of various associated risk factors involves birth variables and the infants' clinical health state results during hospital admittance.

Critical analysis on the methodology of studies

In all 33 studies analyzed, a diversity of methodology was employed in the investigation of risks to preterm infants' development. However, longitudinal lineation was most commonly used among the authors, as it proved more suitable for documentation of preterm infants' developmental responses and evolution throughout time. In analyzing these studies' results, we can observe that, in order to study the developmental process considering biologic risk factor effects, longitudinal prospective and prediction analysis studies were more appropriate to identify delayed or unusual development predicting variables.

In this review, 10 articles presented more appropriate methodology to obtain results. Eight predicting studies[29,38,41,46-48,50,53] presented data analysis sample selection criteria considering biologic factors such as the infants' gender, higher number of neonatal complications, and morbidities such as chronic pulmonary disease and the presence of brain alterations. In addition, abnormal generalized movements in the first months of the infants' life demonstrated high predictive value in posterior developmental delay. Two preterm infant comparison studies[27,40] showed that prematurity associated with neurologic alterations is related to a worse prognosis in regards to the development or presence of neurologic abnormalities, compromising the child's school life.

Regarding the use of standard assessment instruments, 15 studies used this procedure on the researched population. Two studies[41,54] used more than one instrument of methodological lineation, where only one instrument was reported for the standardization of the population. The Chinese Child Development Inventory (CCDI) was standardized for the studied population, while the Bayley Scales of Infant Development II was not standardized for the population in Taiwan[41]. The Alberta Infant Motor Scale (AIMS) and the Pediatric Assessment of Disability Inventory (PEDI) were used, where only PEDI was mentioned as a regulating data instrument for the Brazilian population[54]. Through the analysis of these studies the importance of using standard assessment on preterm infants' development follow-up proves necessary and, when standards are absent, comparison or contrast groups should be used in order to contribute to children's development assessment clinical deployment.

As for the reliability of results analysis and interpretation obtained by instruments, 10 studies[27,38,40-41,44,46-47,50,54-55] reported the participation of *blind* examiners relating previous assessment of infants' and results' biologic and social features. The use of this procedure transfers the methodological care from the authors, with the objective of minimizing analysis bias of results regarding infants' development. This type of care is necessary mainly in predictive longitudinal studies, where variables collected at the beginning of the study will be correlated with future observations on a medium and long term basis.

Regarding the reliability studies among the examiners in charge of the applied instruments' scoring and application, 17 studies mentioned the performance of this type of procedure. In all studies that used standard instruments, the training of professionals administering the assessment was mentioned, guaranteeing higher development of measures reliability. Only two studies[48,50] among those reported an intra-observer, ensuring mode fidelity of the collected data. This factor is important when regarding preterm infant research, since assessments can be difficult and capturing the little details on the behavior of these children is not easy.

From the infant samples used in the researched studies, 19 studies were originated from the samples of chil-

dren inserted in developmental follow-up programs or services in teaching hospitals, and health services admitting high-risk infants and pregnant women. In the remaining 14 studies, the authors do not mention the follow-up context. This data directly implicates the generalization of results in the studies, since the families that look for the services can count on an orientation support, constituting a protective factor for the development of risk infants. Therefore, these samples cannot represent premature infant samples that do not have this type of opportunity or accessibility to resources of this type. In addition, in the studies where children participated in these programs, infants' developmental results were more optimistic regarding other studies' results.

Comparison studies that used preterm and term infant groups extracted on the basis of neonatal clinical evolution were observed. Consequently, studying the development of preterm infants is recommended, comparing them not only in regards to gestational age, but also classifying them according to risk factors, such as neonatal complications, central nervous system injuries and nutritional state.

Regarding the investigated developmental areas, the researchers' emphasis on studying children's developmental indicators in the motor, cognitive and behavioral areas, and low emphasis on children's interaction within the social, family and school environment was observed. In addition, the studies that combined the assessment of different developmental areas in children proved to be more consistent in their analysis and hold higher potential for generalizing results.

Regarding the children's age while undergoing assessment, the studies focused more on the first year of life, especially investigating the motor development area. The studies that performed assessment after the first year of life focused on the investigation of other developmental variables, such as cognitive performance and academic and language abilities.

The studies that used neuroimaging exams and other technologic resources combined with developmental assessment searched for the ability to relate structural aspects and adaptive functioning indicators of the child, aiming at globally investigating the developmental prognosis of these at-risk infants.

CONCLUSIONS

Based on results presented in this review, a tendency towards studying preterm infants' developmental trajectory using longitudinal lineation, with the association of biologic variables and data collection based on neuroimage technique was observed.

Through prediction studies, the abnormal general movements in the first days of life, male gender, neonatal comorbidities, weight <1,500g, imaging exam alterations, and younger mothers were demonstrated to be risk factors holding high predictive value for motor and cognitive developmental delays in preterm birth infants. These studies reaffirm the authors' emphasis on the prevention of deficiencies by initial assessment of the development of infants and the identification of predictive variables in prematurity follow-up programs.

These results may be of great importance for the practical actions of professionals who directly care for preterm infants, such as doctors and nurses. Aside from the acknowledgment of the main risk factors and developmental consequences, these professionals can guide their care perspective towards promoting neurological health and the prevention of risk factors during pregnancy, childbirth or the neonatal phase.

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