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Original articles

Association between neuropsychomotor development and biological and environmental risk factors in early childhood children

Associação entre o desenvolvimento neuropsicomotor e fatores de risco biológico e ambientais em crianças na primeira infância

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ABSTRACT

Objective: to verify the association between infant development and biological and environmental risks.

Methods: 30 children between 0-30 months, living in a town in Minas Gerais, Brazil, attending a Health Center, were selected. The inclusion criteria were children who had a history of prematurity and/or, moderate to severe malnutrition and other risk factors. Their development was assessed through the Denver II test and the quality of stimulation in the home environment assessed by the Home Observation for Measurement of the Environment (HOME).

Results: 60% of the environments were considered to be at risk for child development and 43.3% presented inadequate development. The main domain affected was the language. Higher maternal education and bi-parental families showed a relationship with proper child development. Neonatal complications and hospitalization in intensive care units were more common in children who failed the test. The parents' low receptivity and the availability of materials at home were factors associated with the children's worst development performance.

Conclusion: the results show that the high-risk children in this study had a developmental delay, especially in the language area. These delays are associated with low maternal education, single-parent home, parents' responsiveness and neonatal complications.

Keywords: Child Development; Child Language; Infant, Premature; Malnutrition

RESUMO

Objetivo: avaliar a associação entre o desenvolvimento infantil e riscos biológicos e ambientais.

Métodos: foram selecionadas 30 crianças (0 a 30 meses), residentes em uma cidade no Vale do Jequitinhonha, Minas Gerais, Brasil, atendidas pelo Centro Viva Vida de Referência Secundária. Os critérios de inclusão foram: crianças que tinham história clínica de prematuridade e/ou desnutrição moderada à grave e outros fatores neonatais de risco. As crianças foram avaliadas quanto ao desenvolvimento por meio do teste Denver II e a qualidade de estímulo no ambiente domiciliar foi avaliada pelo *Home Observation for Measurement of the Environment* (HOME).

Resultados: das 30 crianças avaliadas, 60% dos ambientes foram considerados de risco para o desenvolvimento infantil e 43,3% apresentou desenvolvimento inadequado. O principal domínio afetado foi o da linguagem. Maior escolaridade materna, constituição familiar biparental apresentaram associação com o adequado desenvolvimento infantil. A presença de intercorrências neonatais e necessidade de internação no centro de terapia intensiva foram mais presentes nas crianças que falharam no teste. A menor receptividade dos pais e disponibilidade de materiais para aprendizagem no domicílio foram fatores associados ao pior desempenho das crianças no Denver II.

Conclusão: as crianças de alto risco do presente estudo apresentaram atraso no desenvolvimento, especialmente no domínio linguagem. Esses atrasos estão associados à baixa escolaridade materna, à relação monoparental, receptividade dos pais e intercorrências neonatais.

Descritores: Desenvolvimento Infantil; Linguagem Infantil; Prematuro; Desnutrição

INTRODUCTION

Child development is a process of continuity and changes in the different domains of human behavior – motor, cognitive/language, and psychosocial – that occurs during childhood[1]. It is a multifaceted process in which intrinsic factors to the child, related to its genetic inheritance, and biological factor interact with external factors, coming from the physical, social, cultural and emotional environment in which the child lives[2].

Biological factors are those related to pre, peri and postnatal events, such as gestational age and/or birth weight, possible physical deficiencies, child's health and nutritional status, both from the point of view of energy support, and of micronutrients[3]. Children who present biological risks are considered to be at high risk and are vulnerable to developmental delays or even atypical development[3].

Prematurity and malnutrition are examples of biological risk factors. They have been related to children's mortality and morbidity and, in some cases, leading to neuropsychomotor developmental delay[4,5]. Preterm birth is defined as the one whose gestation ends between the 20th and 37th weeks or between 140 and 257 days after the first day of the last menstrual period[6]. According to Ramos and Cuman[5] (2009), there are numerous causes leading to a baby to be born prematurely, especially those related to the female genital tract, placental changes (placenta previa and premature detachment) and excess/decrease of amniotic fluid. In addition, there are other factors such as maternal age, maternal infections, and primiparity. However, in most cases, the cause is unknown.

