Development of low birth weight preterm infants during the first two years of life

Desenvolvimento de prematuros com baixo peso ao nascer nos primeiros dois anos de vida

Desarrollo de prematuros con bajo peso al nacer en los primeros 2 años de vida

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ABSTRACT

Objective: To analyze and describe the neuropsychomotor development of low birth weight preterm infants in the first two years of life.

Methods: This cross-sectional study enrolled preterm infants between 4 and 24 months old at the follow up clinic of Universidade Federal de Santa Catarina, Florianópolis, Brazil. The children were assessed in three moments: 8, 11 and 14 months (chronological age). The sample, initially composed by 69 individuals, was chosen intentionally according to the inclusion and exclusion criteria. The Brunet and Lèzine's Scale was used to evaluate development in the following areas: hand-eye coordination, language, posture and sociability. Data were analyzed using descriptive and inferential statistics.

Results: The average gestational age was 31 weeks and the birth weight, 1236g. The global development quotient improved from the first to the last assessment, reaching 85% of scores within the normal range in the third assessment. The specific areas of hand-eye coordination and language had the worst initial results, while posture had the best scores. Correlation was found between birth weight and posture, language and social areas at the first assessment and between birth weight and social and hand-eye coordination at the third assessment.

Conclusion: Deficits of neuromotor development of the studied population were more evident in the first months of life. Although the follow-up did not show statistic differences between the first and last assessment, there was an improvement in all areas of development.

Key-words: child development; infant, premature; infant, low birth weight.

RESUMO

Objetivo: Analisar e descrever o desenvolvimento neuropsicomotor de prematuros com baixo peso ao nascer nos dois primeiros anos de vida.

Métodos: Estudo transversal realizado com prematuros entre quatro e 24 meses, no Ambulatório de Alto Risco Neonatal do Hospital Universitário da Universidade Federal de Santa Catarina, avaliados em três momentos: 8, 11 e 14 meses de idade cronológica. A amostra, composta inicialmente por 69 indivíduos, teve caráter intencional, segundo os critérios de inclusão e exclusão estabelecidos. A Escala de Brunet e Lèzine foi usada para avaliar o desenvolvimento nas seguintes áreas: coordenação óculo-motriz, linguagem, postura e sociabilidade. Os dados foram analisados por meio de estatística descritiva e inferencial.

Resultados: A idade gestacional média foi de 31 semanas e o peso ao nascer foi de 1236g. O quociente de desenvolvimento global apresentou melhora da primeira

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Conflito de interesse: nada a declarar

Recebido em: 2/6/2010
Aprovado em: 12/1/2011

para a última avaliação, alcançando 85% de escores dentro da normalidade na terceira avaliação. As áreas específicas da coordenação óculo-motriz e da linguagem tiveram os piores resultados iniciais, contrapondo-se à postural, que apresentou os melhores escores. Foi encontrada correlação entre o peso ao nascer e as áreas da postura, linguagem e sociabilidade na primeira avaliação e sociabilidade e coordenação óculo-motriz na terceira avaliação.

Conclusões: O desenvolvimento neuropsicomotor desta população apresentou déficits mais evidentes nos primeiros meses de vida. Embora o seguimento não tenha mostrado diferenças estatísticas entre a primeira e a última avaliação, houve melhora em todas as áreas do desenvolvimento.

Palavras-chave: desenvolvimento infantil; prematuro; recém-nascido de baixo peso.

RESUMEN

Objetivo: Analizar y describir el desarrollo neuropsicomotor de prematuros con bajo peso al nacer en los dos primeros años de vida del niño.

Métodos: Este estudio transversal fue realizado con prematuros entre 4 y 24 meses en el Ambulatorio de Alto Riesgo Neonatal del Hospital Universitario/UFSC, evaluados en 3 momentos. La muestra, compuesta inicialmente por 69 individuos, tuvo carácter intencional según los criterios de inclusión y exclusión establecidos. La Escala de Brunet y Lèzine fue usada para evaluar el desarrollo en las siguientes áreas: Coordinación óculo-motriz, Lenguaje, Postura y Sociabilidad. Los datos fueron analizados mediante estadística descriptiva e inferencial utilizando el *software* SPSS 13.0.

