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Oral language of school-aged children born prematurely: a population-based analysis in Madeira Island, Portugal

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Abstract. Premature birth and low birth weight are very important factors in neurodevelopment. Current research in this field focuses on children born prematurely, with no underlying complications in the post-natal period, who are likely to develop disorders with their language development and consequently with their learning capabilities too. This study aims to analyze the language skills of prematurely born children in comparison to their school-aged peers. The children were assessed in schools, 27 preterm children (16 under 32 weeks and 11 with 32 or more weeks of gestation) and 49 term children paired by age and sex in the same school year. Tests including simple and complex structures for assessing semantics, morphosyntax, and phonology were used as a test of verbal memory. Preterm born children, regardless of their prematurity grade, showed significantly lower results than their peers, and more than a half of them, 52%, presented low scores in all language tests simultaneously, showing an important deficit. In contrast, in the term born children group only 14% showed low scores simultaneously in all tests. Verbal memory proved to be lower than that of their term peers, regardless of the gestational age and birth weight of preterm children. As a result of this analysis we consider that the evaluation of the linguistic development of these children, even in cases of moderate to low prematurity, should be monitored in order to identify earlier the existence of deficits and prevent psychosocial and learning problems.

Keywords: oral language, premature, learning, school-aged children

[es] El lenguaje oral de los niños en edad escolar nacidos prematuramente: un análisis basado en una población de la isla de Madeira, Portugal

Resumen. El nacimiento prematuro y el bajo peso al nacer son factores muy importantes en el neurodesarrollo. Las investigaciones actuales en esta población se centran en los niños nacidos prematuramente, sin complicaciones subyacentes en el período perinatal, que son propensos a desarrollar trastornos específicos en el desarrollo del lenguaje y, en consecuencia, también en sus capacidades de aprendizaje. Este estudio pretende analizar las habilidades lingüísticas orales de los niños nacidos prematuramente en comparación con sus compañeros de edad escolar. Se evaluaron en las respectivas escuelas, 27 niños prematuros (16 con menos de 32 o más semanas de gestación) y 49 a término emparejados por sexo, edad y curso escolar. Se utilizaron pruebas que incluían estructuras simples y complejas para evaluar la semántica, la morfosintaxis y la fonología, así como una prueba de memoria verbal. Los niños prematuros, independientemente de su grado de prematuridad, han demostrado resultados significativamente inferiores a los de sus compañeros, y más de la mitad de ellos, el 52%, presentaron puntuaciones bajas en todas las pruebas simultáneamente, enseñando un importante déficit lingüístico. Al contrario, en el grupo de niños nacidos a término solo el 14% presentaron puntuaciones bajas en simultáneo en todas las pruebas. La capacidad de memoria verbal resultó inferior a la de sus compañeros a término, independientemente de la edad gestacional y el peso al nacer de los niños prematuros. Como resultado de este análisis consideramos que la evaluación del desarrollo lingüístico de estos niños, incluso en los casos de prematuridad moderada a baja, debería ser objeto de seguimiento para identificar antes la existencia de déficits y prevenir problemas psicosociales y de aprendizaje.

Palabras clave: lenguaje oral, prematuro, aprendizaje, niños en edad escolar

Sumario: Introduction. Methods. Results. Discussion. Conclusions. References.

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Introduction

In the last three decades, advances in neonatology have promoted an increase in the survival of preterm children (gestational age below 37 weeks of gestation) and low birth weight new-borns (weight at birth below 2500 g

Nacional de Estatística, IP, 2020). In Portugal, in the last five years, the number of births has been de

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nificantly, contrary to the fact that we are faced with an increase in preterm births, making this condition a reason to better understand the impact of prematurity on neurodevelopment at different ages. This motivated several different types of research, in order to understand whether gestational age and birth weight factors for neurodevelopment disorders in this population.

The results of an important meta-analysis and systematic review involving 64,061 children, which quantify the performance of preterm children in different areas of neurodevelopment at different ages, there is a strong relationship between gestational age and cognitive abilities, both in very preterm children with moderate to late prematurity. Deficits in different areas of neurodevelopment observed in early childhood school age persist beyond the 1st cycle in all domains. Premature children, compared to their term peers, performance in terms of cognitive, language, motor, and academic abilities. At the behavioural level, the higher scores indicative of a diagnosis of attention deficit hyperactivity disorder (Allotey, et al., 2017).

