

Acquisition of motor abilities up to independent walking in very low birth weight preterm infants

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Objective: To determine chronological and corrected ages at acquisition of motor abilities up to independent walking in very low birth weight preterms and to determine up to what point it is necessary to use corrected age.

Methods: This was a longitudinal study of preterms with birth weight < 1,500 g and gestational age ≤ 34 weeks, free from neurosensory sequelae, selected at the high-risk infants follow-up clinic at the Hospital das Clínicas, Faculdade de Medicina de Botucatu, Universidade Estadual Paulista (UNESP) in Botucatu, Brazil, between 1998 to 2003, and assessed every 2 months until acquisition of independent walking.

Results: Nine percent of the 155 preterms recruited were excluded from the study, leaving a total of 143 patients. The mean gestational age was 30±2 weeks, birth weight was 1,130±222 g, 59% were female and 44% were small for gestational age. Preterms achieved head control in their second month, could sit independent at 7 months and walked at 12.8 months' corrected age, corresponding to the 4th, 9th and 15th months of chronological age. There were significant differences between chronological age and corrected age for all motor abilities. Preterms who were small for their gestational age acquired motor abilities later, but still within expected limits.

Conclusions: Very low birth weight preterms, free from neurosensory disorders, acquired their motor abilities within the ranges expected for their corrected ages. Corrected age should be used until independent walking is achieved.

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Introduction

Among the perinatal factors that determine neurological prognosis, prematurity merits the greatest attention because of its elevated incidence and because it is the most prevalent event among the etiologic factors of cerebral palsy. This justifies taking the precaution of assessing child development in a systematic manner, utilizing validated instruments and putting emphasis on motor development during the first years of life.^{1,2}

It is recommended that corrected ages should be used when evaluating the development of premature infants in order not to underestimate their capacities. Notwithstanding, chronological age should also be taken into consideration because the development of some premature infants can be overestimated using corrected age.^{1,3,4}

Over the last decade, many studies have been conducted into the neuromotor and cognitive development of

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This study was carried out at Universidade Estadual Paulista (UNESP), Botucatu, SP, Brazil.

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premature infants during their first years of life, primarily focusing on predicting developmental risk factors and comparing premature and full term infants and different risk subsets among premature infants. There is a diverse range of study methodology, with variable results when the performance of premature and full term newborn infants are compared, and emphasis is on evaluating the development of premature infants within a risk context aimed at preventing deficiencies and at identifying variables that predict abnormal development.⁵ One feature that has received little attention in development studies is the age at which motor abilities are acquired, especially sitting and walking, which can exhibit great variation among healthy children and may be delayed among premature children.⁶ The objective of this study was therefore to determine the chronological and corrected ages at which preterm infants born weighing less than 1500 g and free from neurosensory sequelae acquire their motor abilities and to evaluate up to what point it is necessary to use age correction.

Methods

This was a longitudinal study of very low birth weight preterm infants recruited at a neonatal intensive care unit and followed by the lead author at the rehabilitation unit of the Hospital das Clínicas, Faculdade de Medicina de Botucatu, Universidade Estadual Paulista (UNESP) in Botucatu, Brazil, between 1998 and 2003. The study was approved by the Research Ethics Committee at the institution, and mothers gave informed consent before their children were enrolled on the study.

The neonatology department basically treats patients on the Brazilian National Health Service (Sistema Único de Saúde) and provides multidisciplinary outpatients follow-up free of charge to all high risk infants until they reach school age. The neonatologists use the Denver II test every follow-up visit to screen infant's development and Bayley II scores are calculated at 12 months of corrected age by the department's psychologist. Children with developmental delays according to the Denver test or the Bayley scales are evaluated by the neuropsychiatrist. The occupational therapist is involved in follow-up and carries out two-monthly evaluations of the children at the rehabilitation unit, advising their carers about the best postures during routine activities to encourage the child's motor development. Where there are motor development delays specific neuromotor interventions are undertaken.

Since the study was designed to determine the normal age ranges for acquisition of motor abilities among very low birth weight preterms, preterms at lower neonatal risk of motor development problems were selected, on the basis of the following inclusion criteria:

- Start of follow-up at less than 4 months of chronological age.

- Gestational age less than or equal to 34 weeks and birth weight less than 1,500 g.
- Born at the UNESP maternity unit.
- 5 minute Apgar score greater than 3.
- Absence of neurological abnormalities during hospitalization, periventricular-intraventricular hemorrhage grades 3-4 and/or periventricular leukomalacia, major congenital malformations, genetic syndromes and congenital infections; not on oxygen at discharge; free from retinopathy of prematurity; and with a normal hearing test result.

