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School and language performance in children born with low birth weight

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Abstract

Objectives: To identify the impact of birth weight on the development of metalinguistic skills and performance in reading, writing, and arithmetic in students aged 6 to 10 years, enrolled from the 1st to the 4th grade of Elementary School in public schools of the metropolitan region of São Paulo.

Methods: The concurrent cohort included 315 students. Birth weight was the exposure variable, and the outcomes were performance in receptive and expressive language, oral metalinguistic skills, and performance in writing, arithmetic, and reading. The tools employed were the Test of Language Competence (TLC) and the School Performance Test (SPT). Students were grouped into quartiles by birth weight for data analysis (P1: $<$ 2170 g, P2: from 2171 g to 2450 g, P3: from 2451 g to 3150 g, and P4: $>$ 3150 g).

Results: The authors observed a tendency for the lower performance of the two groups with lower birth weights in listening comprehension and oral expression. The lower-weight group tended to perform poorly compared to the other groups vis-à-vis reading. In the global result of the SPT, worse performance was observed in the students in the first quartile compared to the others (p = 0.019). The multivariate analysis revealed no association between birth weight and results in the tests applied after adjusting for maternal schooling.

Conclusions: Birth weight can interfere with oral and written language development. However, the determination of these processes occurs in the face of complex interaction that includes sociodemographic factors, especially family support and maternal schooling.

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Introduction

Language development occurs through the interaction of biological, psychological, and sociocultural factors.[1] During the gestational period, fetal maturation enables the necessary anatomophysiological constitution for the individual to develop later language,[2] among other mental functions.

Prematurity[3] and low birth weight (LBW)[4] are frequently identified as risk factors for delays and cognitive alterations in oral and written language. Studies indicate that LBW[5] and language disorders[6-8] are also associated with low income, family disruption, fetal and maternal health conditions during the gestational period, maternal age, and schooling. Access to health services, implementation of prevention programs, higher household income, and parental schooling[5-9] are mentioned as protective factors.

Although many studies indicate a higher likelihood of changes in the development of premature and very low birth weight (VLBW) infants,[10,11] there is little definition regarding the evolution of children born weighing 1500—2500 g, including late preterm infants, with a gestational age of 34 to 36 weeks, or even early terms, with 37 weeks, especially more subtle changes that manifest late, such as poor school performance and learning disorders.

Metalinguistic skills, responsible for conscious reflection and the necessary adjustments to properly use language components in oral and writing-mediated communication — reading and manual writing — are predictive of school learning. Therefore, changes in oral language influence scholar performance.[12]

Furthermore, studies show the hypothesis of shared mechanisms in learning reading and mathematics. Phonological processing components relevant to acquiring the oral code and reading learning are related to learning mathematics.[13]

Thus, the present study aimed to identify the impact of birth weight on the development of metalinguistic, reading, writing, and arithmetic skills in schoolchildren aged 6—10 years enrolled in public schools in the municipality of Embu das Artes, São Paulo, Brazil.

Methods

Study population and sampling

This concurrent cohort study is nested in the project linked to the Research Program for the SUS - MS/CNPq/FAPESP/SES-SP - Shared Health Management N° 2009/53129-5 (PPSUS), entitled "*Morbidity, growth, and development of schoolchildren aged 6 to 10 born with low birth weight — comprehensiveness child care and intersectoriality in the local health system — Embu das Artes (SP)*", (CEP n° 1142/09). It considered the population of 315 schoolchildren (176 girls and 139 boys) aged between 6.0 and 10.9 years (mean of 9.13 years), enrolled from the 1st to the 4th grade of Elementary School in municipal public schools of Embu das Artes. One hundred eighty children were born with low weight (< 2500 g) and 135 with weight > 2500 g (NLBW), and 82 were preterm. The State Data Analysis System (SEADE) linked birth weight and other information from the Declaration of Live Births (DLB) to the list of students participating in the study.

The inclusion criteria for the LBW group considered low birth weight (< 2500 g); date of birth between 2000 and 2005, and mothers living in Embu das Artes at delivery. Inclusion criteria for the NLBW Group were birth weight above or equal to 2500 g, meeting the other items established in the LBW group, and belonging to the classroom of one of the LBW individuals. Children with anomalies or chronic diseases that directly interfere with language development and school performance were excluded from the study. This paper analyzed the exposure variable birth weight as a variable stratified into quartiles: P1: < 2170 g; P2: from 2171 g to 2450 g; P3: from 2451 g to 3150 g; and P4: > 3150 g.