One of the findings reported in several studies has been language disabilities, manifesting themselves as common difficulties encountered in preterm (PT) born infants (Guarini, et al., 2009). However, the existence of neurodevelopmental disorders in cases of moderate and late prematurity (from 32 to 37 weeks of gestational age) is sufficiently clarified.

Some studies have analysed the cognitive performance of PT children with low relevance risk factors for neurodevelopment. A wide heterogeneity in the neuropsychological profile of children born prematurely was observed, dependent on the interaction of several factors: the degree of neonatal medical complications, neurological changes, environmental, and social factors (Aylward, 2002; D'Odorini, & Cassibba, 2010). It was found that the most frequent deficits in children born prematurely, are neuromotor deficits, but rather minor neurosensory disorders (Allen, 2008).

The development profile of a PT child can be considered atypical and not just "delayed" in different areas of neurodevelopment (Sansavini, Guarini, & Caselli, 2011). Even premature children with low risk factors for neurodevelopment show specific cognitive deficits due to prematurity, such as: motor-eye coordination disorder; explicit and auditory processing disorder, and when achieving school-age, may present learning difficulties related to higher executive functions (attention, work memory and reasoning) (Bhutta, Cleves, Casey, & Anand, 2002; Schirmer, Portuguese, & Woodward, Thompson, Inder, & Edgin, 2005).

From the age of 6, when formal learning of basic skills such as reading, writing and arithmetic begins, there is a concern in relation to neurodevelopment is the schooling process. As it is quite complex, this process requires the acquisition of skills that are pre requisites for academic skills to develop. As a result of the possibility of an atypical neurodevelopment in PT children, it is not surprising that the lack of these prerequisites is reflected in their performance (Allen, 2008; Clark, et al., 2013; Odd, Evans, & Emond, 2019).

To assess the effects of prematurity on language development and the acquisition of reading and writing skills, researchers have sought to identify specific language difficulties that persist at school-age. They observed that some children present greater difficulties with complex language functioning (Noort-van der Spek, Franken, & Vervaeke, 2012) because at the age of eight, during the language consolidation phase (grammar understanding and phonemic fusion) and in the initial phase of literacy consolidation (reading and writing), their performance is significantly lower than that of their term peers (Guarini, Sansavini, Fabbri, Faldella, & Karmiloff-Smith, 2009).

A systematic review and meta-analysis to determine the developmental course of language functioning in preterm-born children from 3 to 12 years of age has demonstrated that the preterm born children score lower compared with term born children on simple, as well as on complex, language function tests throughout childhood, even in the absence of major disabilities. For complex language function, group differences between both preterm and term born children significantly increased from 3 to 12 years of age. These results suggest that complex language function might be a more useful index of language functioning in preterm born children than simple language function. From a linguistic perspective, this finding could be explained by the fact that complex language function depends more on higher order semantic and syntactic knowledge, entailing integration of different language domains and having a significant working memory component (Noort-van der Spek, J. P. Weisglas-Kuperus, 2012).

These difficulties can be explained by the changes in brain areas linked to language abilities observed based on neuroimaging, such as: changes in microstructures of the arched fascicle (Salvan, et al., 2017) and properties of the white substance found in the brains of children born PT (Acheson, Hamidi, Binder, & Peterson, 2012). It has also been found that the size of the adolescent's brain is smaller and shows a significant correlation with intelligence quotient, with the digit span and with the reading abilities shown for that age (Feldman, Leong, & Yeom, 2012; Peterson, et al., 2002). The presence of deficits in complex language functions in school children could be an indication that the plasticity of the developing brain is limited (Noort-van der Spek, J. P. Weisglas-Kuperus, 2012).

The main objective of this study is to analyse the influence of prematurity in the various domains of language and to verify whether there are differences in linguistic performance between children born prematurely and their peers born term. The aim is to analyse this performance according to the degree of prematurity of children, to the classification of the World Health Organisation (WHO, 2018): a) Extremely preterm (<28 weeks), b) Moderate to late preterm (28 to <32 weeks), and c) Moderate to late preterm (32 to <37 weeks).

Methods

Participants

All children in the study were attending primary school in public and private schools in the Autonomous Region of Madeira, Portugal. The study includes 27 children born preterm (PT) in 2007 and 2008, between the age of 7 and 9 years, without neurological pathology (cerebral palsy and related neurological diseases) and without being diagnosed with an intellectual deficit. This number corresponds to the total number of children born in the public hospitals of Madeira in the years indicated, and who fulfilled the required characteristics. The contrast group included 49 children born at term (T) and was formed taking into account the following requirements: for each child born prematurely, 2 term children were selected in the same calendar year, of the same gender, attending the same classroom, and with no language and/or learning difficulties. In 5 cases only one contrast child could be recruited per each PT child. There were no statistically significant differences in age between the two groups ($t=1.916$, $df=74$, $p=.06$) (Table 1). All children attended school between the 2nd to the 4th grade (Table 1).

