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Systematic Review
Revisão Sistemática

Effects of prematurity on language acquisition and auditory maturation: a systematic review

Efeitos da prematuridade na aquisição da linguagem e na maturação auditiva: revisão sistemática

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Keywords

Language
Hearing
Prematurity
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ABSTRACT

Purpose: To verify which damages prematurity causes to hearing and language. **Research strategies:** We used the decriptors language/*linguagem*, hearing/*audição*, prematurity/*prematuridade* in databases LILACS, MEDLINE, Cochrane Library and Scielo. **Selection criteria:** randomized controlled trials, non-randomized intervention studies and descriptive studies (cross-sectional, cohort, case-control projects). **Data analysis:** The articles were assessed independently by two authors according to the selection criteria. Twenty-six studies were selected, of which seven were published in Brazil and 19 in international literature. **Results:** Nineteen studies comparing full-term and preterm infants. Two of the studies made comparisons between premature infants small for gestational age and appropriate for gestational age. In four studies, the sample consisted of children with extreme prematurity, while other studies have been conducted in children with severe and moderate prematurity. To assess hearing, these studies used otoacoustic emissions, brainstem evoked potentials, tympanometry, auditory steady-state response and visual reinforcement audiometry. For language assessment, most of the articles used the Bayley Scale of Infant and Toddler Development. Most studies reviewed observed that prematurity is directly or indirectly related to the acquisition of auditory and language abilities early in life. **Conclusion:** Thus, it could be seen that prematurity, as well as aspects related to it (gestational age, low weight at birth and complications at birth), affect maturation of the central auditory pathway and may cause negative effects on language acquisition.

Descritores

Linguagem
Audição
Prematuridade
Desenvolvimento Infantil
Saúde da Criança

RESUMO

Objetivo: Verificar quais os prejuízos a prematuridade causa à linguagem e à audição. **Estratégia de pesquisa:** Utilizou-se os descritores *language/*linguagem, *hearing*/audição, *prematurity/*prematuridade nas bases de dados LILACS, MEDLINE, Biblioteca Cochrane e Scielo. **Critérios de seleção:** Ensaios randomizados controlados, estudos de intervenção não randomizados e estudos descritivos (transversais, de coorte, projetos de caso-controle). **Análise dos dados:** Os artigos foram avaliados independentemente por dois autores, conforme os critérios de seleção. Foram selecionados 26 estudos, sete publicados no Brasil e 19 na literatura internacional. **Resultados:** Dezenove estudos fizeram comparação entre nascidos a termo e prematuros. Dois dos estudos fizeram comparações entre prematuros pequenos para idade gestacional e adequados para idade gestacional. Em quatro estudos a amostra era composta de crianças com prematuridade extrema, os demais trabalhos foram realizados em crianças com prematuridade acentuada e moderada. Nestes estudos, foram utilizados, para análise da audição, as Emissões Otoacústicas, o Potencial Evocado de Tronco Encefálico, a timpanometria, o Potencial Evocado Auditivo de Estado Estável e audiometria de reforço visual. Para avaliação de linguagem, a maioria dos artigos utilizou a Escala Bayley de Desenvolvimento Infantil. Observou-se na maioria dos estudos revisados a prematuridade relacionando-se direta ou indiretamente à aquisição de habilidades auditivas e de linguagem nos primeiros anos de vida. **Conclusão:** Dessa forma, pôde-se constatar que a prematuridade bem como os aspectos relacionados a ela (idade gestacional, baixo peso e intercorrências ao nascer) influenciam a maturação da via auditiva central podendo causar efeitos negativos na aquisição da linguagem.

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INTRODUCTION

In order to discuss the effects of premature birth in language acquisition and auditory maturation, it is important to bear in mind that full-term birth is defined as occurring within 37 and 42 weeks of gestational age, whereas preterm birth is considered before 37 weeks(1). It is also worth noting that the gestational age at birth establishes if prematurity is moderate (32 to 36 weeks of gestational age), severe (28 to 31 weeks) or extreme (less than 28 weeks). This factor, as well as weight at birth (low weight <2,500 grams; very low weight <1,500 grams and moderate low weight between 1,500 and 2,499 grams)(2), determines the basic biological conditions. These, in addition to perinatal and environmental conditions, can shape the development of infants.

It is known that, as medicine advances, survival of infants born with low weight (500-600 grams) increases, as does the responsibility of healthcare professionals in monitoring the clinical evolution of these infants(2,3). This increase in survival rates of ever smaller and premature infants compels questioning as to the quality of their future life as well as a growing interest in predicting their long-term global development(4,5). It is worth noting that in order to carry out these analyses in premature infants it is recommended that, for the first two years of life, the corrected age - also known as adjusted age - be considered as well(6). Corrected age translates the adjustment of chronological age according to the degree of prematurity, and is assessed by means of the Capurro or *New Ballard* method(7).