External factors are those related to the environment in which the child lives. The family's socioeconomic status, as well as the parents' level of education play a role in the quality of the home environment, in the possibilities of interaction between parents and children, in the routines established by the family, as well as in the affordance of resources fostering child development available at home[7-9]. The home environment, the first environment experienced by the infant in early life, has been pointed out as the main extrinsic factor that potentializes child development[8].

According to the World Health Organization, inadequate cognitive stimulation, malnutrition, iodine deficiency and iron deficiency anemia are considered the main risk factors for changes in child development (WHO)[10] in developing countries. Such risk factors for child development are predominant in the Jequitinhonha Valley region, which possibly predisposes infants in this locality to greater vulnerability.

In this context, there is in the Jequitinhonha Valley the *"Centro Viva Vida de Referência Secundária (CVVRS)"* (Living Life Center of Secondary Reference). This center is part of the Government of Minas Gerais' *Viva Vida* Program, which is constituted by a team with physicians, nurses, nutritionist, psychologist and social services. They receive high biological risk children, i.e., preterm babies, with low birth weight and/or who had had perinatal asphyxia, as well as those with alterations in the bloodspot test, with moderate or severe malnutrition and/or with respiratory diseases, such as asthma and frequent pneumonia[11].

Therefore, the objective of this study is to assess the neuropsychomotor development of children with biological and environmental risk, attending the CVRRS and living in the city of Diamantina, as well as verify possible association between the family's socio-cultural and environmental characteristics and aspects of children's neuropsychomotor development.

METHODS

This is a cross-sectional study approved by the Research Ethics Committee of the Federal University of the Jequitinhonha and Mucuri Valleys under number 39495414.2.0000.5108.

The study population consisted of all children's records, from 0 to 30 months old, living in Diamantina-MG, attended by the Centro Viva Vida (Living Life Center Secondary Reference), with a clinical history of preterm (gestational age lower than 37 weeks) and/or clinical diagnosis of moderate to severe malnutrition (below the third percentile of the growth curve)[12].

The following was considered as exclusion criteria: lack of telephone number or address for the initial contact with the family; no location of the child's parents/guardians after three home visits; and the absence of the signed Free and Informed Consent Term.

Initially, 76 medical records fitting the inclusion criteria were included. Of these, 46 were excluded and, thus, 30 were the sample of the present study.

A semi-structured form was used to collect sociodemographic data on the child's pre, peri and postnatal data. The *"Inquérito da Associação Brasileira de Empresas de Pesquisa – ABEP"* (Enquiry of the Brazilian Survey Companies Association), based on questions about goods and services to which the family

has access and that allow to classify them in economic levels in a descending scale that goes from A to E[13].

DENVER II, a developmental screening test, was used to evaluate child development. The test consists of 125 items distributed in four areas of development: personal-social (aspects of child socialization inside and outside the family environment); fine motor (eye/hand coordination, manipulation of small objects); language (sound production, ability to recognize, understand and use language); and gross motor (body motor control such as sitting and walking)[14]. During the test, an age line is plotted on the map of assessed items, and, according to the child's performance, the answers are categorized as Pass (P); Fail (F); Refusal (R), and No Opportunity (NO). Thus, *caution* is considered when a child does not perform or refuses to perform an activity that is already performed by 75 to 90% of children of that age. Similarly, it is considered a *delay* when the child does not perform or refuses to perform an activity that is already performed by more than 90% of children of the same age. The test is classified as (A) **normal** when it does not present any item with *delay* and at most one single *caution*; (B) **abnormal** when presenting two or more *delays*; (C) **suspect** when presenting a *delay* and/or two or more *cautions*; and (D) **untestable** according to the child's number of refusals and the inventory[14].