Resultados: La edad gestacional mediana encontrada fue de 31 semanas, ya el peso mediano al nacer fue de 1236g. El cociente de desarrollo global presentó mejora de la primera para la última evaluación, alcanzando 85% de escores dentro de la Normalidad en la 3ª evaluación. Las áreas específicas de la coordinación óculo-motriz y del lenguaje tuvieron los peores resultados iniciales, contraponiéndose a la postural, que presentó los mejores escores. Se encontró correlación entre el peso al nacimiento y las áreas de la postura, lenguaje y sociabilidad en la 1ª evaluación y sociabilidad y coordinación óculo-motriz en la 3ª evaluación.

Conclusiones: El desarrollo neuropsicomotor de esta población presentó déficits más evidentes en los primeros meses de vida. Aunque el seguimiento no haya mostrado diferencias estadísticas entre la primera y la última evaluación, hubo mejora en todas las áreas del desarrollo.

Palabras clave: Desarrollo infantil; prematuro; recién nacido de bajo peso.

Introduction

As a result of advances in the care provided to preterm and low birth weight newborn infants, the survival rates of these children, who are high-risk from a biological point of view, have increased significantly[1]. However, the direct and indirect repercussions associated with these conditions can cause harm that compromises these children's future development[2].

The motor abilities acquired during the first year of life are appropriate milestones to indicate prognosis for global development, since the first 12 months after birth are considered one of the most critical periods in child development[3]. It is during this phase that children, and particularly children such as preterms and low birth weight infants who are at increased risk of developing deficiencies, should be monitored in appropriate follow-up programs that assess their development longitudinally[4] in order to detect signs of abnormalities, with a view to referring them for intervention programs aimed at minimizing the effects of these abnormalities.

Many different studies have shown that low birth weight children are more likely to develop neurological problems[5-11], ranging from mild cognitive, behavioral or learning difficulties[5,9,10] through to cerebral palsy[5,6,8]. Other factors predisposing to these dysfunctions are prematurity[6-9] and a low ratio of weight/gestational age (small for gestational age - SGA)[12].

It is concern with the impact that low birth weight and prematurity have on global development that motivated this study. The study objectives were to analyze and describe the neuropsychomotor development of low birth weight preterms during their first 2 years of life.

Methods

This was a descriptive, cross-sectional field study, with data collected from each patient at three different times[13]. The study was approved by the Human Research Ethics Committee at the *Universidade do Estado de Santa Catarina*.

The study recruited children who were enrolled on a neurodevelopment follow-up program entitled

"Neuropsychomotor Assessment of Preterm Infants" run by the High Risk Neonatology Clinic at the pediatrics department of the *Universidade Federal de Santa Catarina's* University Hospital between August of 2006 and July of 2007. The entire population comprised 118 children seen over the period and the sample of 69 was selected intentionally (failures to attend appointments meant that this figure had reduced to 53 by the second evaluation and to 39 by the third). Inclusion criteria were as follows: premature birth; authorization from parents or guardians for children to take part in the study; child registered with the high risk neonatal clinic; gestational age <37 weeks according to the Ballard method; birth weight <2,500g; and postnatal age of 4 to 24 months (the age by which children had been assessed three times) between August 2006 and July 2007, since this is considered the ideal age range for the instrument employed. Exclusion criteria were as follows: diagnosis of sensory disorders (sight or hearing), malformations, and severe diseases such as central nervous system infections, prior diagnosis of cerebral palsy (based on significant tonus abnormality), severe heart disease and genetic syndromes.