The outcomes of interest were performance in receptive and expressive language and oral metalinguistic skills (assessed by the Test of Language Competence — Extended Edition (TLC),[14] translated and adapted to Brazilian Portuguese[15]) and performance in writing, arithmetic, and reading (verified through the participants' School Performance Test (SPT).[16] All study participants underwent audiological assessment before the application of the tests. The independent variables were the child's age, gender, and schooling, and the mother's age and schooling. All parents/guardians of study participants signed the informed consent form.

Study procedures

A questionnaire was applied to those responsible for obtaining information about the child's communication, health services referrals, and school performance verification. Subsequently, hearing screenings were performed, and tests were applied to assess the participants' language skills: TLC and SPT.

The TLC was adopted to assess language and metalinguistic skills, with Level 1 for children aged five to 9 years and 11 months and Level 2 for pre-adolescents and adolescents aged nine to 18 years and 11 months. Each TLC level consists of four subtests: 1) Ambiguous sentences - assesses the ability to recognize and interpret the possible meanings of sentences that contain a word or syntactic ambiguity without a closed context (gross score - maximum 52 points); 2) Listening comprehension: making inferences - assesses listening comprehension by the child making inferences; each item describes the beginning and end of an everyday situation and the child must infer the two events that justify the end of the story among four possible reasons (gross score - maximum 48 points); 3) Oral expression: recreating speech acts - assesses the oral expression through the ability to plan and formulate speech acts, based on grammar, information processing, and speech act model, from keywords related to a context predetermined by a figure (gross score - maximum 96 points); 4) Figurative language - assesses the ability to interpret the figurative meaning of idiomatic or metaphorical expressions (gross score - maximum 85 points).

The SPT was employed to assess the writing, reading, and arithmetic skills. Concerning handwriting assessment, the child signed his/her name and words under dictation. The arithmetic assessment had a first part, in which the child answered three problems orally, and a second written part, where arithmetic resolution items were presented. In the reading assessment, the child read words presented as isolated items on a reading board. The Total Gross Score (TGS) was calculated from the total scores obtained in the three

subtests, which were classified into five categories: low, medium-low, medium, medium-high, and high. This classification is established by comparing the score obtained by the child with the SPT standardized school grade table.

Statistical analysis

Data were entered and consolidated in an Excel table (Microsoft Office 365) and analyzed using the SPSS 28.0 statistical package (IBM). Categorical variables were presented as total numbers and absolute percentages and compared using the chi-square test. Continuous variables were evaluated for distribution using the Shapiro-Wilk test, kurtosis values, and histogram plots. Those with a parametric distribution were presented as mean and standard deviation. They were compared using the t-student and ANOVA tests. Those with nonparametric distribution were presented as median and interquartile range and compared using the Mann-Whitney and Kruskal-Wallis tests. The significance level adopted at the end was 5%.

Linear regression adjusted for maternal schooling, the variable with a statistically significant difference concerning the birth weight quartiles, was used to assess the association between birth weight, stratified into quartiles, and the TLC and SPT components. Gestational age was collinear with birth weight and, thus, not included in the regression as an independent variable. The significance level adopted was 5%. The medium, medium-high, and high categories were grouped for statistical analysis regarding SPT performance.

This research project was submitted to the Research Ethics Committee and approved (CEP n° 0172/2017) after consent of the municipal Health and Education secretariats of Embu das Artes.

Results

Table 1 describes the general characteristics of the students by birth weight ranges in quartiles. The authors observed that maternal schooling of fewer than eight years was more frequent in schoolchildren with birth weights in the first and second quartiles vs. third and fourth (87−54.4% vs. 51−32.9%; $p < 0.001$). The other variables, such as gender, child's age, and mother's age, did not differ between the compared groups.

The results obtained in the tests applied to schoolchildren, stratified regarding the birth weight quartile, are shown in Table 2. The bivariate analysis revealed a tendency towards lower values of the sub-test "Listening comprehension: making inferences" of the TLC in the schoolchildren who were in the second birth weight quartile compared to the other quartiles ($p = 0.081$) and in the subtest "Oral expression: recreating speech acts" in schoolchildren who were in the first birth weight quartile compared to the others ($p = 0.130$).