The Home Observation Instrument for Measurement of the Environment (HOME) was used to assess the stimulus quality in the home environment. HOME has six categories: (I) parental responsivity; (Ii) acceptance of the child; (III) organization of the environment; (IV) learning materials; (V) parental involvement; (VI) variety in experience. According to the HOME manual, scores lower than or equal to 27 points, that is, five points below the reference median of the instrument, represent an environment at risk for child development. According to the specifications of the manual[15], it is also possible from the reference medians to establish risk points for each subscale.

It should be emphasized that Denver II and HOME are international standardized instruments and, although their psychometric measures have not yet been officially analyzed in Brazilian children, they are currently used in Brazil by health professionals[7].

Two previously trained examiners, Physiotherapy students, collected the data at the child's home. The evaluations took about 40 minutes each. The parents or guardians who accepted the invitation to participate in the study signed the free and informed consent form.

The children were divided into two normative categories, according to their performance at Denver II. Group I consisted of children with adequate development, that is, they were able to carry out the activities proposed by the items of the test, in which the line age went through it or could not perform, but they were still between 25-75%. Group II consisted of children with *delay*/*caution*, those who could not perform the activities in the items, in which 75-100% of children of the same age can. According to the test pattern, a specific database was created for this study in SPSS 19.0 software.

Frequency distribution of the categorical variables involved in the evaluation was carried out for the purpose of a descriptive analysis. The inferential statistical analysis of the data included the application of the chi-square test, taking as reference values of $p \leq 0.05$.

RESULTS

We evaluated thirty children. 50% were male, 66.7% had a neonatal diagnosis of preterm and low birth weight infants (PTNLBW); 13.3% were preterm newborns (PTN) and 20% were low birth weight newborns (LBWN).

For preterm infants, we considered the corrected age, with the mean at the time of evaluation being 15.6 months (± 8.9 months), with a minimum of 3 and a maximum of 29 months.

As for the gestational history, 13 mothers (44.3%) had some kind of intercurrence during gestation, such as hypertension, diabetes mellitus, preeclampsia, and others.

As for the type of delivery, we found that 53.3% of the children were born by normal birth, of which 6.7% used the forceps.

As for neonatal complications, 20 neonates (66.7%) presented some type of intercurrence; 13 infants required intensive care and were hospitalized in an intensive care unit for an average of 24 days, with a minimum of 1 and a maximum of 96 (average 15 days); 3 remained on mechanical ventilation, and 4 required phototherapy.

As for the children's family, 66.7% lived in two-parent families, that is, with the presence of a father and a mother. One third (33.3%) had a single-parent (only the mother). Mothers had a mean age of 27.3 years (± 7.2), with a minimum of 17 and a maximum of 43 years, and the majority (60%) of them completed high school and/or attended higher education. The mean paternal age was 31.2 years (± 8.7) with a minimum of 19 and a

maximum of 58 years, and only 48.1% had completed high school and/or attended higher education.

As for family economic classification, according to ABEP, 3 families (10%) belonged to class B1; 6 (20%) to class B2; 5 (16.7%) to class C1; 7 (23.3%) to class C2; 7 (23.3%) to class D and 2 (6.7%) to class E.

As for children's neuropsychomotor development, it was observed that 17 children (56.7%) had normal test results and 3 (10%) were untestable. The item of language presented the highest percentage of *caution* and/or *delay* from the domains tested in Denver II, followed by the gross motor (Figure 1).

Figure 2 shows the results of the subscales and total sum of HOME. It is observed that the results found are almost all below the Home's referral medians and that 60% of the family environments were considered to be at risk for child development. When the subscales are analyzed, 80% of the homes are at risk for "parental involvement" and 60% for "learning materials".