Children were assessed individually on the same days that they had appointments for their three-monthly medical consultations at the clinic. Children who did not attend their appointments could not be assessed three times and the sample size was reduced as a result. Each participant underwent a neuropsychomotor development assessment conducted by the clinic's physiotherapist using the Psychomotor Development Scale for Early Infancy, created by Brunet and Lèzine[14]. If any developmental abnormalities were detected, the child's carers were given instructions on how to stimulate specific areas and the children were prescribed stimulation therapy, but were not excluded from the study (only three of the children in the sample had physiotherapy while follow-up was ongoing).

The Psychomotor Development Scale for Early Infancy, comprises a kit including the testing instruments themselves and a questionnaire to be administered to parents or guardians. The scale is designed to assess the development of children aged 1 to 30 months in the following areas: Eye-hand and fine-motor coordination (E), Language (L), Posture and gross motor function (P) and Social reactions (S), in addition to Global development (G). This scale has been validated internationally and was shown to have criterion validity of 0.68 (concurrent validity with the Stanford-Binet, Terman-Merril, Cattel, Charlotte Bühler and Arnold Gesell scales) and reliability of 0.85 (correlation coefficient for test-retest)[14]. The original scale developed by Brunet and Lèzine was translated into Portuguese in 1981[14], but has not been validated or adapted for the Brazilian population.

Developmental quotients (DQ) were calculated for each development area and participants' motor development was classified for each area as Very High (>130), High (129 to 120), High Normal (119 to 110), Mid Normal (109 to 90), Low Normal (89 to 80), Low (79 to 70) or Very Low (<70)[15].

The following biopsychosocial data relating to the children were also investigated: identification details; anthropometry and histories of intercurrent conditions during prenatal (eclampsia, infection, diabetes or arterial hypertension in the mother), perinatal (asphyxia, meconium aspiration and oligohydramnios, among others) and postnatal or neonatal periods (respiratory diseases, infections and ventricular hemorrhages). Data were collected from patients' medical records and supplemented with information provided by parents to complete a standardized chart.

Chronological ages were corrected to 40 weeks' gestation by manual calculation[16]. Data were analyzed using descriptive and inferential statistics, with Pearson's correlation and the paired *t* test, using SPSS 13.0 software.

Results

The first neuropsychomotor development assessment investigated 69 children who met the inclusion criteria, which corresponded to 58% of the total population. Fifty-eight percent of these 69 children were male and 42% were female. Mean gestational age was 31 weeks, with extremes of 24 weeks and 36 weeks and 6 days, while 74% were born before 32 weeks' gestation. Mean birth weight was 1236±372g, varying from 515 to 2215g. Mean length at birth was 37.5±3.6cm and mean head circumference was 26.8±2.8cm, varying from 20 to 34cm.

Seventy-three percent of the mothers received prenatal care and 50% attended an average of 5-6 consultations. Prenatal intercurrent conditions were present in 68% of gestations, with the most common being diabetes and arterial hypertension, while 38% had perinatal complications, primarily oligohydramnios and fetal distress. Eighty-eight percent of the infants analyzed suffered some type of neonatal complication, with 39% put on mechanical ventilation. Around 10% of these infants remained more than 6 days on ventilation. Multiple births are associated with low birth weight. Just 19% of those investigated here were multiples.

Table 1 - Minimum and maximum values, means and standard deviations for Developmental Ages (DA) for all three assessments