Due to this interest, several authors have identified abnormal neurological signs during these infants' first year of age, although the studies encounter difficulties in predicting if these signs are definitive or temporary(4-8). It is observed that premature infants are at greater risk of development deficits than full-term infants, as the chances of premature infants presenting disabilities in cognitive and attention development and self-regulation are higher. These issues tend to continue throughout childhood, having been associated with learning and attention disabilities and behavioral problems(3-8).

Thus, we highlight the importance of studying the development of preterm infants within a context guided by association with different risk factors, which involve variables such as the birth and the outcomes of the infant's clinical conditions during hospitalization(1).

It is known that certain neonatal complications may cause hearing impairment and are characterized as risk indicators for this condition - namely stay in neonatal ICU for 48 hours or more, weight at birth lower than 1,500 gr and/or small for gestational age (SGA); this category also includes infants large for gestational age (LGA) and appropriate for gestational age (AGA); hyperbilirubinemia/ exsanguinotransfusion; ototoxics and prolongued mechanical ventilation(9). Due to these factors, it is key to monitor these infants judiciously so as to monitor the development of their hearing and identify any types of hearing loss in time to harness the ideal period for language acquisition (first three years of life) and prevent effects of hearing on language development, as suggested by studies that found receptive and expressive linguistic deficits in these infants(10). Among deficits observed are smaller vocabulary, delay in language acquisition, less complex language, difficulties in phonological processing and short-term memory(11).

Therefore, understanding that prematurity is a biological risk factor for infants' global development, which may be particularly harmful to the auditory pathway and language, this paper aims to verify which harms prematurity causes to language and hearing.

METHODS

A systematic review is carried out by phrasing specif questions that guide the search for publications. Thus, this study's investigative question was: "Which harms does prematurity cause to language and hearing?"

Study selection criteria

In order to select and assess the scientific studies found by the electronic search, criteria which contemplated the following aspects were determined: types of studies, participants, intervention, assessment of outcomes. The papers identified by the initial search strategy were independently assessed by two judges according to the following inclusion criteria: language, prematurity and hearing in premature infants, statistical analysis with level of significance and tests used. In addition, a third judge compared the two searches and selected the common papers. From these criteria, it is expected that all papers significant and relevant to the conclusion of this study are identified and included.

Types of studies

Studies published in the last 5 years were selected for analysis, i.e. studies in English, Spanish or Portuguese published between 2011 and 2015. As to the level of scientific evidence, the criteria shown in Table 1 were used(12). Studies with evidence levels 2, 3 and 4 were included in this research.

Participants

Research studies carried out with premature infants were included in this review.

Intervention

Studies selected were required to contain language and/or hearing assessments.

Assessment of results

Studies were selected upon existence of statistical tests, as well as verification of results that answered the question proposed: "Which harms does prematurity cause to language and hearing?"

Localization of the studies

Descriptors

The descriptors were collected by means of the trilingual structured vocabulary - Descritores em Ciências da Saúde (*Decs*) - created by Bireme for use in indexation of scientific journal articles, books, congress annals, technical reports and other materials, as well as for search and retrieval of scientific literature topics in the databases.

This research used descriptors both in English and Portuguese languages, namely: language*/linguagem*, hearing/*audição*, prematurity*/ prematuridade*.

Search strategy

A specific search strategy was established and employed descriptors in groups of at least two keywords: Hearing AND prematurity/*audição AND prematuridade*, language AND prematurity/*linguagem AND prematuridade*, language AND prematurity AND hearing/*linguagem AND prematuridade AND audição*. Additional terms were not used.

Sources of studies

For the bibliographic search for articles to be potentially included in this systematic review, the following sources of research were referred to: LILACS, MEDLINE, Biblioteca Cochrane and Scielo. These bases were accessed by means of Biblioteca Virtual em Saúde (BVS) and Pubmed. The last search for data was carried out in July 2015.

RESULTS

The search resulted in 288 references (sum of the searches carried out by the two judges) Of these 288 references, 142 were found by the two judges. One of the judges found 20 references more, adding up to 162 references found in the search. The results per database are highlighted in Table 2.

Systematic Reviews/Meta-analyses, Case Studies and Expert Opinions were excluded from the final sample. Papers that didn't contemplate all of the inclusion criteria were also excluded.