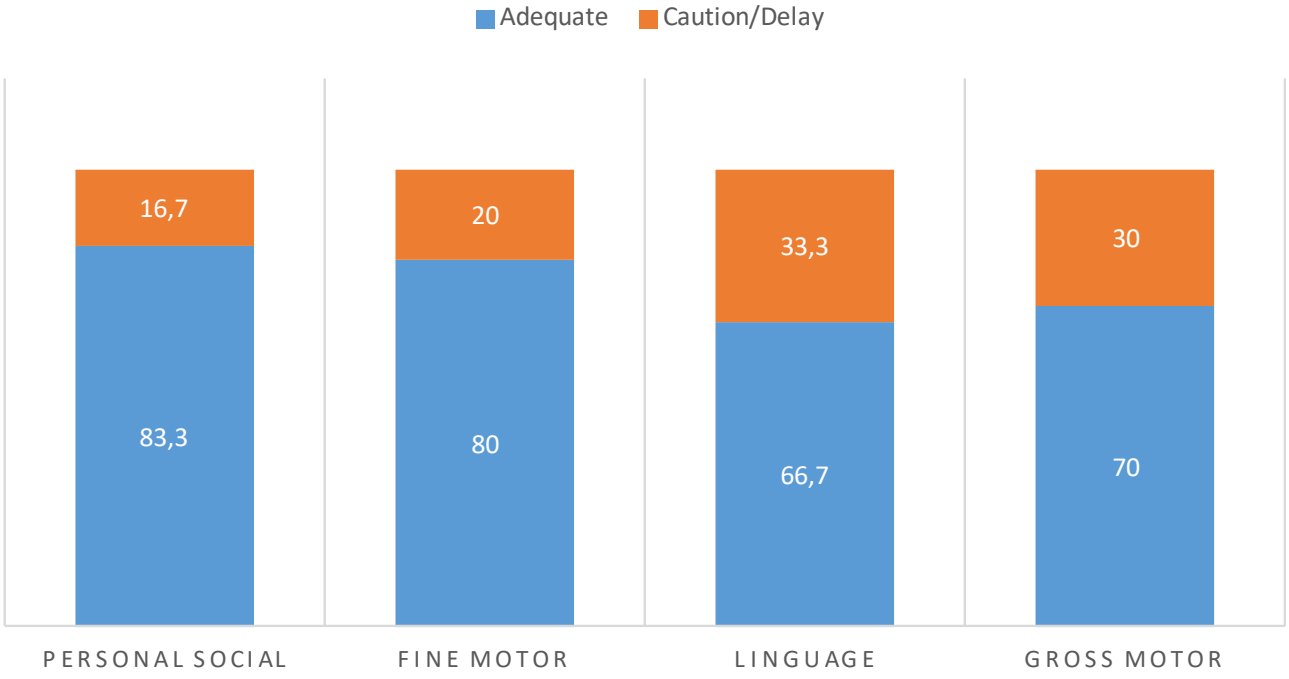

Figure 1. Results of Denver II test per domains

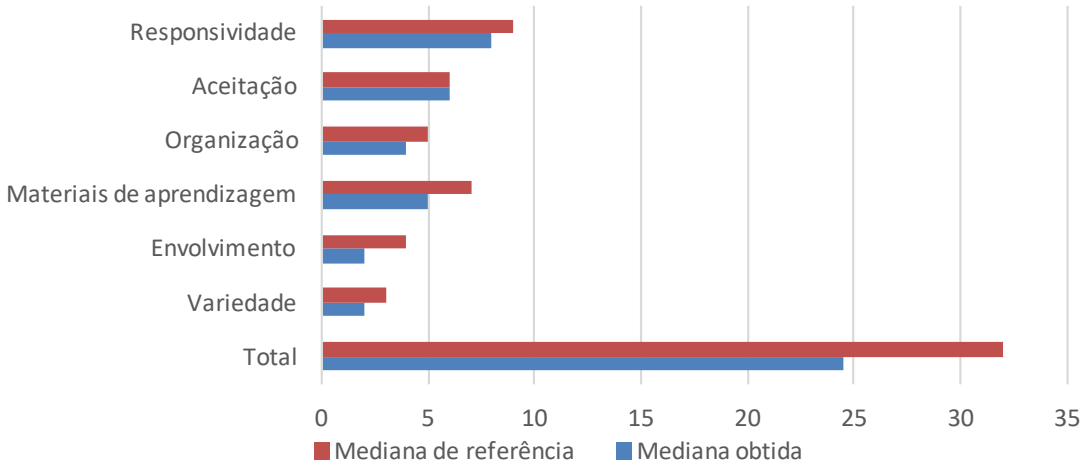

Figure 2. Medians obtained in each subscale compared to HOME reference medians

The association between Denver II outcomes and maternal schooling is shown in Table 1.

There was an association between Denver II results and the types of families (two-parent or single-parent) (Table 2).

Table 1. Association between the domains and the overal result of Denver II test and mother's schooling

		Mother's schooling					
		Up to Elementary Education		Secondary Education and/or Higher Education		X^2 test	p value
		N	%	N	%		
Denver PS	Adequate	9	36	16	64	1.000	0.32
	Delay/caution	3	60	2	40		
Denver MF	Adequate	7	29.2	17	70.8	5.868	0.01*
	Delay/caution	5	83.3	1	16.7		
Denver LGG	Adequate	9	45	11	55	0.625	0.42
	Delay/caution	3	30	7	70		
Denver MG	Adequate	9	42.9	12	57.1	0.238	0.62
	Delay/caution	3	33.3	6	66.7		
Denver Total	Normal	7	41.2	10	58.8	0.023	0.88
	Retest	5	38.5	8	61.5		

PS = Personal social, MF = Fine Motor, LGG = Language, MG = Gross Motor. Chi-square test. *p≤0.05

Table 2. Association between the domains and the overal result of Denver II test and the family type.

		Type of family					
		Two-parent		Single-parent		X^2 test	p value
		N	%	N	%		
Denver PS	Adequate	17	68	8	32	0.120	0.72
	Fail	3	60	2	40		
Denver MF	Adequate	16	66.7	8	33.3	0.000	1.00
	Fail	4	66.7	2	33.3		