Variables	n	Min	Max	Mean	Standard deviation
Posture and gross motor function DA1	69	1.0	18.0	6.26	3.28
Hand-eye and fine motor coordination DA1	69	0.0	14.4	5.90	3.15
Language DA1	69	2.0	18.0	6.05	3.14
Social reactions DA1	69	1.0	16.5	6.17	3.44
Global DA1	69	0.9	15.3	6.10	3.17
Posture and gross motor function DA2	53	5.0	21.0	9.77	3.14
Hand-eye and fine motor coordination DA2	53	4.7	16.0	8.97	2.27
Language DA2	53	4.0	20.0	9.18	3.26
Social reactions DA2	53	4.3	18.0	9.44	2.90
Global DA2	53	4.9	18.9	9.28	2.69
Posture and gross motor functionDA3	39	8.3	21.0	13.55	3.53
Hand-eye and fine motor coordination DA3	39	8.5	19.0	12.34	2.39
Language DA3	39	9.0	21.0	12.79	3.13
Social reactions DA3	39	8.5	19.5	12.91	2.94
Global DA3	39	8.5	19.8	12.81	2.75

Table 2 - Values minimum, maximum, mean and standard deviation for Developmental Quotients (DQ) for all three assessments

Variables	n	Min	Max	Mean	Standard deviation
Posture and gross motor function DQ1	69	25.6	153.8	99.84	24.34
Hand-eye and fine motor coordination DQ1	69	25.6	160.0	92.11	26.66
Language DQ1	69	43.5	151.5	97.17	22.99
Social reactions DQ1	69	25.6	151.5	97.39	24.60
Global DQ1	69	22.0	153.8	96.61	22.04
Posture and gross motor function DQ2	53	74.6	142.6	107.10	15.56
Hand-eye and fine motor coordination DQ2	53	67.3	157.4	100.11	16.15
Language DQ2	53	63.1	153.0	100.69	19.43
Social reactions DQ2	53	69.3	153.0	103.85	16.89
Global DQ2	53	72.2	144.4	102.53	14.75
Posture and gross motor function DQ3	39	69.1	140.2	110.41	16.66
Hand-eye and fine motor coordination DQ3	39	70.8	130.3	101.47	11.20
Language DQ3	39	67.6	150.0	104.85	18.00
Social reactions DQ3	39	70.8	132.7	105.74	15.02
Global DQ3	39	70.8	129.5	104.90	11.58

In terms of weight, 75% of the infants were appropriate for their gestational ages while 25% were small for gestational age. Mean chronological age (CA) at the initial assessment (n=69) was 8 months with extremes of 4 and 20 months. Mean corrected chronological age (CCA) was 6 months, varying from 3 to 18 months.

The results for neuropsychomotor development are given in the form of specific and global developmental ages and developmental quotients. Tables 1 and 2 list developmental ages and developmental quotients for each of the areas of development at the three assessments, together with their ranges and standard deviations. It will be observed that the

developmental ages for all areas were below the sample's mean CCA at the first assessment, indicating a negative developmental age in all areas.

At the second assessment (n=53) mean chronological age was 11 months, varying from 7 to 23 months. After correction, mean CCA was 9 months, varying from 5 to 21 months. Mean developmental age was higher than mean CCA, for the majority of areas, with the exception of hand-eye coordination, which had an age that was negative by 0.2 months.

The third assessments (n=39) were conducted an average of 6 months after study outset, with mean CA of 14 months and a range of 10 to 21 months. Mean CCA was 12 months; minimum was 9 months and maximum was 18 months. Table 1 shows that none of the (mean) developmental ages were negative at the third assessment and that all developmental ages were greater than mean CCA.

At the first assessment, 58% of cases had a global development quotient within normal limits; 16% were in the At-Risk Zone (Low Normal), and 14% had their development classified as Low or Very Low. It will be observed that there was a steady improvement in global development quotient, with 85% of scores within normal limits by the