There was also a tendency towards worse performance in the "Reading" subtest of the SPT in those in the first birth weight quartile ($p = 0.097$). A worse performance was observed in the students in the first quartile against the others ($p = 0.019$) in the general result of the SPT, highlighting that only 17.9% of the total students had medium, medium-high, and high performance (Table 2).

The multivariate analysis revealed no association between birth weight, the TLC and SPT subtests, and the overall SPT after adjusting for maternal schooling (Table 3).

Discussion

LBW is an indicator of vulnerability that points to the need for greater care. Health care, access to school, and other public policies can function as protective factors for this condition's early and late repercussions. It makes up a heterogeneous group with a known multicausal nature. A Brazilian systematic review of studies identified an association between LBW and 15 variables. The most cited were maternal age, number of prenatal care visits, child's gender, duration of pregnancy, and maternal schooling. Access to health services, represented by the number of prenatal care visits, and maternal schooling are highlighted as factors that tend to persist after birth and contribute to its early and late repercussions.[17]

Table 1 General characteristics of schoolchildren and mothers, by birth weight quartile ($n = 315$). Embu das Artes, 2012.

		Birth weight (in quartiles)					
		P1 ($n = 80$)	P2 ($n = 80$)	P3 ($n = 77$)	P4 ($n = 78$)	Total ($n = 315$)	p-value
General characteristics							
Gender[a]	Female	44 (55.0%)	48 (60.0%)	48 (62.3%)	36 (46.2%)	176 (55.8%)	0.181
Child's age[b]	Years	9.2 ± 0.8	9.0 ± 1.1	9.2 ± 1.0	9.1 ± 1.0	9.1 ± 1.0	0.554
Mother's age[b]	Years	25.4 ± 6.6	24.5 ± 6.9	25.6 ± 6.6	25.3 ± 6.2	25.3 ± 6.6	0.955
Maternal schooling[a]	< 8 years	44 (55.0%)	43 (53.8%)	26 (33.8%)	25 (32.1%)	138 (43.8%)	0.002
Children's schooling[a]	1st and 2nd grades	32 (40.0%)	36 (45.0%)	26 (33.8%)	25 (32.1%)	119 (37.8%)	0.313
Gestational age[a]	Preterm	54 (67.5%)	18 (22.5%)	9 (11.7%)	1 (1.3%)	82 (26.0%)	< 0.001

P1 (< 2170 g), P2 (2171 to 2450 g), P3 (2451 to 3150 g), and P4 (> 3150 g).
[a] N (%).
[b] Mean (standard deviation).

Table 2 Students' performance in the TLC subtests, subtests, and general SPT, by birth weight quartile (n = 315). Embu das Artes, 2012.

		Birth weight (in quartiles)					
		P1 (n = 80)	P2 (n = 80)	P3 (n = 77)	P4 (n = 78)	Total (n = 315)	P-value
TLC							
Ambiguous sentences[a]	Score (from 0 to 52)	31.0 (22.0;40.0)	33.0 (27.0; 40.7)	34.0 (23.5;40.0)	37.0 (27.2;43.0)	34.0 (24.0; 41.2)	0.185
Listening Comprehension: Making Inferences[a]	Score (from 0 to 48)	24.0 (18.0; 30.0)	22.0 (18.0; 30.0)	24.0 (15.0;27.5)	27.0 (21.0;33.0)	24 (18.0; 30.0)	0.081
Oral expression: Recreating speech acts[a]	Score (from 0 to 96)	65.0 (50.0; 77.0)	73.0 (54.0; 80.0)	75.0 (59.0; 80.0)	72.5 (50.0; 81.2)	71.0 (53.0; 80.0)	0.130
Figurative language[a]	Score (from 0 to 85)	22.0 (16.0; 29.0)	20.5 (15.0; 27.5)	24.0 (14.0; 32.5)	24.5 (12.7; 33.2)	23.0 (15.0; 31.0)	0.649
SPT							
Writing Subtest[b]	medium, medium-high, and high	8 (10.0%)	9 (11.3%)	15 (19.5%)	12 (15.4%)	44 (14.0%)	0.306
Arithmetic Subtest[b]	medium, medium-high, and high	7 (8.8%)	8 (10.0%)	11 (14.3%)	8 (10.3%)	34 (10.8%)	0.706
Reading Subtest[b]	medium, medium-high, and high	14 (17.5%)	28 (35.0%)	21 (27.3%)	22 (28.2%)	85 (27.0%)	0.097
General[b]	medium, medium-high, and high	5 (6.3%)	19 (23.8%)	16 (20.8%)	14 (17.9%)	54 (17.9%)	0.019

P1 ($<$ 2170 g), P2 (2171 to 2450 g), P3 (2451 to 3150 g), and P4 ($>$ 3150 g).
[a] Mean (interquartile range).
[b] N (%).