Denver LGG	Adequate	16	80	4	20	4.800	0.02*
	Fail	4	40	6	60		
Denver MG	Adequate	15	71.4	6	28.6	0.714	0.39
	Fail	5	55.6	4	44.4		
Denver Total	Normal	14	82.4	3	17.6	4.344	0.03*
	Retest	6	46.2	7	53.8		

PS = Personal social, MF = Fine Motor, LGG = Language, MG = Gross Motor. Chi-square test. *p≤0.05

There was no association between neuropsychomotor development and socioeconomic status, as well as gestational history and maternal age.

As for neonatal complications, one or more intercurrences were considered and these presented statistically significant results when associated with the Denver II test (Table 3). However, being admitted to the intensive care unit was not considered in this analysis. This parameter was analyzed separately and is shown in Table 4.

The association between Denver II and HOME showed statistically significant results in subscales I and IV. They are shown in Tables 5 and 6.

Table 3. Association between the domains and the overal result of Denver II test and the presence of neonatal complications

		Neonatal complications					
		No		Yes		X^2 test	p value
		N	%	N	%		
Denver PS	Adequate	9	36	16	64	0.480	0.48
	Fail	1	20	4	80		
Denver MF	Adequate	8	33.3	16	66.7	0.000	1.00
	Fail	2	33.3	4	66.7		
Denver LGG	Adequate	10	50	10	50	7.500	0.00*
	Fail	0	0	10	100		
Denver MG	Adequate	9	42.9	12	57.1	2.857	0.09
	Fail	1	11.1	8	88.9		
Denver Total	Normal	9	52.9	8	47.1	6.787	0.00*
	Retest	1	7.7	12	92.3		