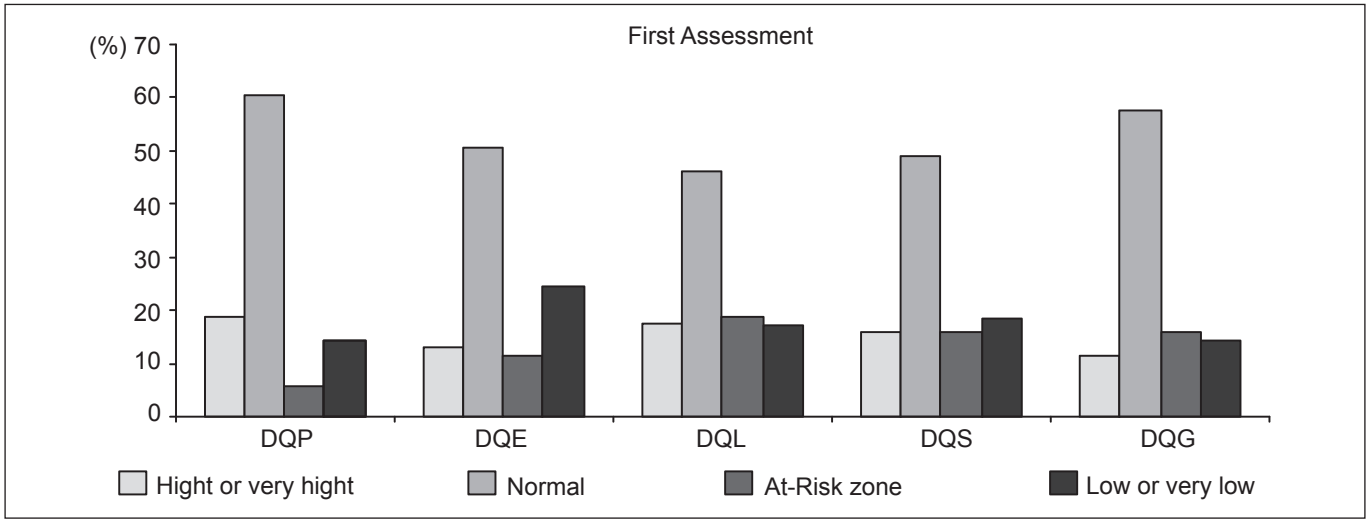

Figure 1 - Graph of DQs for each development area, according to development classification at the first assessment. DQP: developmental quotient for posture and gross motor function; DQE: developmental quotient for hand-eye and fine motor coordination; DQL: developmental quotient for language; DQS: developmental quotient for social reactions; DQG: global developmental quotient; LN: low normal