The premature infants enrolled were seen every 2 months until they were able to walk, exhibited normal development, on the basis of Denver II and Bayley II results and did not receive any specific neuromotor interventions. In order to avoid examiner bias, all children were evaluated by the same examiner (the occupational therapist) who was aware of the neuromotor development diagnosis, but did not have access to the results of the items assessed on the two scales until the end of the study.

At each consultation the therapist assessed the child's motor performance, focusing on those abilities that should be present at the current child's age, according to the limits for normality used at the department, which are based on data proposed for full term newborns by Bobath, the Brazilian Ministry of Health and Flehmig.⁷⁻⁹ If an appointment was missed, the family was contacted by telephone and asked whether the motor abilities for that age had been achieved and in order to schedule the next consultation.

Data on the age at which each motor ability was acquired were obtained from the mothers and from the occupational therapist's assessment, with preference given to the therapist's findings if the mother's reports were in contrast with the child's performance during the consultation.

The following were exclusion criteria:

- Less than four consultations during the first year of life or dropping out of follow-up before acquisition of walking.
- Failure to attend two consecutive consultations.
- Need for neuromotor intervention or sensory deficiency, convulsions or other intercurrent conditions that could compromise neuromotor development, such as meningitis, fractures and/or surgery with hospitalization of 30 days or more.

Where preterms had a delay in acquisition of a single motor ability and did not present dystonias or any other indication of developmental delay, the guidance on posture during routine activities in order to stimulate development was emphasized to the child's carer. These patients were reevaluated 2 months later and if a neuromotor intervention proved necessary they were excluded from the study.

Study variables: gestational age, taking the best available estimate, in the following order: precise date of last menstruation, obstetric ultrasonography before 20 weeks or New Ballard method¹⁰; anthropometry at birth; appropriateness of birth weight for gestational age, according to the Alexander et al. criteria,¹¹ defining appropriate weights as between the 10th and 90th percentiles for gestational age and small when below the 10th percentile; sex; 5 minute Apgar score; and neonatal morbidity.

Outcomes of interest were the ages at which motor abilities were acquired in relation to the ranges of normality adopted at our institution's rehabilitation unit⁷⁻⁹:

- Controls head = 1-3 months.
- Grips with hands = 4-6 months.
- Rolls over = 4-7 months.
- Supports own weight on feet = 5-6 months.
- Creeps = 6-7 months.
- Sits without support = 7-9 months.
- Crawls on hands and knees = 8-10 months.
- Walks = 12-15 months.

The premature infants were evaluated with respect to both their chronological and corrected ages. Corrected age was calculated as follows:

$$\text{Corrected Age (weeks)} = \text{Chronological Age (weeks)} - [40 - \text{Gestational Age (weeks)}].$$

The ages at which motor abilities were acquired were analyzed according to sex and appropriateness of birth weight for gestational age.

For the descriptive data analysis, continuous variables are presented as means and standard deviations with minimums

and maximums and categorical variables are expressed as frequencies and proportions of events. Differences between means for different groups were tested using Student's *t* test and proportions were compared using the chi-square test. The significance level was set at 5% for all tests.

Results

During the period studied, 155 very low birth weight preterms met the inclusion criteria, but 9% (n = 12) of them were excluded from the study, four because they required neuromotor interventions and eight because of severe conditions that could compromise their development. The remaining 143 premature infants comprised the study sample and the ages at which each of them acquired each of their motor abilities up to independent walking was recorded.

The mean gestational age was 30±2 weeks (variation of 24-34 weeks), mean birth weight was 1,130±222 g (variation of 560-1,490 g), mean length was 37±2.7 cm and mean head circumference was 27±2.0 cm. The majority of the sample (86%) had a 5 minute Apgar greater than 7 and 59% were girls. There was a high percentage of small for gestational age premature infants (44%). Respiratory distress syndrome was the most common neonatal disease, affecting 55% of the sample. The motor ability acquisition ages did not differ according to the infants' sex.

The mean ages for all motor abilities were within the expected ranges according to corrected age and even using chronological age several abilities were present within the range of normality, with head control, creeping and crawling on hands and knees being acquired later (Table 1).