PS = Personal social, MF = Fine Motor, LGG = Language, MG = Gross Motor. Chi-square test. *p≤0.05

Table 4. Association between the neuropsychomotor development and the admission at the intensive care unit

		Admission at ICU					
		No		Yes		X^2 test	p value
		N	%	N	%		
Denver PS	Adequate	14	56	11	44	0.429	0.51
	Fail	2	40	3	60		
Denver MF	Adequate	12	50	12	50	0.536	0.46
	Fail	4	66.7	2	33.3		
Denver LGG	Adequate	14	70	6	30	3.696	0.01*
	Fail	2	20	8	80		
Denver MG	Adequate	13	61,9	8	38.1	2.066	0.15
	Fail	3	33.3	6	66.7		
Denver Total	Normal	12	70.6	5	29.4	4.693	0.03*
	Retest	4	30.8	9	69.2		

PS = Personal social, MF = Fine Motor, LGG = Language, MG = Gross Motor, ICU=Intensive Care Unit. Chi-square test. *p≤0.05

Table 5. Association between Denver II and HOME Subscale I

Home subscale I – Responsivity							
		Risk		No risk		X^2 test	p value
		N	%	N	%		
Denver PS	Adequate	6	24	19	76	0.545	0.46
	Fail	2	40	3	60		
Denver MF	Adequate	6	25	18	75	0.170	0.68
	Fail	2	33.3	4	66.7		
Denver LGG	Adequate	3	15	17	85	4.176	0.04*
	Fail	5	50	5	50		
Denver MG	Adequate	7	33.3	14	66.7	1.591	0.20
	Fail	1	11.1	8	88.9		
Denver Total	Normal	2	11.8	15	88.2	4.455	0.03*
	Retest	6	46.2	7	53.8		

PS = Personal social, MF = Fine Motor, LGG = Language, MG = Gross Motor. Chi-square test. *p≤0.05

Table 6. Association between Denver II and HOME Subscale IV

HOME Subscale IV – Learning Materials							
		Risk		No risk		X^2 test	p value
		N	%	N	%		
Denver PS	Adequate	14	56	11	44	5.250	0.02*
	Fail	0	0	5	100		
Denver MF	Adequate	11	45.8	13	54.2	0.033	0.85
	Fail	3	50	3	50		
Denver LGG	Adequate	12	60	8	40	4.286	0.03*
	Fail	2	20	8	80		
Denver MG	Adequate	12	57.1	9	42.9	3.087	0.07
	Fail	2	22.2	7	77.8		
Denver Total	Normal	11	64.7	6	35.3	5.129	0.02*
	Retest	3	23.1	10	76.9		

PS = Personal social, MF = Fine Motor, LGG = Language, MG = Gross Motor. Chi-square test. *p≤0.05

DISCUSSION

Neonatal context and environmental factors play an important role in a child neuropsychomotor development. Therefore, this study aimed at verifying if the neonatal intercurrences and socio-demographic factors interfere in the typical development of children who were born with some type of risk. The study results show that the development domain most associated with risk factors was the linguistic. This corroborates with findings from the literature, in which preterm or low birth weight children are at greater risk for delays in language development[16,17].

It is observed that the language domain was the item with the highest percentage of *cautions*/*delays* in this study evaluated by Denver II. Volpiano et al. (2014) assessed the neuropsychomotor development in preterm and low birth weight children using the Bayley III scale and also found statistically significant changes in language (29.3%)[18]. Therefore, children born with low birth weight, preterm or another perinatal risk factor may present adequate motor development and yet present a delay in language development[19-21]. Thus, since we found a great change in the language domain, we came up with some hypotheses, such as parental schooling, socioeconomic level, biparental relationship, neonatal intercurrences, as well as the environment in which these children are inserted.