The third judge analyzed all references found by the two judges who carried out the searches and compared their findings. Figure 1 shows the number of papers excluded for not presenting the inclusion criteria required and the number of papers used in the final sample.

The papers found by both judges and which were deemed relevant to the topic by the third judge are described in Table 3.

Firstly, the main characteristics of the studies will be presented, followed by their main results.

Main characteristics of the studies

Participants

Of the studies selected, seven were published in Brazil and 19 were published in international literature. The sample size of the studies varied from 34 to 34,010 neonates, amongst them preterm and full-term infants. Of the 26 studies selected, 20 compared groups of preterm infants to groups of full-term infants. Two studies compared premature infants small for gestational age (SGA) to appropriate for gestational age (AGA). In four studies, the sample was composed of children with extreme prematurity; one study carried out an analysis between genders with extreme prematurity; one study assessed late premature infants and the other works were carried out in children with moderate and severe prematurity degrees.

Procedures and instruments used in the study

Language and/or hearing assessments in premature and full-term infants were used in the studies reviewed. Four studies used Otoacoustic Emissions (OAE) for hearing tests; four studies used Brainstem Evoked Potential (BEP); and two papers also

Table 1. Assessment of Level of Evidence[12]

1	Systematic Reviews and Meta-analysis of clinical studies of controlled randomized tests
2	Controlled randomized tests
3	Non-randomized intervention studies
4	Descriptive studies (cross-sectional studies, cohort studies, case-control projects)
5	Case studies
6	Expert Opinions

Table 2. Databases search results

Descriptors	Database				TOTAL
	LILACS	IBECS	MEDLINE	PUBMED	
Hearing AND prematurity/*audição AND prematuridade*	12	2	32	3	49
language AND prematurity/*linguagem AND prematuridade*	11	1	78	92	182
language AND prematurity AND hearing/*linguagem AND prematuridade AND audição*	18	3	12	24	57
Excluded	18	5	61	42	126

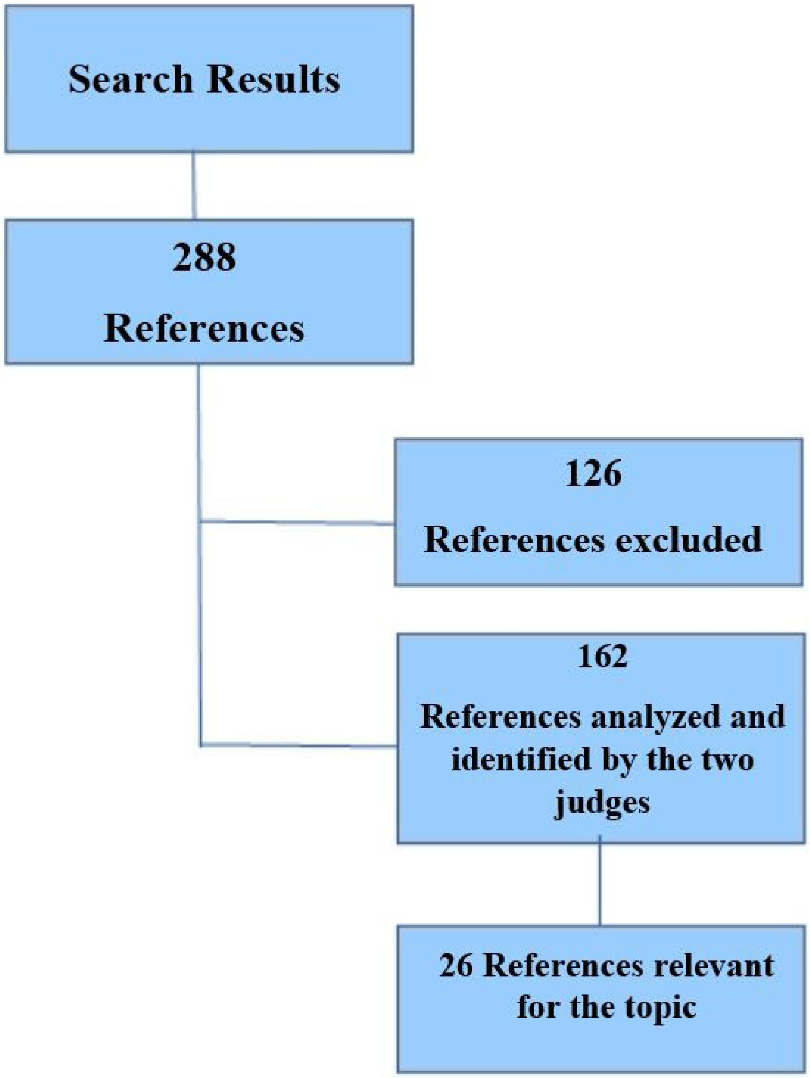

Figure 1. Flowchart of articled found, excluded and relevant for the topic

used tympanometry for testing. Only one of the studies tested Auditory Steady-State Response (ASSR). Another study used Visual Reinforcement Audiometry.

