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Phonological acquisition in pre-school children and iron deficiency: a population study

Aquisição fonológica em pré-escolares e deficiência de ferro: um estudo populacional

Adquisición fonológica en preescolares y deficiencia de hierro: un estudio populacional

*Maristela Cavalheiro Tamborindeguy França**
*Milene Urrutia de Azevedo***
*Marcio Pezzini França****
*Liane Esteves Daudt****
*Rudimar dos Santos Riesgo****

Abstract

Introduction - This research aimed to analyze the phonological acquisition and its relationship with demographic data and iron deficiency in preschool children from Vicente Dutra-RS. **Method** - It was performed a cross-sectional study, using hemogram data (hemoglobin, ferritin and transferrin saturation), and data on acquisition of oral and written language in a population of 51 children (26 girls, 51%), with 5.3±0.3 years of age. **Results** - It was not found an association between iron deficiency and acquisition of oral and written language. However, it was observed an association between the variables phonological acquisition and chance of writing (value), p = 0.006, and phonological acquisition and phonetic deviations (p = 0.012). **Conclusions** - The data found in this cross-sectional research do not suggest a relationship between language and iron deficiency; however, larger samples in longitudinal studies would be interesting for a better understanding of the findings.

Keywords: Iron deficiency; Child language; Preschool Children.

* Hospital Nossa Senhora da Conceição, Porto Alegre, RS, Brazil
** Prefeitura Municipal de Vicente Dutra, Vicente Dutra, RS, Brazil
*** Universidade Federal do Rio Grande do Sul – UFRGS, Porto Alegre, RS, Brazil

Authors' contributions:
MCTF, MUA: data collection and article writing; MPF: Academic co-advisor; article writing and review, LED: Academic co-advisor; article writing and review, RSR: Academic advisor; article writing and review.

Correspondence e-mail: Maristela França - maristela@franca.bio.br
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Resumo

Introdução – Esta pesquisa teve o objetivo de analisar a aquisição fonológica e sua relação com dados demográficos e a deficiência de ferro em pré-escolares da cidade de Vicente Dutra-RS. **Método** – Foi realizado estudo transversal, utilizando dados de hemograma (hemoglobina, ferritina e saturação transferrina) e dados sobre a aquisição da linguagem oral e da escrita numa população de 51 crianças (26 meninas, 51%), com 5,3±0,3 anos de idade. **Resultados** – Não foi encontrada associação da deficiência de ferro com aquisição da linguagem oral e escrita. Contudo, foi observada associação entre as variáveis aquisição fonológica e hipótese de escrita (valor sonoro), p=0,006, e aquisição fonológica e desvios fonéticos (p=0,012). **Conclusões** – Os dados encontrados nesta pesquisa transversal não sugerem relação entre linguagem e deficiência de ferro; contudo, amostras maiores em estudos longitudinais seriam interessantes para melhor compreensão dos achados.

Palavras-chave: Deficiência de ferro; Linguagem infantil; Pré-escolar.

Resumen

Introducción - Esta investigación tuvo el objetivo de analizar la adquisición fonológica y su relación con datos demográficos y la deficiencia de hierro en preescolares de la ciudad de Vicente Dutra-RS. **Método** – Se realizó un estudio transversal, utilizando datos de hemograma (hemoglobina, ferritina y saturación transferrina) y datos sobre la adquisición del lenguaje oral y de la escritura en una población de 51 niños (26 niñas, 51%), con 5,3 ± 0, 3 años de edad. **Resultados** - No se encontró asociación de la deficiencia de hierro con adquisición del lenguaje oral y escrito. Sin embargo, se observó asociación entre las variables de adquisición fonológica y hipótesis de escritura (valor sonoro), p = 0,006, y adquisición fonológica y desvíos fonéticos (p = 0,012). **Conclusiones** - Los datos encontrados en esta investigación transversal no sugieren una relación entre el lenguaje y la deficiencia de hierro; sin embargo, muestras más grandes en estudios longitudinales serían interesantes para una mejor comprensión de los hallazgos.

Palabras claves: Deficiencia de hierro; Lenguaje infantil; Preescolar

Introduction

Due to its association with anemia, a disease at risk of morbid outcomes, iron deficiency has been studied for many decades. This deficiency represents the largest nutritional deficit in the world, being considered a growing deficiency in all segments of society, and affecting mainly children under two years old and pregnant women. Although no national surveys have been conducted yet, studies indicate that approximately half of Brazilian preschoolers are anemic, that is, about 4.8 million children[1].