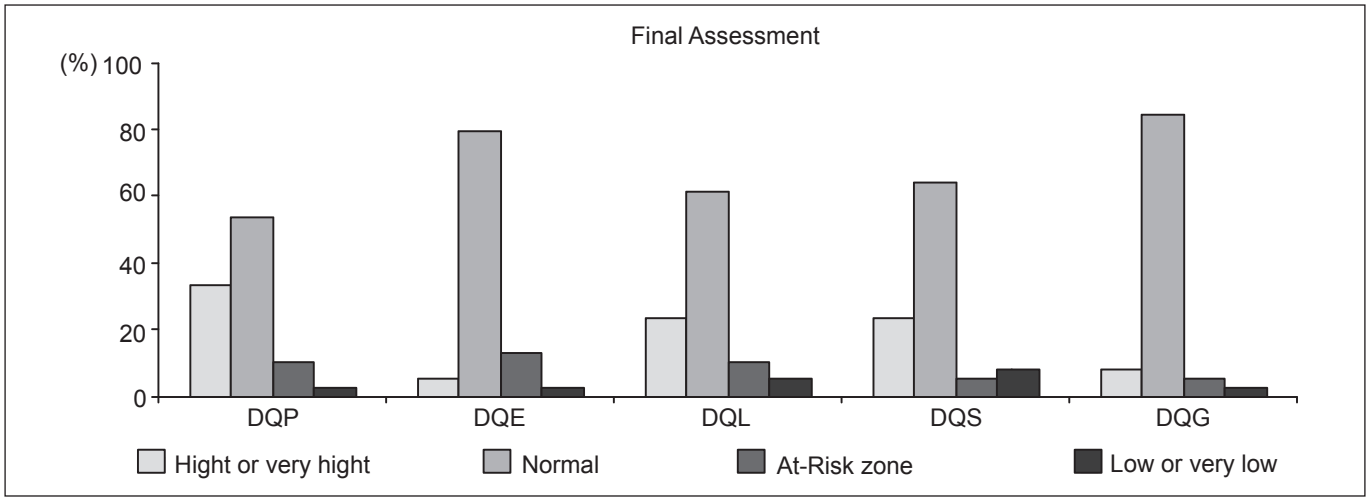

Figure 2 - Graph of DQs for each development area, according to development classification at the final assessment. DQP: developmental quotient for posture and gross motor function; DQE: developmental quotient for hand-eye and fine motor coordination; DQL: developmental quotient for language; DQS: developmental quotient for social reactions; DQG: global developmental quotient; LN: low normal

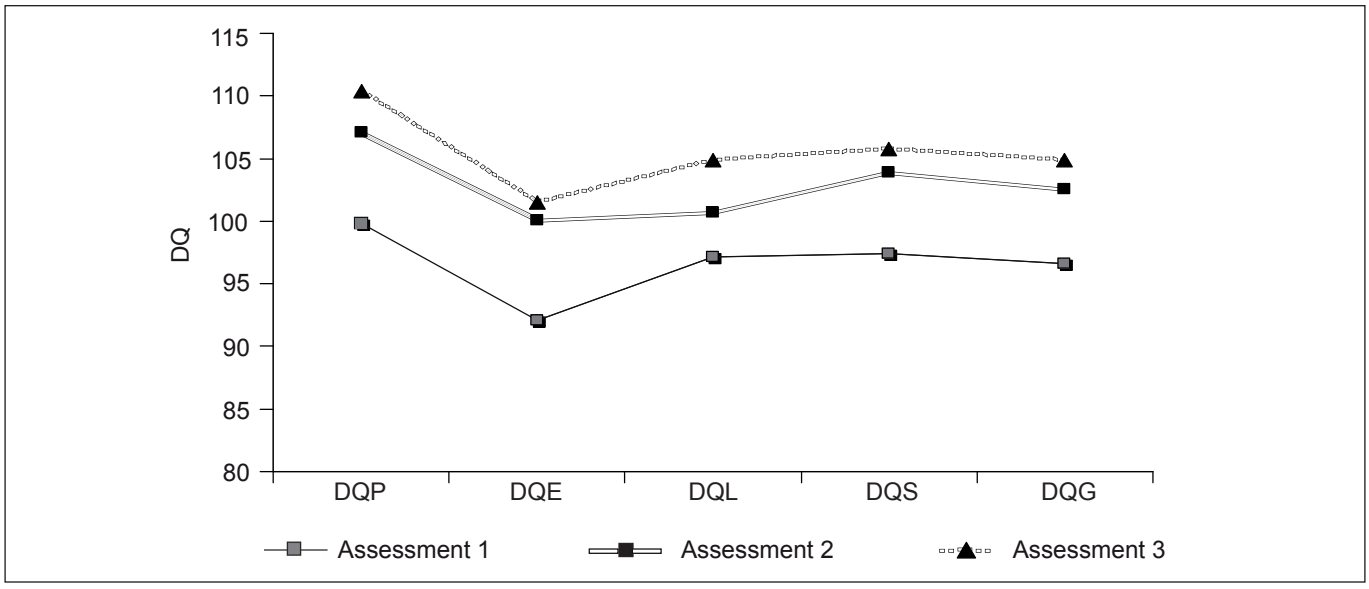

Figure 3 - Graphical representation of mean DQs over neuropsychomotor follow-up period. DQP: developmental quotient for posture and gross motor function; DQE: developmental quotient for hand-eye and fine motor coordination; DQL: developmental quotient for language; DQS: developmental quotient for social reactions; DQG: global developmental quotient; LN: low normal

third assessment, just 5% classified in the At-Risk Zone and a single case (3%) with a Low developmental quotient (Figures 1 and 2)