In order to assess language, most studies used the Bayley Scales of Infant and Toddler Development[13-38]. The studies selected were divided into works that aimed to assess the effects and risks of the association of abnormalities and other aspects of development with prematurity. In these, assessments of language and hearing were part of the procedures to carry out such studies in a complementary basis[13-27]. On the other hand, other studies found focused mainly on language and/or hearing impairments in premature infants[28-38].

Main results

The following categories were created in order to lay out the results: studies that associate prematurity with other clinical states and their effects on child development, among them hearing and language; and studies focusing mainly on language and/or hearing impairments associated with prematurity.

The studies containing language and/or hearing assessments as secondary analysis are listed below:

One study observed that premature infants born from mothers with clinical chorioamnionitis scored below average in language development on the Bayley Scales of Infant and Toddler Development at 18 months, designating the association of clinical chorioamnionitis with delayed neurodevelopment in premature infants, particularly in terms of language. When infants who suffered from retinopathy of prematurity were observed, one study found that premature infants with retinopathy at different levels had no association between hearing and speech scores at 3 years old on the Griffiths Mental Development Scales, but male infants with lower gestational age and low birth weight showed lower language performance[23]. Additionally, another study[20] did not find association between language scores on the

Table 3. Articles selected according to inclusion criteria

Title of Paper	Year	Authors	Sample	Control group	Assessments Performed	Statistical Test	Level of Significance
ADHD and learning disabilities in former late preterm infants: a population-based birth cohort.	2013	Harris et al.[21]	256 Preterm between 34/37 weeks of GA	4,419 full-term from 37 to 42 weeks of GA	Kaplan-Meier	X2 and Wilxocon Test	Level of Significance of 0.05
Análise das Emissões otoacústicas transientes em recém-nascidos a termo e pré-termo	2014	Cavalcante and Isaac[37]	25 preterm	41 full-term	Transient Otoacustic Emissions	Anova	Confidence level of 95%
Anterior cingulate and frontal lobe white matter spectroscopy in early childhood of former very LBW premature infants.	2011	Phillips et al. [13]	28 preterm	15 full-term	Bayley-III Scales of Infant and Toddler Development	Mann-whitney e Wilcoxon	Level of Significance of 0.05
Attention problems and language development in preterm low-birth-weight children: cross-lagged relations from 18 to 36 months.	2011	Ribeiro et al.[14]	1,288 preterm	37,010 full-term	Child Behavior Checklist (CBCL), Ages and Stages Questionnaires (ASQ)	SPSS (Statistical Package for the Social Sciences) – covariância	Level of Significance of 0.05
Auditory evoked potentials in premature and full-term infants.	2011	Porto et al.[31]	17 preterm	19 full-term	Auditory Brainstem Evoked Potential and Auditory Steady-State Evoked Potential	Mann-whitney e Wilcoxon	Level of Significance of 0.05
Caracterização eletrofisiológica da audição em prematuros pequenos para idade gestacional	2013	Angrisani et al.[35]	35 preterm SGA	37 full-term AGA	Transient Otoacustic Emissions, Tympanometry and Auditory Brainstem Evoked Potential	Chi-square (Fischer's exact)	Level of Significance of 0.05
Comparação do desenvolvimento da linguagem de crianças nascidas a termo e pré-termo com indicadores de risco para surdez	2011	Lima et al.[30]	44 children /ICU from birth, with some risk indicators for hearing impairments (IRDA)	Full-term and premature	Early Language Milestone - ELM; Hearing tests	The SAS system was used Fischer's Exact Test	Level of Significance of 0.05
Comparison of non verbal learning difficulties in preschoolers born preterm with the term born peers.	2014	Patil and Metgud D[25]	100 moderate preterm neonates - 32 to 36 weeks	100 full-term	First STEP Screening Test for Evaluating Preschoolers	Chi-square (Fischer's exact)	Level of Significance of 0.05
Developmental outcome in preterm infants <29 weeks gestation with < Stage 3 retinopathy of prematurity (ROP): relationship to severity of ROP.	2012	Todd et al.[23]	68 premature neonates with GA below 29 weeks	No	Griffiths Mental Development Scale	ANOVA with Tukey's post-hoc test, Chi-Square, Fisher's Exact Test and Mann–Whitney U-test or Kruskal–Wallis test	Level of Significance of 0.05
Does maternal depression predict developmental outcome in 18 month old infants?	2012	Piteo et al.[16]	48 preterm	312 full-term	Bayley-III Scales of Infant and Toddler Development	Chi-square (Fischer's exact)	Confidence Interval 95%
Earlier speech exposure does not accelerate speech inquisicion.	2012	Peña et al.[33]	56 preterm	92 full-term	Mismatch Response	Anova	Level of Significance of 0.05

Legend: LBW = Low Birth Weight; IQ = Intelligence Quotient

Table 3. Continued...