Iron is crucial for the Central Nervous System, being present in enzymes (succinic dehydrogenase, nicotinamide dehydrogenase and xanthine oxidase) that are essential for cellular oxidative metabolism, which is directly linked to the brain energy efficiency. Iron deficiency also affects neurobiochemical processes involved in the synthesis and degradation of catecholamine and serotonin, which act as neurotransmitters; and with monoamine oxidase, which is involved in catecholamine catabolism and norepinephrine metabolism, which promotes the integration/connection of the brain regions involved in the cognitive process of attention[2]. According to Chudo[3], an iron-deficient child may have "... growth delay, impaired learning ability (cognitive development), motor coordination and language, behavioral effects such as lack of attention, fatigue, reduced physical activity and affectivity as well as a low resistance to infections."

This research is part of a population study that examined several biological markers and their association with child development. The study specifically focused on speech-language pathology was motivated by the possibility of analyzing a biomarker - iron deficiency -, which is linked to several factors associated with language development, such as attention, cognition and learning. Researches involving language are widely studied in its relationship with observational variables of developmental, neuropsychological and environmental issues. However, there is a lack of studies

that could offer biological markers from laboratory tests to the scientific community. First of all, this is explained by the natural difficulty in adherence of families with typical/normal developing children to undergo blood tests. In addition, these surveys are costly and have important logistics challenges.

Therefore, this study aimed to identify the demographic characteristics of the study population; and to analyze the association between iron deficiency and oral and written language acquisition.

Methods

An observational, quantitative and cross-sectional study was conducted in a population of 5.3±0.3-year old preschoolers in Vicente Dutra-RS. According to IBGE 2010, there were 784 children from 0-9 years old living in the municipality. An active search for children was conducted through the promotion of the project in meetings at Childhood education schools, home visits by Community Health Agents and Participants of the *Programa Primeira Infância Melhor* (Best Early Childhood Program). The study included children who were 5 years old in 2014, and excluded children with chronic diseases that could affect the neuropsychomotor development, according to the Municipal Health Department. Data collection was performed from June to December 2014, initially with the collection of laboratory tests and anthropometric data, which was organized and collected by the municipal health team, and then with the speech-language pathology assessments in the school environment in the following week. In the absence of a child who was already scheduled, their family was contacted to arrange a new date for collection and further clarification. Then, the blood samples were submitted to the municipal reference laboratory for clinical analysis, where the following values were measured: hemoglobin, ferritin, transferrin, transferrin saturation, iron deficiency, hematocrit, MCV and RDW. As recommended by the World Health Organization[4], participants with hemoglobin <11.5g/dl and/or ferritin <12mg/l were considered iron-deficient. The Children's Phonological Assessment (CFA) protocol was used to investigate oral language[5]. This protocol provided a large speech sample, which allowed the classification of phonological acquisition and the verification of phonetic changes. Phonological acquisition data were classified as Complete and Incomplete Phonological Acquisition[6]; And, as for the phonetic, children were classified with a phonetic deviation when an articulatory inaccuracy was observed in the production of a phoneme. Then children received a self-dictation sheet with seven drawings so that they could graphically represent the name of each figure in order to analyze the writing hypothesis. The following drawings should be written: knife, grape, flower, car, frog, ball and church. The strategy of investigating the writing hypothesis through a self-dictation is routinely used in the school environment and in studies aimed at identifying the development of children's writing[7-9], as observed by the assumptions of Ehri's model of phases of learning to read[10]. In this study, the result of the evaluation aimed specifically to check for any sound or writing representation with conventional sound value (phoneme-grapheme relationship) in the writing hypotheses of each figure[9,10], that is, to be in the partial alphabetic phase of Ehri's classification[11]. For this analysis, each word was analyzed by two speech-language pathologists in order to identify the presence of at least one sound representation in each word. The word received 1 point when this agreement was reached; therefore, data resulting from the self-dictation of each child were presented on a scale from 0 to 7, where 0 (zero) indicated when no words had sound representation and 7 (seven) indicated when all words had at least one phoneme-grapheme representation. Language assessment was preceded by a hearing screening to ensure the integrity of the hearing acuity and to exclude this variable as potential cause of language delays. A meatoscopy was also conducted in order to identify earwax buildup or another component that would prevent hearing screening. The assessment proceeded with acoustic immittance testing using an acoustic immittance device, Interacoustics AT235, in which tympanometry and Acoustic Reflex tests were performed with a 226 Hz probe tone. The acoustic reflexes investigated were: ipsilateral acoustic reflex, for 1000 and 2000 Hz; and contralateral acoustic reflex for 500, 1000, 2000 and 4000 Hz. The maximum intensity of the acoustic reflex was 120 dB. None of the children had alterations that could result in their withdrawal from the study.