At the first assessment, Hand-eye and fine motor coordination was the specific developmental area with the highest number of cases classed as Low or Very Low (25%) and in the At-Risk Zone (11%), with 36% below Mid-Normal. Thirty-six percent of cases had a Language DQ below Mid-Normal, with 19% in the At-Risk Zone and 17% Low or Very Low (Figure 1). Posture and gross motor function had the best quotients, with 79% of cases classified as Mid-Normal or higher. There was a significant improvement in Hand-eye and fine motor coordination by the third assessment (Figure 2), with just 3% of cases classed as Low or Very Low.

Figure 3 illustrates the mean developmental quotients for each developmental area as neuropsychomotor follow-up progressed. Note the linearity of the results, demonstrating that neuropsychomotor follow-up of infants born low weight did not lead to detectable significant differences, although there was a discrete improvement in all areas from the first to the third assessment.

When Pearson's linear correlation was used to correlate developmental quotients for each area by pairs (first *vs* second assessments and first *vs* third assessments), it was found that differences between the majority of pairs were statistically significant, with the exception being Hand-eye and fine motor coordination (p=0.177) between first and third assessments.

When the means for each specific area were compared by pairs using the paired t test, there were no statistical differences at a 95% confidence level.

When birth weight was correlated with neuropsychomotor developmental quotients at the first assessment using Pearson's linear correlation, statistical significance was detected for the relationships between weight and posture and gross motor function (p=0.035), Language (p=0.022) and Social reactions (p=0.009). When the correlations between birth weight and neuropsychomotor developmental quotients were tested for the third assessment, however, only Social reactions (p=0.034) and Hand-eye and fine motor coordination (p=0.0340) were significant.

Discussion

Children with low birth weight often exhibit a different pattern of motor development during their first year of life to the pattern expected of children born at full term[4]. The high rate of prenatal, perinatal and neonatal complications and conditions in this study was because 74% of the sample was made up of preterms born at less than 32 weeks. According to Neubauer, Voss and Kattner[6], neonatal complications are significant risk factors for compromised development at school age.

It is very often necessary to use mechanical ventilation to treat these complications, as was observed here. Castellanos[17] found that 27% of a group of low weight neonates who had been on mechanical ventilation had normal neuromotor

development results at 2 years of life, with 54% suffering mild developmental disorders and 19% with severe problems. Just 2% of a control group that had not been ventilated, but which was also recruited from low birth weight neonates had severe neurological development disorders.

Also as a result of the high rate of prenatal and perinatal intercurrent conditions, the most common type of delivery in the sample was caesarean (65%). Data for 2005 from the Brazilian live births register (SINASC - *Sistema de Informações de Nascidos Vivos*) show that there were a greater proportion of low birth weight babies in the city of Rio de Janeiro among mothers who had had caesareans[18].

Although 73% of the mothers had received prenatal care, half of them had only attended 5 or 6 consultations. Data on Brazil from the SINASC database show that a smaller percentages of mothers who attended seven or more prenatal consultations give birth to low birth weight infants[18].

Mean birth weight was 1236g, with a range of 515 to 2215g. Halpern *et al*[19] showed that children born with low birth weight (<2500g) have a three times greater risk of developmental delays, in comparison with those born heavier than 2500g ($p<0.001$). In a 2008 study, Halpern *et al*[20] concluded that the prevalence of suspected cases of delay reduces as income and birth weight increase. In that study suspected delay was more prevalent among the children of poorer families, but the association with birth weight was stronger. Birth weight was also strongly associated with childhood developmental problems in a study conducted by Wilcox[21].

At the initial assessment, mean Chronological Age (CA) and Corrected Chronological Age (CCA) were 8 and 6 months respectively. At the second assessment, mean CA was 11 months and mean CCA was 9.17 months, while at the third assessment mean CA and CCA were 14 and 12 months respectively. On the basis that the Brunet and Lèzine scale assesses global and specific motor development by age, the children's developmental quotients (DQ) were classified according to their CCA.