Title of Paper	Year	Authors	Sample	Control group	Assessments Performed	Statistical Test	Level of Significance
Effect of clinical and histological chorioamnionitis on the outcome of preterm infants	2013	Nasef et al.[18]	274 neonates with less than 30 week of GA in ICU	Clinical chorioamnionitis, histological chorioamnionitis, without chorioamnionitis	Bayley-III Scales of Infant and Toddler Development	Turkey's Test, Chi-Square; Fischer's Exact; OR	Confidence Interval 95%
Effect of primary language on developmental testing in children born extremely preterm	2013	Lowe et al.[17]	850 preterm with less than 28 of GA (98 mother tongue Spanish and 752 mother tongue English)	No	Bailey III E Brief Infant Toddler Social Emotional Assessment (BITSEA)	Chi-square (Fischer's exact)	Level of Significance of 0.05
Estudo maturacional da via auditiva em prematuros nascidos pequenos para a idade gestacional	2014	Angrisani et al.[34]	35 preterm SGA	41 full-term AGA	Transient Otoacustic Emissions, Tympanometry and Auditory Brainstem Evoked Potential	Turkey's Test	Level of Significance of 5%
Evaluation of optic nerve development in preterm and term infants using handheld spectral-domain optical coherence tomography.	2014	Tong et al.[20]	90 premature infants (< 30 weeks of GA)	60 full-term (>36 weeks GA)	Bayley-II Scales of Infant and Toddler Development	Wilcoxon; Kruskal-Wallis and Tukey's	Level of Significance of 5%
Executive function skills are associated with reading and parent-rated child function in children born prematurely.	2012	Loe et al.[22]	72 preterm <36 weeks and <2,500g	42 full-term >37 weeks and >2,500g	Cambridge Neuropsychological Test Automated Battery (CANTAB), QI, The Woodcock–Johnson III Tests of Achievement (WJ-III), Child Behavior Checklist for ages 6–18 (CBCL)	Chi-square (Fischer's exact)	Level of Significance of 0.05
Extremely preterm birth affects boys more and socio-economic and neonatal variables pose sex-specific risks	2015	Mansson et al.[38]	217 extremely premature children, male, and 181 female	No	Bayley Scales of Infant and Toddler Development, third edition (Bayley-III)	Student's *t* Test	Level of Significance of 5%
Follow-up study of 2 year olds born at very low gestational age in Estonia.	2013	Toome et al.[19]	155 premature infants- (GA< 32 weeks	yes/full-term	Bayley-III Scales of Infant and Toddler Development	Mann-whitney U-Test, Fisher's Exact and OR (odd ratio)	Level of Significance of 5%
Impact of gestational age on neonatal hearing screening in vaginally-born late-preterm and early-term infants.	2013	Smolkin et al.[36]	1,572 born with more than 35 weeks of GA	full-term from 38 to 40 weeks of GA	EOAT, PEATE-A	Mann-whitney U-Test and x2	Confidence Interval 95%
Impaired language abilities and white matter abnormalities in children born very preterm and/or very low birth weight.	2013	Reidy et al.[26]	198 premature infants with less than 30 weeks of GA	70 full-term	Clinical Evaluation of Language Fundamentals (CELF-4)	Mann-whitney U-Test, Fisher's Exact	Level of Significance of 5%

Legend: LBW = Low Birth Weight; IQ = Intelligence Quotient

Table 3. Continued...