At the end, of the 60 children who were 5 years old in 2014 and who were enrolled in a childhood education school in the municipality, 9 did not attend the laboratory tests. Therefore, this study population consisted of 51 children. Results were analyzed using SPSS version 21.0 statistical software.

This project was approved by the Research Ethics Committee of the Hospital de Clínicas de Porto Alegre through a submission to Plataforma Brasil, according to the CAAE no.: 23517313.0.0000.5327 and parents or guardians signed the Free Prior Informed Consent.

Results

Data obtained in this research were selected and shown in three tables, in order to show (i) the characteristics of the population; (ii) the association of language acquisition and iron deficiency; and (iii) the association between variables of the speech-language pathology assessment. Table 1 presents the characteristics of the study population with the frequency of demographic, anthropometric and speech-language pathology data. The study included a population of 51 children representing 85% of the 5-year-old students enrolled in the childhood education network in the municipality.

Table 1. Characteristics of the study population

Variables		n (%)
Gender	Male	25 (49%)
	Female	26 (51%)
Age Range	Years (mean)	5.3 ±0.3
Weight	Kg (mean)	20.7±3.7
Height	Cm (mean)	112.1±6.0
Household Income	Less than one minimum wage	15 (29.4%)
	2-3	20 (39.2%)
	3-4	9(17.6%)
	More than four minimum wages	7(13.7%)
Housing	Rural	21(41.2%)
	Urban	30(58.8%)
Duration of breastfeeding	Months Median (P25-P75)	8.5(2.3-24)
Pacifier use	Yes	6 (11.8%)
	No	45 (88.2%)
Bottle-feeding use	Yes	19(37.3%)
	No	32(62.7%)
Phonetic deviation	Yes	13 (25.5%)
	No	38 (74.5%)
Phonological acquisition	Complete	34(66.7%)
	Incomplete	17(33.3%)

Table 2 analyzes the association of phonological acquisition and iron deficiency. Participant groups have homogeneity regarding gender and age; iron deficiency was observed in 29.4% of the studied population; however, no statistically significant association was found with the phonological acquisition variable.

Table 2. Association between phonological acquisition and iron deficiency

Variables		PHONOLOGICAL ACQUISITION		P
		Complete	Incomplete	
Gender	Male Female	14(41.2%) 20(58.8)	11(64.7%) 6(35.3%)	0.198a
Age	Years (mean)	5.4±0.4	5.2±0.3	0.301b
Iron Deficiency	Yes No	10(29.4%) 24(70.6%)	5(29.4%) 12(70.6%)	1.000a

a = T-test; b = Pearson's correlation; * p<0.05; 95% Confidence Interval.

Table 3 shows specific data from the speech-language pathology assessment in order to analyze the association between children who had complete and incomplete phonological acquisition, phonetic deviations and writing hypothesis with sound value (partial alphabetic phase of Ehri's classification[11]). The findings confirm the relationship between oral and written language in the alphabetic system, regardless of the iron deficiency, where the complete phonological acquisition correlates with the median of the writing hypothesis, showing a greater capacity for the phoneme-grapheme association. In addition, children with phonetic deviation are associated with the incomplete phonological acquisition group, a finding that relates language and orofacial motricity (speech articulatory awareness).

Table 3. Association between phonological acquisition, phonetic deviation and writing hypothesis

		PHONOLOGICAL ACQUISITION		p-value
		Complete	Incomplete	
Writing hypothesis with sound value	Median (percentile)	3 (2-6)	1(0-4)	0.006a*
Phonetic Deviation	Yes n(%) No n(%)	5 (14.7%) 29 (85.3%)	8 (47%) 9 (53%)	0.012b*

a = Spearman's correlation; b = Chi-squared test; * p<0.05; 95% Confidence Interval.

Discussion

Iron deficiency is a well-known issue in the Brazilian population and it is linked to various aspects of child development, including memory and learning. At the same time, language is a cortical function associated with memory and used in learning. Thus, this study is justified by its methodological differential; firstly, for being a population study; and, secondly, due to the limited amount of research work associating data from blood tests and children's language.

Stoltzfus[12] measured the effects of iron supplementation and anthelmintic treatment and development of children from 6-59 months of age, from Pemba Island, Zanzibar. Language development and motor skills were assessed before and after treatment in age-adjusted subgroups. Iron supplementation improved language development by 0.8 (95% CI; 0.2-1.4) points, and also improved motor development (P=0.015); development results increased by 0.4 (-0.3-1.1) points on the motor scale and 0.3 (- 0.3-0.9) points on the language scale. Findings showed that iron replacement favored motor skills and language development of preschoolers in this rural area of Africa.