The prevalence of cases in which global DQ was Low Normal (16%) and Low or Very Low (15%) at the first assessment is in line with results reported by other studies[11,20,21], which confirm that neuropsychomotor development is slower in children with low birth weight.

In addition to investigating low birth weight, the children were also classified for appropriateness of weight to gestational age, with 75% of patients being appropriate for gestational age (AGA) and 25% SGA. Many articles have linked low birth weight with intrauterine growth restriction and increased risk of mortality and of cognitive dysfunctions[22] and also with increased neurological morbidity, even including permanent brain damage, such as cerebral palsy and mental retardation[16], through subtle forms of delayed development[12]. With regard to specific areas of development, Language was cited as one area that is affected in preterm and low birth weight children[11,23]. Motor delays were also detected (including both posture and Hand-eye and fine motor coordination)[4,11]. Sociobehavioral problems were observed in low birth weight preterms in a meta-analysis by Bhutta *et al*[9].

There was a visible improvement in the global development quotient between first and last assessments. The percentage of normal cases rose from 58% at the first assessment, to 70% at the second and 85% at the third assessment, while cases in the At-Risk and Low or Very Low zones respectively reduced from 16 and 14%, through 11% and 7%, to 5% and 3%, from the first to the second to the third assessments, respectively. This improvement was not sufficient to provide evidence of significant differences within this sample. A larger patient sample would possibly have confirmed the differences statistically.

Drillien's classic study[24] found that 40% of 281 patients with birth weight <2000g had neuromotor abnormalities during the first months of life and that these abnormalities were transitory, calling this group of neurological symptoms "transient dystonia associated with low birth weight". Pedersen, Sommerfelt and Markestad[4], citing several different studies, state that transient dystonia is most often detected between 3 and 5 months of age, with a subsequent reduction in motor abnormalities from 8 months on, with normal levels achieved at 12 to 18 months. A similar pattern was also observed in the study described here, since improvement was observed in global development and in all of the specific areas of development.

Hand-eye and fine motor coordination, which includes functional integration of object-eye-hand[25], was the area with the greatest percentage of delayed development at the first assessment (11% of cases were in the At-Risk zone and 24% in Low or Very Low), but it was also the area that exhibited greatest improvement in development as the systematic follow-up continued. The deficits observed here at these ages should be taken as a warning that stimulation is necessary from a very tender age, since these deficits could negatively impact on the child's future academic performance.

Differences in cognitive functions and academic performance between children with low and normal birth weight are more evident during childhood. The risk of

delayed academic development is greater among children with low birth weight than among those with normal birth weight, which reflects cognitive limitations caused by prematurity[26].

Language was the second-most affected area, which is in line with other studies of similar populations[27-29]. Language development involves many different processes and progress is dependent on interactions involving biological, social and psychological factors[27]. One condition that can cause language problems is motor limitations caused by difficulties exploring and interacting with surroundings[30]. Motor development can therefore have a negative impact on language development.

Certain trends and correlations could not be investigated in this study because of the small number of participants, caused by the study design that imposed many restrictions on recruitment. Furthermore, the large losses from the sample, which reached 43% by the last assessment, also made data analysis more difficult.

The results of this study show that low birth weight preterms suffer from neuropsychomotor development delays and that these delays are more easily detected during the first months of life. Correlations were observed between birth weight and the developmental areas Posture and gross motor function, Language and Social reactions at the first assessment and with Social reactions and Hand-eye and fine motor coordination at the third. The lowest scores were for Language and Hand-eye and fine motor coordination, which is worrying since delays in these areas can be reflected in future learning difficulties at school. Assessment of these children's neuropsychomotor development is therefore indispensable and abnormalities must be detected as early as possible to enable stimulation to be provided in order to minimize future harm.

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