Table 1. Characteristics of pre-term (PT) and term (T) children.

	PT	T
Age M ± SD	9.1 ± 0.5	8.8 ± 0.8
Gender		
Male	16	29
Female	11	20
Total	27	49
Gestational age M ± SD Range	33.7 ± 4.2 26 - 36	40.2 ± 1.7 37 - 44
Birth weight	1 583.9 ± 520.5 814 – 2 700	3 357.3 ± 305.3 2 710 – 3 960
School Year		
2 ^o year	7	10
3 ^o year	12	23
4 ^o year	8	16

Regarding the descriptive measures of the variables gestational age (GA) and birth weight (BW), it was found that in the PT group the mean GA was 33.7 weeks and the mean birth weight was 1583.9 g. In the term group the mean GA was 40.2 weeks and the mean BW was 3357.3 g (Table 1).

In the PT children, all preterm subcategories are represented (Table 2), although the extremely preterm (GA < 28 weeks) is only represented by three children and the very preterm (28 to < 32 weeks) by 13 children. The total of these two subcategories is 16 children, most of whom are male. As for the birth weight, the majority of these children were born below 1500 gr. In the group of moderate to late preterm children, composed of 11 children, all of them are also male, and all of them had a birth weight above 1500 gr.

Table 2. Subcategories of preterm birth based on gestational age (GA).

GA	Gender		Birth Weight (gr)		Total
	Male	Female	<1500	≥1500	
	N	n	n	n	n
Extremely Preterm (< 28 weeks)	2	1	3	0	3
Very preterm	8	5	8	5	13

(28 to <32 weeks)					
Moderate to late preterm (32 to <37 weeks)	6	5	0	11	11
Total	16	11	11	16	27

Instruments

For the oral language evaluation, the tests used were measured for the Portuguese population, with normative data for the different age groups. For the generic assessment of oral language skills, a language test for school children (*GOL-E; Grelha de Observação da Linguagem – idade escolar*) (Sua-Kay & Santos, 2012) aims at assessing abilities at the level of semantic structure (definition of words, semantic categorisation of opposites), morphosyntax (recognition of agrammatical sentences, coordination and subordination of word ordering and derivation of words), and phonology (auditory discrimination of words and pseudo-imitation of rhymes and syllabic segmentation). Maximum score: 122.

The assessment of complex abilities in semantics was carried out through a specific test for this purpose (*Teste de Avaliação Semântica*) (Sua-Kay, Santos, & Tavares, 2014), with tasks concerning syntagmatic lexical field, synonymy/antonymy, and paronyms. Maximum score: 98.

For verbal memory analysis was used a verbal memory span test (*TMP; Teste de Memória de Palavras*) (Sua-Kay & Santos, 2016), which aims to observe the capacity of verbal memory through tasks of repeating words (3,4,5 and 6 words) in three attempts. Maximum score: 54.

When testing, the rules of application set out in the manual for each test were taken into account. Data were collected in the morning, individually and in the same manner for all children. The order of the application was as follows: TAS, TMP and GOL-E, so that the most complex tasks were carried out at the beginning of the assessment. The 76 children were assessed between February and March 2018 in their respective schools.

Procedures

For general information about the child, such as personal history (pregnancy, childhood, schooling), and any impairments, was consulted the interview protocol of medical history used in the hospital unit where they were born. The missing data was collected from the respective parents/carers. All parents/carers gave informed consent before the evaluation process, and confidentiality relating to participants and data was guaranteed. The study was authorised by the Ethics Committee of the Regional Health Service of the Autonomous Region of Madeira.

Data Analyses

The statistical treatment of data was based on the use of descriptive methods and methods of statistical inference. The methods associated with statistical inference allowed assessing the differences between the study group and preterm, through parametric tests, the T-Student test for independent samples, or non-parametric tests when normality restrictions, such as the Mann-Whitney test. The normality of the variables under study was verified using the Kolmogorov-Smirnov or Shapiro Wilk tests, depending on the sample size to be tested. For paired comparisons, the significance of the difference between the two paired measurements was assessed using the Wilcoxon test, a non-parametric alternative to the T-Student test when the assumption of normal distribution of the variables for the two measurements is not verified.