Title of Paper	Year	Authors	Sample	Control group	Assessments Performed	Statistical Test	Level of Significance
Indicadores cognitivos, linguísticos, comportamentais e acadêmicos de pré-escolares nascidos pré-termo e a termo	2011	Oliveira, et al.[32]	17 low-weight (<2,500g) premature infants (<37 weeks of GA)	17 full-term (>37 weeks) and weight >2,500g	Basic Repertoire for Literacy Assessment Tool (IAR); Behavioral: Child Behavior Checklist (CBCL); Linguistic: Peabody Picture Vocabulary Test (PPVT), Expressive Picture Vocabulary Test (EPVT); Cognitive: Columbia Mental Maturity Scale, Children's Analogical Thinking Modifiability-CATM	Student's *t* Test	Level of Significance of 0.05
Neonatal white matter abnormalities an important predictor of neurocognitive outcome for very preterm children.	2012	Woodward et al.[24]	104 extremely premature infants with less than 32 weeks of GA	107 full-term	Clinical Evaluation of Language Fundamentals (CELF-P)	Odds Ratio	Level of Significance of 5%
Neurodevelopmental outcomes following late and moderate prematurity: a population-based cohort study.	2015	Johnson et al.[27]	1,130 preterm (moderate and late)	1,255 full-term	SES-Index scores, Parent Report of Children's Abilities-Revised (PARCA-R), Scores for non-verbal cognition (NVC)	*X^2 Test* Poisson Regression (Logistic Regression)	Confidence of 95%
Preverbal skills as mediators for language outcome in preterm and full term children	2011	De Schuymer et al.[28]	25 preterm	35 full-term	Reynell Developmental Language Scales, Early Social Communication Scales.	MANOVA, Pearson	Level of Significance of 0.05
Psychomotor development of preterm infants aged 6 to 12 months.	2012	Eickmann et al.[15]	45 preterm	90 full-term	Bayley-III Scales of Infant and Toddler Development	Student's *t* test or Analysis of Variance (ANOVA)	Level of Significance of 5%
Specific language and reading skills in school-aged children and adolescents are associated with prematurity after controlling for IQ	2011	Lee et al.[29]	65 preterm	35 full-term	Wechsler Abbreviated Scale of Intelligence (WASI), Comprehensive Evaluation of Language Fundamentals–Fourth Edition (CELF-4), Peabody Picture Vocabulary Test–Third Edition (PPVT-III), Test for Recep- tion of Grammar–Version Two (TROG-2), Woodcock-Johnson III Tests of Achievement (WJ-III)	MANCOVA, ANOVA, Chi-square	Confidence Interval 95%

Legend: LBW = Low Birth Weight; IQ = Intelligence Quotient

Bayley Scales at 18 and 22 months old with other conditions related to the optical nerve.

Three studies[13,24,26] investigated the association between language scores and white matter abnormalities in the neonatal period. The low weight at birth variable was found to be associated with white matter abnormalities in the abnormal language endpoint in assessments carried out between 18 and 22 months[13], four[24], and six years[24,26] of age, indicating delayed language as a possible outcome.

Another variable that seems to influence language is gender, since premature girls have scored higher in cognitive, language and fine motor skills tests than boys[38], although both genders have presented similar performance when submitted to environmental, socio-economic and multilingualism assessments[17]. Only infants having Spanish as mother tongue presented lower scores when assessed by the Bayley in English, in cases where the latter was their second language[17].

Psychosocial aspects such as maternal mood, particularly maternal depression during the first six months after birth, were not associated with language abnormalities at 18 months according to the Bayley Scales[16].

In assessing performing functions and their relation to language, several studies indicated a positive correlation between attention abnormalities and other performing functions and poorer language performance[22,27], having also related it to lower gestational age[27] and poorer nonverbal learning[27]. Premature children presented poorer performing functions[22], although they are not different from full-term infants in terms of attention-deficit and hyperactivity disorder[21]. One study[14], however, indicates that attention at 18 months predicts language abnormalities at 36 months, ratifying attention span as a precursor of language, although attention is not positively associated with the mother's educational level, as is language in general. Furthermore, in this study[14], gender and corrected age emerged as predictors of language at 18 months.

The studies presented below are mainly focused on investigating the potential relationship between prematurity and hearing and/or language.

One of the studies selected[30] compared development of language at 12 and 24 months of age in full- and preterm children by means of a longitudinal study. Forty-four children who stayed in Neonatal Intensive Care Unit for over 48 hours were monitored until 24 months of age. In the case of those who presented language abnormality according to the Scale of Early Language Acquisition, parents were guided as to how to stimulate language development based on the items provided in the scale itself. The temporary disorders found in this group at 12 months of age were normalized at 24 months, which demonstrates the importance and need to advise parents to intervene appropriately, thus preventing the disorders from continuing throughout infancy. Another study[28] also highlighted the risk of a less favorable pre-verbal development in premature children, confirming that the conditions at birth partially affect development of language by means of pre-verbal skills, which is significant for clinical practice.