Table 1 - Mean chronological and corrected ages (months) of motor ability acquisition for 143 very low birth weight preterms

Variable*	Chronological age		Corrected age	
	Mean ± SD	Minimum-maximum	Mean ± SD	Minimum-maximum
Controls head	4.7±1.0	3-8	2.4±1.2	0-5
Grips with hands	6.3±1.0	4-10	4.0±1.2	2-8
Rolls over	7.6±1.0	5-12	5.3±1.3	2-11
Supports own weight on feet	7.4±2.3	5-16	5.1±2.3	2-14
Sits without support	9.4±1.5	6-14	7.0±1.6	4-13
Creeps	9.7±1.8	6-17	7.4±1.9	3-15
Crawls on hands and knees	11.4±1.7	8-17	9.0±1.9	5-15
Walks	15.2±1.9	12-24	12.8±1.9	10-22

SD = standard deviation.

* The number of observations was 143 for all variables.

Figure 1 illustrates that the great majority of the premature infants acquired their abilities within the expected range for their corrected ages, with a significant difference in comparison with the chronological ages, according to which a lower percentage acquired all abilities.

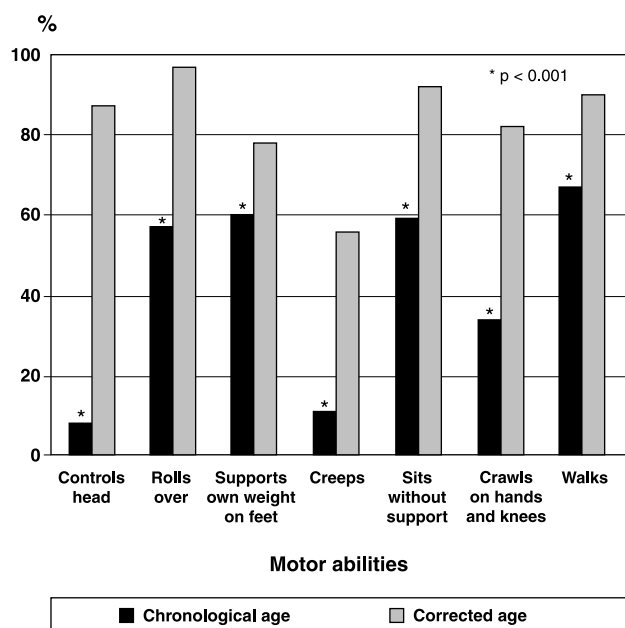


Figure 1 - Percentage of premature infants acquiring motor abilities within expected age range, according to chronological and corrected ages

According to the corrected age, all abilities, with the exception of supporting weight on feet, were acquired later in the group small for gestational age, compared with those appropriate for gestational age. This difference was not detected using the chronological age (Table 2).

Discussion

The neuromotor development of premature infants has been the subject of great interest in the literature and has been investigated using a variety of different standardized assessment instruments. However, infants' performance varies depending on socioeconomic and cultural factors, which can affect the results obtained using instruments validated in different cultures, which emphasizes the need to determine the range of normality for Brazilian children, which is the objective that prompted this study.^{1,2,4,12}

Several different studies have shown the importance of correcting gestational age, have demonstrated that there are many risk factors for abnormal development and have illustrated differences between the performance of premature infants and those born at full term. Restiffe & Gherpelli¹ studied the motor development of premature infants free from neurological sequelae using the Alberta scale and found that scores were higher using corrected age than using chronological age for the first 12 months of life, leading them to recommend that corrected age be used for the first year. There is not, however, consensus on the subject. Some authors correct for the first 6 or 12 months; the majority use corrected ages to the first 2 years; others use partial correction, i.e., take the midpoint between chronological and corrected age; and some authors question whether age correction should be used at all.^{4,13-15} The data from our study show the importance of age correction up to the acquisition of independent walking, since 90% of these premature infants walked within the normal range for their corrected ages, whereas only 67% did so according to their chronological ages. This means that without age correction a high percentage of these premature infants would have had their development underestimated when they achieved independent walking (Figure 1).

This sample of premature infants achieved satisfactory motor development, since even taking their chronological ages several abilities were achieved within the expected

Table 2 - Mean chronological and corrected ages of motor ability acquisition (months) for very low birth weight infants according to appropriateness of birth weight for gestational age

Variable*	Chronological age			Corrected age		
	AGA (n = 80)	SGA (n = 63)	p	AGA (n = 80)	SGA (n = 63)	p
Controls head	4.7±0.9	4.6±1.0	0.372	2.1±1.1	2.7±1.1	0.001
Grips with hands	6.4±1.0	6.1±1.1	0.175	3.7±1.1	4.2±1.1	0.008
Rolls over	7.6±1.1	7.4±1.0	0.349	5.0±1.3	5.6±1.2	0.006
Supports own weight on feet	7.6±2.3	7.2±2.2	0.327	5.0±2.4	5.4±2.2	0.294
Sits without support	9.4±1.4	9.3±1.7	0.667	6.7±1.4	7.4±1.7	0.009
Creeps	9.8±1.9	9.6±1.6	0.559	7.1±2.0	7.7±1.7	0.050
Crawls on hands and knees	11.3±1.6	11.4±1.8	0.682	8.6±1.7	9.5±1.9	0.004
Walks	15.2±1.6	15.4±1.7	0.142	12.2±1.5	13.5±2.0	< 0.001

AGA = appropriate for gestational age; SGA = small for gestational age.