After conducting all the tests, a detailed descriptive analysis of the results obtained was carried out. A comparison of the results obtained between the study group (PT) and the contrast group (T) was made using the t-Student test for paired samples, using the mean obtained by each pair of contrast children. We also compared the results according to the degree of prematurity by creating two groups of PT children: group A which included 3 extremely preterm and 13 very preterm) and group B which included 11 children (moderately preterm). Thus, in order to understand whether the gestational age and birth weight influence the results obtained for the group of premature children, an analysis using the non-parametric Mann-Whitney test was carried out on subgroups of premature children: group A and group B. For the analysis of the influence of birth weight, a comparison between children below 1500 gr and equal to or above 1500 gr was considered, in the total of the group of PT children. The Pearson correlation coefficient was applied to determine whether there was a correlation between the different linguistic skills evaluated in these children.

1. Generic language assessment (GOL-E) – preterm and term children

Table 3. Results on general language tasks (GOL-E).

GOL-E		Group			
		PT	T	t (df)	
Semantics	M ± SD	24.78 ± 6.46	28.28 ± 2.76	-2,65 (26)	
	Range	11.00 – 34.00	23.00 – 35.00		
Morphosyntax	M ± SD	33.11 ± 9.07	37.80 ± 4.26	-2,44 (26)	
	Range	16.00 – 46.00	26.50 – 46.00		
Phonology	M ± SD	36.33 ± 4.89	39.02 ± 1.58	-3.10 (26)	
	Range	18.00 – 40.00	36.00 – 43.00		
Total	M ± SD	94.22 ± 18.71	105.09 ± 6.00	-2.93 (26)	
	Range	49.00 – 120.00	91.50 – 115.50		

1.1. Generic language assessment in PT children

Table 4. Results of general language tasks (GOL-E) in preterm groups.

Preterm Groups		Semantics	Morphosyntax	Phonology	
Group A	M ± SD	23.5 ± 7.2	29.4 ± 9.1	35.3 ± 5.7	88
	Range	11 – 34	16 - 46	18 - 40	4
Group B	M ± SD	26.6 ± 4.8	38.6 ± 6.0	37.9 ± 3.1	10
	Range	18 – 34	25 - 46	31 - 40	
Mann-Whitney U test	U	65.0	34.0	52.0	
	p	.25	.008	.072	

Regarding the variable weight at birth, PT children under 1500 gr. had a significantly lower perform morphosyntactic tasks ($M=28.64 \pm 8.02$ vs $M=37.47 \pm 7.23$, $p=.009$) and for the total value of GOL-E 19.09 vs $M=101.93 \pm 14.36$, $p=.043$).

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It was verified that there are statistically significant differences between the two groups in all the components of the semantic complex test (lexical field, syntactic relations, synonyms and antonyms, and paronyms) with the results being for the PT group (table 5).

Table 5. Results on Semantics tasks (TAS).

TAS		Group		t (df)
		PT	T	
Lexical field	M ± SD	12.07 ± 4.20	14.46 ± 2.33	-2,74 (26)
	Range	5.00 – 21.00	9.00 – 17.50	
Syntagmatic relations	M ± SD	14.93 ± 5,66	18.41 ± 3.08	-3,28 (26)
	Range	5.00 – 23.00	10.50 – 22.50	
Synonyms / Antonyms	M ± SD	12.37 ± 5.57	16.22 ± 2.94	-3,66 (26)
	Range	0.00 – 23.00	6.00 – 20.00	
Paronymous	M ± SD	13.41 ± 5.37	17.07 ± 2.93	-2,98 (26)
	Range	1.00 – 21.00	11.00 – 21.50	
Total	M ± SD	52.78 ± 18.26	66.17 ± 9.58	-3,71 (26)
	Range	20.00 – 83.00	40.00 – 81.00	

t-Student Test for paired samples.

2.1 Evaluation of complex semantic tasks in PT children

When comparing the mean results of the semantic evaluation, by component, according to gestatic differences found were statistically significant for all of them. We observed that children extremely or very low prematurity show a significantly lower performance when compared to the group with moderate to late prematurity.

Table 6. Results on Semantics tasks (TAS) in preterm groups.