Another study[13] assessed the effects of chronic iron deficiency on neuropsychological traits of infants. Nutritional iron and neuropsychological characteristics of 58 children from 14-18 months of age were evaluated. The findings showed that the chronic iron deficiency group had significantly lower scores on language, ambient sound perception and motor measures when compared to infants with normal nutritional iron status at 6 and 14-18 months of age. Therefore, it was concluded that language development and motor skills were sensitive to the effects of chronic iron deficiency in infants.

Santos[14] developed a longitudinal study to evaluate the effect of iron deficiency anemia on

children's language development in the State of Minas Gerais (Brazil). Its sample consisted of 14 anemic children and 22 children in the control group, aged from 2-7 years old, followed up for 12 months (under treatment in the case of anemic children). Language of children with and without anemia differed significantly before the treatment. After 12 months of iron replacement therapy, anemic children remained with poor performance rates on language reception aspects. Therefore, the results suggest that language changes may be persistent in anemic children even undergoing ferrous salt therapy, as recommended by the literature. Another study[15] compared the auditory and language development of anemic and non-anemic children between 3-6 years old from a public day-care center in Belo Horizonte-MG. The case group consisted of 19 anemic children, while the control group consisted of 38 healthy children, selected by paired random sampling. Children's hearing ability was assessed with otoacoustic emissions, tympanometry and simplified auditory processing evaluation. The language development of each participant was also observed through the behavior observation script of children from 0-6 years old. It was concluded that anemic children differed statistically from non-anemic children as to changes in the acoustic reflex and language performance indexes, and had a higher prevalence of changes in the peripheral auditory assessment.

Table 1 shows the characteristics of the population, which stand out for: 41.2% live in rural areas, about 70% have a family income of up to 3 minimum wages, the median breastfeeding is 8.5 months, 88.2% no longer use a pacifier and only 37.3% still use bottle-feeding. As for the speech-language pathology aspects observed, a quarter of the children have some phonetic deviation and one third of them did not complete the phonological acquisition.

As shown in the data analysis in Table 2, there was no association between phonological acquisition and iron deficiency. A literature review found several studies with a child population[12,13,16-18] associating iron deficiency with cognitive impairment or neuropsychological tests, on samples of varying ages, from newborns to preschoolers, which suggest certain evidence of cognitive and behavioral deficit in their conclusions. Specifically on language development and iron deficiency anemia, only two studies were found in Brazil[14,15], which showed a significant association between iron deficiency anemia and language; however, both reported that iron replacement was not effective in rebalancing this relationship, that is, in most cases.

Nevertheless, it should also be noted that other authors corroborate the findings without statistical significance. Pratt e Khan[19] conducted a meta-analysis study of 21 recent studies on non-anemic iron deficiency and the main outcomes for human health and/or development, including cognitive, educational and language issues. Although no statistical significance was found in the cases studied, the authors acknowledge that there are many indications for further research on this disease and its impact on child development. Similarly, McCann and Ames[17] suggest that there are a limited number of papers on this subject to allow a definitive assessment of the causal relationship.

As for the results shown in Table 3, the association found between the complete phonological acquisition and the higher number of writing hypotheses in a partial alphabetic phase (Ehri's classification[11]), shows that children's language development path is a continuum, in which the maturation of a modality is a requirement for the emergence of another[20]. Relating at least one phoneme to a grapheme presupposes that the organization of the phonological framework will have direct implications for written language acquisition, which is in full compliance with the data found in the literature [6,21-24].

In addition, the results showed a statistical significance between incomplete phonological acquisition and phonetic deviations. These findings corroborate studies that investigate oral language delay, orofacial motricity disorders and speech articulatory awareness issues[25-29]. Phonology is known to be associated with the cognitive processes of language and its oral expression occurs at the oral motor level (phonetic). These elements are distinct but correlated, usually dedicated to the areas of language and orofacial motricity in speech-language pathology. This result allows us to conclude that although they are an issue of speech articulatory awareness, phonetic deviations may represent an indication or risk for phonological acquisition delay. These same conclusions can also be found in studies that use nonverbal strategies with oropraxis exercises in order to facilitate the rehabilitation of both phonetic and phonological deviations[30-32].

Finally, data found in this cross-sectional study suggest no association between language and iron deficiency; however, other longitudinal studies with larger samples would be relevant to better understand this hypothesis.

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