The first hypothesis is related to the socioeconomic level, given that children who belong to economically disadvantaged families have less access to health services, nutrition, education and culture[7]. Although studies indicate that the family' socioeconomic level

may interfere in children development, we did not observe significant associations between these two variables in this study. Thus, it is suggested that other factors have negatively interfered in language development, as will be discussed below.

Maternal schooling significantly interferes with children's neuropsychomotor development, so the higher the schooling, the greater the protection factor for development[20,22]. In this context, we noticed that the mother's lower level of education was associated with impaired neuropsychomotor development only in the domain of fine adaptive motor skills. One study reported that a high maternal schooling is related to the children's fine motor performance[23]. Thus, we suggested that greater access to information is related to greater availability of toys and, consequently, to a better stimulation of fine motor skills. Previous studies indicate that preterm children present significantly worse performance in writing, in sensory-motor tasks, manipulative tasks, visuomotor integration, visuo-perceptive tasks and sensorial awareness when compared to children born at term[24].

The single-parent family was associated, in this study, with the child's worst development, especially with regard to language. The literature is emphatic in affirming the importance of maternal and paternal presence as predictors of typical childhood development[25]. In this context, we observed that children whose mothers live with a partner in the family environment have greater stimulation and have a better language development[20,26]. As far as language is concerned, the dialogical model experienced by the children in their routine gives them more interactive stimuli[22]. In this sense, it is possible to emphasize the importance of family structure, especially for at-risk children.

Moreover, neonatal complications or the need for hospitalization at the intensive care unit were also more likely to atypical development, especially in the language domain. These results are supported by previous findings, which reported that children who underwent oxygen therapy presented central nervous system impairment[27]. This impairment may be explained by the intensification of free radical production by oxygen therapy, which can cause diffuse hypomielinization, which is associated with chronic neurological damage, promoting a possible developmental delay[28].

Besides these factors mentioned as determinants for the delay in child development in our study, we believe that the home environment quality was also relevant. More than half of the home environments were considered to be at risk for child development. This was mainly due to the items "supply of learning material" and "parent involvement". Our results are in agreement with other Brazilian studies that used the HOME test in the context of economically disadvantaged families[7].

Thus, when associating the HOME subscales with the language domain in Denver II, we observed a statistical significance in subscale I, which addresses the parents' responsivity with the child. The results indicate that those parents who were more communicative had children with lower risk of language delay, according to the Denver II evaluation, suggesting that the mother-child dyad plays an important role in adequate development.

The subscale IV of HOME, "learning material", had a statistically significant relationship, but inverse to Denver II. That is, children who had language delay in the Personal Social domain and who had an *abnormal* or *suspect* result in the Denver II test had the right toys according to HOME. However, the analysis suggests that the fact of possessing toys does not predict the typical neuropsychomotor development in these children. When studying the relationships between environment, socioeconomic level and motor development in children, the authors found that the socioeconomic level and home affordances explain a very low percentage of children's motor performance, suggesting that these children's toys may not be the most adequate[29].

As limitations of this study, we can mention that Denver II is a screening test and does not have a diagnostic function, but rather indicates the need for a deeper investigation[30]. Also, Denver II and HOME need studies that target their adaptations and validations in the Brazilian versions. However, given the scarcity of validated Brazilian instruments in the child development area, Denver II and HOME are instruments that have been widely used in other researches because they are fast and relatively easy to apply and provide guidance on child development [7,9,31].

CONCLUSION

Adequate neuropsychomotor development depends on intrinsic and extrinsic factors related to the child. The findings indicate that high-risk children are more likely to present a delay in neuropsychomotor development, especially in the language domain. These delays are directly related to low maternal schooling, single-parent relationship and neonatal intercurrences. In addition,

the environment in which the child lives, especially regarding the parents' responsivity is directly related to the typical development.

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