Preterm Groups		Lexical field	Syntagmatic Relations	Synonyms /Antonyms	Paronymou	
Group A	M ± SD	10.3 ± 2.7	13.3 ± 5.3	10.3 ± 2.2	11.7 ± 5.2	4
	Range	6 – 15	5 – 22	7 – 15	1 – 21	
Group B	M ± SD	14.7 – 4.7	17.4 – 5.5	15.4 – 7.5	15.9 – 4.8	6
	Range	5 – 21	7 – 23	0 – 23	7 – 21	
Mann-Whitney U test	U	32.0	45.0	40.0	44-5	
	p	.005	.033	.017	.031	

The differences regarding birth weight, are also statistically significant for all components: lexical field (M=10.27 ± 2.37 vs M=13.80 ± 4.4, p=.023), paronyms (M=11.73 ± 3.79 vs M=15.47 ± 5.05, p=.033), synonyms and antonyms (M=10.27 ± 2.37 vs M=14.20 ± 6.72, p=.045) and for the total of the test (M=46.18 ± 10.79 vs M=59.00 ± 10.35, p=.035).

3. Verbal memory span (TMP) – preterm and term children

In the verbal memory evaluation, it was found that in the first two repetitions children from both groups gave correct answers, but in the third repetition the PT group performed less successfully, as well as performing less in the total results of the testing (table 7).

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Table 7. Results on verbal memory tasks (TMP) of preterm and term children.

Repetition		Group		t (df)	
		PT	T		
1ª R	M ± SD	9.59 ± 2.87	10.64 ± 1.78	-1,50 (26)	
	Range	3.00 – 15.50	7.75 – 14.00		
2ª R	M ± SD	12.00 ± 2.86	13.29 ± 1.58	-1,99 (26)	
	Range	6.00 – 15.50	10.00 – 15.50		
3ª R	M ± SD	12.70 ± 3.41	14.81 ± 1.86	-2,76 (26)	
	Range	5.00 – 18.00	11.25 – 18.00		
TOTAL	M ± SD	34.30 ± 8.33	38.73 ± 4.62	-2,31 (26)	
	Range	15.00 – 44.50	30.50 – 46.25		

t-Student Test for paired samples

3.1 Verbal memory span in premature children

There were no statistically significant differences in word memory due to gestational age or birth weight of PT children (Table 8).

Table 8. Results on verbal memory tasks (TMP) in preterm groups.

Preterm Groups		1ª R	2ª R	3ª R	
Group A	M ± SD	10.2 ± 3.2	11.7 ± 2.8	12,2 ± 3.3	34
	Range	3.0 – 15.5	7.0 – 15.5	7.0 – 17.0	18
Group B	M ± SD	8.8 ± 2.3	12.5 ± 3.0	13.5 ± 3.6	34
	Range	4.0 – 11.0	6.0 – 15.0	5.0 – 18.0	15
Mann-Whitney U test	U	58.5	70.0	65.0	
	p	.143	.372	.255	

From the analysis made to the total values obtained in the three oral language assessments, it can be seen that children have a lower performance profile when compared to their term peers (Figure 1). The comparison of PT children with lower or higher prematurity showed that the overall performance is better in group B (

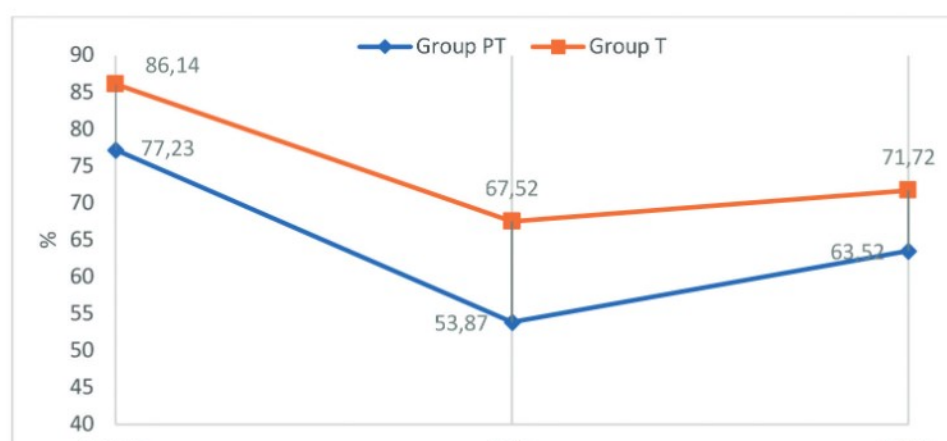
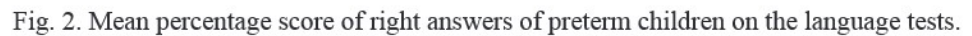




Fig. 1. Mean percentage score of right answers of preterm and term children on the language test



There is a statistically significant association, represented by a positive linear correlation coefficient, results of the three language tests – GOL-E (general language components), TAS (complex semantic: (verbal memory) in PT children. The higher the value obtained in one of them, the higher the values language tests (table 9).