Other studies[15-29-32] indicate the need to monitor premature children independently or not of other variables such as gender, socio-economic status, and low weight. They observed that premature infants presented a lower than average index of language related to expressive communication. Thus, it is important to investigate and understand the development of children with risk factors

Two studies[34,35] assessed premature infants small for gestational age with regard to hearing. In one of the studies, the authors[34] monitored maturation of the auditory pathway in premature neonates small for gestational age (SGA) by analyzing absolute and interpeak latencies of the auditory brainstem evoked potential (ABEP) in the first six months of age compared to infants appropriate for gestational age (AGA). The results of both studies[34,35] evinced a symmetry between the ears in both groups, SGA and AGA, observing that they behave similarly with regard to hearing. It was also observed that preterm nurslings appropriate and small for gestational age present accelerated maturation, particularly during the first three months of age, thus characterizing a catch-up period with regard to hearing. Thus, it is noted that the influence of prematurity in the maturation process of the central auditory nervous system is greater than the influence of the weight at birth factor.

In a study that evaluated the effect of gestational age in the baby hearing test carried out with Otoacoustic Emissions (OAE), the authors[36] compared late preterm infants to full-term infants and found it was two times more necessary to repeat listening tests in the first group, because these children presented higher failure rates in the first EOA performed up to 42 hours after birth. As there was no significance in failure rates after 42 hours in both groups, they concluded that the results in late preterm infants are related to late maturation of the auditory system after birth, in agreement with one of the studies selected[34], in which it was verified that maturation of the auditory system has a greater influence than factors such as weight at birth. Another article[33] also points to the importance of maturation, since it has been found that, although preterm infants can benefit from earlier exposure to the language environment that favors speech transmission, such exposure has no effect on language acquisition in isolation. They understood that language acquisition in the first year of life also depends on the maturation of the Central Nervous System and not only on exposure to speech, since the formation of phonological representations by the environment is strongly conditioned by the brain and factors related to maturation, i.e. language is not favored only by the time of exposure to language, but by the maturational conditions of the child.

One of the papers[31] sought to investigate the clinical applicability, in premature and full-term infants, of auditory brainstem evoked potential with tone burst stimulus (ABEP TB) and auditory steady-state response (ASSR) at 2 kHz, and another one[37] examined the auditory pathway through transient evoked otoacoustic emissions (EOAE-T). Significant differences were observed in the duration of ASSR and at 3 kHz and 4 kHz frequency bands in the EOAE-T. The research using the ABEP

(Tone Burst stimulus) and ASSR was carried out at the post-conception age of 47 weeks. The maturation occurred between the 35th and 47th week was probably responsible for the similar behavior observed in full- and preterm infants. The EOAE-T test is indicated as an important instrument to assess peripheral auditory system in full- and preterm neonates, as it allows visualization of responses regardless of gender and gestational age.

DISCUSSION

The majority of papers selected for this systematic review point to the effects of prematurity on language acquisition, whether these effects are comorbidities of other clinical states, associated with prematurity, or related to prematurity itself, as a biological risk factor. Some of the studies verified impairments related to language outcomes in premature children, these having presented compromised language in relation to full-term children[13-32]. A study[19] also found association with hearing impairment.

In contrast, two studies[20-23] found no association of retinopathy of prematurity with language outcomes. However, the study suggests that gestational age, low weight at birth and gender may be more influential in the long term in these children, thus being necessary to monitor this population - as has been observed in other studies reviewed[15-29]. These results evidenced the importance of monitoring these children from birth, although none of them followed-up on psychological factors such as those proposed by Kupfer et al.[39], indicated as closely related to language acquisition[40].

Among the psychosocial factors that may affect child development, maternal mood states were analyzed in a study with Clinical Risk Indicators for Child Development (CRICHD) [41]. In spite of the usual relationship between altered maternal mood and increased risk to infant development, one of the studies[16] found that there was no significant association between maternal depression in the first six months after childbirth and language after control of infant prematurity, breastfeeding, socioeconomic status and level. This study also disagrees with the findings of other authors[42] that highlighted aspects of maternal responsiveness and sensibility as predictors of better receptive and expressive language in children.

These language abilities, related to reception and expression, are the ones found to be compromised by most of the studies reviewed, which identify difficulties in acquisition in the different domains of language[26]. These findings correspond to those of another study[43], which identified differences in many aspects of phonetic and phonological development, such as consonant inventory, at 12 and 18 months of age, and syllabic complexity at 18 months of age in premature children. Concerning the abilities considered pre-linguistic, another study reviewed[28] agrees with the aforementioned[43] by evidencing that such abilities are influenced by the child's birth situation.