* For all variables, AGA: n = 80 and SGA: n = 63.

age ranges. Allen & Alexander¹⁶ found similar results when they studied 100 premature infants with gestational ages of 32 weeks or less and emphasize the importance of age correction, since according to chronological age motor abilities were achieved 2 to 3 months later.

Age correction had the greatest impact on the results for head control. It is to be expected that very low birth weight preterms who have been kept in incubators for prolonged periods and deprived of social and environmental interaction will take longer to acquire head control.¹⁷

According to corrected ages, these premature infants acquired their motor abilities within the normal age ranges, but there was great variation between minimum and maximum ages, which suggests that for some premature infants age correction overestimates their development, whereas others acquired their motor abilities later, even with age correction. In this study there was an evident delay in acquisition of the ability to creep, however this did not have repercussions for motor development since the majority of the premature infants were able to sit and walk independent within the expected age ranges. This finding may indicate that premature infants have a different neuromotor development profile.¹⁸

One important result of this study is the observation that small for gestational age premature infants had worse performance than appropriate for gestational age infants with significant differences in the corrected acquisition ages for the majority of the motor abilities investigated. Of particular note was the fact that, on average, small for gestational age infants crawled and walked 1 month after appropriate for gestational age premature infants. This demonstrates the deleterious effects of inadequate fetal growth on the developmental prognosis of premature infants, evident with the correction for the degree of prematurity. This is a topic of concern in the literature, although the results published to date have not been uniform.¹⁹⁻²¹

When the Bayley scales were used to assess the mental and motor development of 36 pairs of monozygotic twins, 58% of whom were premature infants, at between 12 and 42 months' corrected ages, no influence from intrauterine growth restriction was detected.²² Notwithstanding, several different studies have shown an association between fetal and postnatal growth and neurocognitive development. A recent study showed that being small for gestational age is an independent risk factor for poor neurodevelopment among premature infants born before 30 weeks, multiplying their chances of developmental delays by a factor of 4.5.²³ When schoolchildren who had been very low birth weight preterms were assessed, it was observed that inadequate intrauterine growth had an effect on cognitive development, but not on motor development.²⁴

This variation between study results is probably because of differences in patient samples, methods and follow-up duration, but, in general, the data warn that small for

gestational age premature infants have poor developmental prognosis, having been exposed to a situation of double risk: a reduced gestation period and intrauterine growth restriction.

Independent walking is the final result of successful gross motor development. In order to achieve this ability a child must have exercised global corporal mobility and must have had experience with kneeling and walking with support.^{25,26} From this perspective, our results are most satisfactory, showing that very low birth weight preterms free from neurosensory sequelae learn to walk within the expected age range, i.e. at 12.8 months' corrected age, whereas studies published by Gabriel et al.⁶ and de Jeng et al.²⁶ describe very low birth weight preterms walking at 13.6 and 14 months, respectively. Nevertheless, premature infants were enrolled on those studies with greater neonatal morbidity and neurosensory sequelae.^{6,26}

This study suffers from the limitations inherent in a descriptive study that did not investigate the perinatal and neonatal factors associated with motor ability acquisition ages and from the limitation of not including a full term control group. Nevertheless, selecting a large and homogenous sample of premature infants at low risk of motor development problems and assessing them repeatedly at short time intervals means that the data obtained can be considered to illustrate the "motor ability acquisition expectancy for very low birth weight preterms". The study has therefore allowed us to answer the main question: what are the corrected and chronological acquisition ages for the principal motor abilities in very low birth weight preterms, in addition to demonstrating the importance of age correction up to acquisition of walking, providing useful information in the daily practice of professionals involved in infants' healthcare.

Pediatricians and the entire healthcare team should be encouraged to accept information provided by mothers and to assess children's motor performance during medical consultations, since doing so provides fundamental data on motor development and makes it possible to put expectations about premature infants' motor performance during the first years of life into perspective.

It can be concluded that very low birth weight preterms free from neurosensory sequelae acquire their motor abilities within the normal ranges for their corrected ages. Corrected age should be used until independent walking is achieved.

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