Tests		TMP	TAS	GOL-E
TMP	Pearson Correlation Coefficient	-	.640**	.747**
	P	.	.000	.000
TAS	Pearson Correlation Coefficient	.640**	-	.863**
	P	.000	.	.000
GOL-E	Pearson Correlation Coefficient	.747**	.863**	-
	P	.000	.000	.

Discussion

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nents (semantics, morphosyntax, and phonology) in more than a half of the observed subjects, especially and very preterm children. However, there were no differences between the results obtained on verbal memory by preterm children, in average always below the results of the contrast group.

The preterm children do not show the improvement with the word repetition observed in their term testing verbal memory. Scientific evidence shows that memory abilities, specifically those related to th

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storage of verbal information, are associated with language development (Snowling & Nag, 2012). It is a potential biological factor that correlates with verbal memory ability and in turn with linguistic performance in verbally expressive language (D'odorico, Costantini, & Cassibba, 2010). The present study tends to validate these statements, as we found that premature children had lower results in comparison to their peers, in both language and verbal memory. Contrary to what might have been expected, there were not many differences between children with a higher or lower degree of prematurity in general language tasks and in verbal memory. In the results obtained differed only in morphosyntactic and in complex semantic tasks. However, these differences became somewhat more evident when comparing birth weight. An important aspect was that there was no difference on verbal memory of either gestational age or birth weight, which could be influenced by the fact that extremely premature children included only 3 subjects.

If the existence of an adequate linguistic processing depends on the complex interaction of functions of the executive domain, where the attentional, mnemonic and executive processes stand out, we may question as to whether the deficits presented by PT children, may be compromised due to changes at the level of the different stages of the memory system, which are: acquisition/codification; retention/consolidation, and recovery/evocation (Aylward, 2002; Baddeley, 2003).

Another important aspect of the learning process is working memory. Based on the assumption that working memory is an important factor for the understanding of language, which intervenes in problem solving, in the performance of complex tasks and in the acquisition of new knowledge; it is evident that the results obtained in tasks of language, as well as, in tasks of semantic domain and verbal memory, proving that premature children are at risk in these areas, since atypicality is visible in linguistic development when compared with their term peers (Hamidi, Binder, & Postle, 2011; Baddeley, Hitch, & Allen, 2009; Riva, Cantiani, Marini, Dionne, & Milner, 2010). An important factor that correlates with language performance in children born preterm is attention capacity. It is known that lower gestational age was significantly related to lower alerting attention capacities and lower language functioning (Allotey, et al., 2017; Noort-van der Spek, Franken, & Weisglas-Kuperus, 2012; Šušteršič, Verhoeven, & Van Baar, 2020;).

The results of this study show that children born prematurely, even those born of late to moderate prematurity, present a lower linguistic performance that is strictly related to verbal memory skills. Based on this assumption and taking into account the results of the literature review, it may be suggested that this performance may also be related to attention difficulties, once it is also mentioned as a consequence of prematurity. These limitations may lead to learning difficulties at school as it is based essentially on verbal skills (Snowling & Nag, 2012).

Limitations

The small sample size of children born preterm is considered a limitation of this study. Due to the heterogeneity of the sample and its number, it was not possible to characterise the linguistic profile in all degrees of prematurity considering gestational age and birth weight.

Conclusions

Preterm born children, regardless of their prematurity grade, showed significantly lower results than the term children. They presented low scores in all language tests simultaneously, showing an important language deficit. Verbal memory was proved to be lower than that of their term peers, regardless of the gestational age and birth weight of preterm children. As a result of this analysis we consider that the evaluation of the linguistic development of these children should be monitored in order to identify earlier the existence of deficits. In cases of moderate to late prematurity, should be monitored in order to identify earlier the existence of deficits. In cases of moderate to late prematurity, should be monitored in order to identify earlier the existence of deficits. In cases of moderate to late prematurity, should be monitored in order to identify earlier the existence of deficits. Therefore, we defend a paradigm shift in the monitoring of these children, from pre-school and school level, who often do not show any disorders and are therefore not "flagged", to the need to intervene in time to allow for a more balanced development and successful learning.

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