The authors above[43] point out that few studies on the vocal and communicative abilities of preterm children can be found, and these have produced contrasting results regarding the linguistic development of premature children. However, the authors state that it is necessary to investigate if this development presents peculiarities that may explain the differential linguistic abilities found in some samples of preterm populations, as it is pointed out by most of the studies of this review, since these present language impairments in pre-school and school children, i.e after the critical period of language development.

Thus, prematurity is identified as a biological risk factor to the language development of children. However, in this analysis, it is worth noting the interaction of the biological factor with the environmental factor as enhancing risk factors for the effects on language development[44]. The environmental factor, understood as a moderating variable, interferes and modifies the relationship between biological risk and child development outcomes. This observation demonstrates the importance of looking into environmental variables, which have not been widely explored in the studies found, since only two of them[14-16] emphasized the importance of such variables in association with prematurity and its effects on children's language.

The relationship between genetics and the environment is dynamic and also cumulative in its ability to influence the individual's development and change subsequent behaviors. In addition, another study[42] found that interactive maternal behaviors exert a differential moderating effect on the development of vulnerable children with a history of biological risk.

Moreover, reflecting on the prematurity condition, in addition to the biological risk and its association with the environment, premature birth may pose risks not only to the physical life of the infant, but also to its first subjective marks and emotional bonds, besides the mismatch, on the part of the parents, between what was dreamed of the imaginary child and what actually takes place with the real child[45]. Thus, the infant is at risk, and may even be at high biopsychosocial risk, since the mother may deconstruct herself and lose the desire to play the maternal role due to the actual absence of the child, which can lead her not to fulfill their demands (not assuming "absent" response of the child), as well as positioning her as not receiving the their calls. This situation was observed in case study[46], in which the mother was unable to identify the child's demands, who presented risk factors to development such as prematurity and psychological risk.

In this perspective, the entire construction of mother and child is affected. The fulfillment of the mother role is impaired, since in order to perform this task satisfactorily she must be emotionally stable, as the main caregiver. Psychological risk affects mother, child, and bond, which is key for development[3,4], particularly the development of language[11].

Considering hearing conditions, it is known that auditory monitoring of premature children is also extremely important, not only to avoid or remedy hearing problems, but also to minimize their effects on language acquisition. Some research results suggest that prematurity affects the maturation process of the central auditory nervous system, including maturation of the auditory pathway, as well as the weight at birth factor, which may negatively impact the process of language acquisition and learning[33-36]. In line with these works, another study[47] observed a statistically significant association among maturation of the auditory pathway, cognition and communication (at 12 months) and receptive language (at 24 months).

This demonstrates that premature children may not present peripheral auditory abnormalities at the time of the test (normal hearing), but this result does not guarantee full maturation of the auditory pathway. Therefore, longitudinal follow-up of children born premature is necessary, as maturation occurs in the first two years of life and appropriate sound experimentation may be essential in this period of greater plasticity[48]. Such experimentation, in addition to the biological and environmental conditions to which the child is exposed, is also anchored in the process of interaction, in which adult and child are partners. Family relationships play an essential role in the child's acquisition of early abilities[49].

Thus, monitoring for an appropriate maturation of the auditory system is of the essence to allow for the development of auditory abilities, which will allow the child to acquire language and, consequently, foster future learning that depends on it. Such follow-up should be carried out in order to allow early detection and intervention, when necessary, in cases of hearing and language impairment.

CONCLUSION

From the studies reviewed it was possible to verify that prematurity, as well as aspects related to it (gestational age, low weight at birth and complications during birth), can negatively influence hearing and language acquisition.

The studies indicate that prematurity is a risk factor that may affect the maturation process of the central auditory system, thus impairing hearing in premature infants. Language acquisition during the first year of life depends on the appropriate maturation of the central auditory pathway because formation of linguistic representations by the environment is strongly conditioned by the brain and factors related to the maturation. In this vein, the importance to observe maturational conditions of the auditory pathway in premature children is highlighted, since language is favored by such conditions.

It was also observed that prematurity affects the development of pre-linguistic abilities and linguistic outcomes in premature children. Delay and abnormalities in these children's language development, impairments in phonetic and phonological aspects, such as consonant inventory and syllabic complexity, may be related to premature birth and aspects intrinsic to prematurity. Thus, it is important for clinical practice to monitor children exposed to risk factors, such as prematurity, in order to investigate and understand the development of auditory and linguistic abilities in them.

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Author contributions

ICR took part in the selection and assessment of the scientific studies and in writing the paper; EPVB took part as co-advisor of the research and in writing the paper; AHC took part in the selection and assessment of the scientific studies; LDO took part in writing the article; APRS took part as advisor of the research and in writing the paper.