The joint occurrence of other constitutional factors with low birth weight, such as prematurity, may be associated with structural and functional changes in the CNS[18] and, later, impaired mental processes such as, for example, cognition and language.[4]

The present research observed that students whose mothers had completed less than eight years of formal education were born with a lower weight. International[19] and national[20] studies have shown maternal schooling level correlates with language delays. Although this association is not always found,[21] many studies[5,22-24] have pointed to low maternal education as a risk factor for child development and academic performance, or the higher education of mothers acted as a protective factor for the development of groups of children born with some specific risk, such as low birth weight. Furthermore, a study[25] found that maternal schooling over five years was positively associated with better organization of the physical and temporal environment, more significant opportunity for variation in daily stimulation, and greater emotional and verbal involvement of the mother with the child.[7]

The low performance in the SPT by most students participating in the present study suggests a risk situation in school learning[26,27] when compared to other studies. Birth weight alone did not influence the development of metalinguistic skills assessed orally in the students participating in the present research since no associations were found with performance in the TLC, both for receptive and expressive language. Except for the low performance in the figurative language subtest, the other results of the descriptive analysis of the TLC showed a medium performance of the students, using the total gross score of the subtest as a reference. This result suggests that the study population is in a situation of greater vulnerability.

It is noteworthy that the P1 group showed the worst results in the tests, which gathered preterm children and less educated mothers. The most frequent findings point to lower oral and written language and math skills of individuals born with low birth weight compared to those born with adequate weight.[28]

The multifactorial nature of the oral and written language development process and other mental functions responsible for school performance corroborates the above-mentioned data.

The predominant influence of environmental factors on oral language development is related to the impact of experiences lived over time in the family core. Less educated mothers with a lower income have fewer opportunities to interact with their young children than those with a better socioeconomic level. As a result, the family core would assume most responsibility for the experiences transmitted to children.[29]

On the other hand, the worse performance of P1 in the General SPT indicates that difficulties in appropriating written and mathematical language could be associated with BW, reinforcing its lasting and late manifestation nature.[30]

This study was conducted with schoolchildren who had already overcome problems early in life, and those with diseases with potential developmental impairment were excluded. Thus, part of the repercussions associated with low birth weight, especially the most severe ones, would not be identified in this study.

Table 3 Linear regression evaluating the association between birth weight and performance in the TLC subtests and the general and SPT subtests adjusted for maternal education (n = 315). Embu das Artes, 2012.

	Dependent variables	Adjusted β	95% Confidence Interval	P-value
TLC	Ambiguous sentences	0.881	−0.473 to 2.235	0.202
	Listening Comprehension: Making Inferences	0.372	−0.638 to 1.381	0.469
	Oral expression: Recreating speech acts	0.796	−1.584 to 3.177	0.511
	Figurative language	0.136	−1.110 to 1.383	0.830
SPT	Writing Subtest	0.014	−0.020 to 0.049	0.416
	Arithmetic Subtest	0.006	−0.026 to 0.037	0.719
	Reading Subtest	0.019	−0.026 to 0.064	0.396
	General	0.029	−0.009 to 0.067	0.130

Dependent variables: TLC and SPT items. Exposure variable: birth weight (quartiles). Adjustment variables: maternal schooling (< 8 years).

Although birth weight can interfere with the development of oral and written language, the determination of these processes occurs in the face of a complex interaction that also includes sociodemographic factors such as advancement in schooling and family support, often represented by maternal schooling, which can be considered as protective factors. In this sense, research that seeks associations between BW and school performance in different sociodemographic settings may contribute to understanding the role of different aspects involved in language development and the school performance of individuals with lower birth weights.

However, the results obtained in the present study support the adoption of public policies that consider intersectoral and prolonged follow-up of individuals with risk factors for development, such as birth weight.

Conflicts of interest

The authors declare no conflicts of interest.

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