Original Article

Artigo Original

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Prevalence of phonological disorders and phonological processes in typical and atypical phonological development

Ocorrência do desvio fonológico e de processos fonológicos em aquisição fonológica típica e atípica

Keywords

Articulation Disorders
Child
Speech
Speech Disorders
Epidemiology

ABSTRACT

Purpose: To determine the occurrence of phonological disorders by age, gender and school type, and analyze the phonological processes observed in typical and atypical phonological development across different age groups. **Methods:** The sample consisted of 866 children aged between 3:0 and 8:11 years, recruited from public and private schools in the city of Santa Maria/RS. A phonological evaluation was performed to analyze the operative phonological processes. **Results:** 15.26% (n = 132) of the sample presented atypical phonological acquisition (phonological disorders). Phonological impairments were more frequent in public school students across all age groups. Phonological alterations were most frequent between ages 4 -to 6, and more prevalent in males than females in all but the youngest age group. The most common phonological processes in typical phonological acquisition were: cluster reduction; nonlateral liquid deletion in coda; nonlateral liquid substitution in onset; semivocalization of lateral liquids in coda; and unstressed syllable deletion. In children with phonological disorders, the most common phonological processes were: lateral and nonlateral liquid substitution in onset position; nonlateral liquid deletion; fronting of fricatives in onset position; unstressed syllable deletion; semivocalization of nonlateral liquid in coda; and nonlateral liquid deletion in coda position. **Conclusion:** Phonological processes were highly prevalent in the present sample, and occurred more often in boys than in girls. Information regarding the type and frequency of phonological processes in both typical phonological acquisition and phonological disorders may contribute to early diagnosis and increase the efficiency of treatment planning.

Descritores

Transtornos da Articulação
Criança
Fala
Distúrbios de Fala
Epidemiologia

RESUMO

Objetivo: Determinar a ocorrência de desvio fonológico quanto à idade, gênero e tipo de escola, além de verificar e analisar os processos fonológicos em casos de aquisição fonológica típica e atípica em diferentes faixas etárias. **Método:** Participaram 866 crianças com idades entre 3:0 e 8:11, matriculadas em escolas públicas e privadas de Santa Maria-RS. Realizou-se avaliação fonológica para analisar os processos fonológicos operantes. **Resultados:** 15,26% (n = 132) das crianças avaliadas apresentavam aquisição fonológica atípica (desvio fonológico). As escolas públicas tiveram maior ocorrência de desvio fonológico para todas as idades pesquisadas. Houve maior ocorrência de desvio fonológico nas idades de 4 anos, 5 anos e 6 anos. O gênero masculino teve maior ocorrência que o feminino, com exceção na idade de 3 anos. Na aquisição fonológica típica, os processos que mais ocorreram foram: redução do encontro consonantal, apagamento de líquida não lateral em *coda*, substituição de líquida não lateral em *onset*, semivocalização de líquida não lateral em *coda* e apagamento de sílaba átona. No desvio fonológico, foram: substituição de líquida lateral e não lateral em *onset*, apagamento de líquida não lateral, anteriorização de fricativa em *onset*, apagamento de sílaba átona, semivocalização de líquida não lateral em *coda* e apagamento de líquida não lateral em *coda*. **Conclusão:** A média da ocorrência foi considerada alta e mais frequente nos meninos. É importante saber a ocorrência e conhecer os processos fonológicos operantes na fala das crianças, pois estes podem auxiliar no diagnóstico precoce das alterações fonológicas, bem como na elaboração do planejamento terapêutico.

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Received: February 02, 2016

Accepted: August 30, 2016

Study carried out at Programa de Pós-graduação em Distúrbios da Comunicação Humana, Departamento de Fonoaudiologia, Universidade Federal de Santa Maria – UFSM - Santa Maria (RS), Brazil.

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Financial support: nothing to declare.

Conflict of interests: nothing to declare.

INTRODUCTION

Language - or phonological - acquisition is a gradual process which culminates in the mastery of all speech sounds in a given language. As children grow, their phonological inventories become increasingly complete, and less susceptible to individual variability[1]. In Brazilian Portuguese (BP), phonological mastery is usually achieved by age 5[2].

Phonological acquisition does not follow a uniform pattern across the population, with some children experiencing delays or deviations in the process[3]. Phoneme substitutions or even deletions, leading to the omission of a phoneme or even an entire syllable from a particular word, are a common part of phonological acquisition[4]. However, over the course of typical development, children will gradually overcome these difficulties and fill out their phonological inventory. Unfortunately, in some cases, these difficulties persist well beyond the expected time frame, for reasons ranging from impairments in speech motor planning (speech apraxia)[5], to articulatory distortions, or phonetic disorders[5,6]; to linguistic difficulties arising from the mental organization of speech sounds, or phonological disorders[6,7].

The phonological disorders observed in children with atypical phonological acquisition are characterized by the inability to produce a given phoneme, often a consonant or consonant cluster, by its expected age of acquisition[8]. In moderate to severe cases, phonological disorders can render speech unintelligible[9,10], leading to significant impairments in communication and social interaction[6,8,10,11].

Phonological disorders are among the most common linguistic impairments in children[8,11-13]. According to the literature, the availability of prevalence estimates for these conditions is crucial for prevention and intervention strategies in speech pathology, especially in the context of oral language and phonological acquisition[14].

Both typical and atypical phonological development are associated with the use of strategies to simplify speech sounds which are more complex or still in the process of acquisition[2,3]. These strategies are known as phonological processes.

Although some phonological processes are to be expected during the phonological acquisition process, these should gradually disappear with age[2]. Few phonological processes persist after age 6, with cluster reduction being among the most common to do so[1].

The concept of prevalence refers to the number of people in a population who share a particular characteristic. Prevalence rates for different illnesses at a certain point in time are often calculated in the context of health care[15]. However, few studies to date[8,14,16-22] have sought to analyze the occurrence of phonological disorders in Brazilian children. Although some of these studies were conducted in recent years, they vary widely in terms of their methods, sample sizes (where larger samples indicate greater reliability), and geographical coverage. Additionally, only a few studies have been able to report the occurrence of phonological disorders by age group.

Therefore, the aim of this study was to determine the occurrence of phonological disorders by age, gender and school type, while analyzing the phonological processes observed in children of different ages with both typical and atypical phonological development.

METHODS

This quantitative, cross-sectional study was approved by the Research Ethics Committee (REC) of a higher education institution under protocol number 23081.005433/2011-65. All children provided oral assent to participation in the study, while legal representatives provided written informed consent.

Participants and inclusion criteria

The sample was recruited from seven public schools and four private institutions in the city of Santa Maria (RS), and one public school in the city of Guaíba (RS). Participants were selected by convenience, and as a result, sample size was not determined based on the demographic profile of the cities where the study was conducted, but rather, by the number of children and guardians who agreed to participate. Of the 1448 children considered eligible for the study, 1075 (73%) received parental consent to participate and were evaluated by speech pathologists from June 2013 to September 2014.

All participants had a brief conversation with the speech pathologist prior to undergoing the assessment. Participants' parents/guardians and teachers were asked to provide additional information about the children through a questionnaire inquiring into alterations in speech comprehension and production, hearing difficulties, school performance, classroom behavior, etc.

The sample was also screened for the following exclusion criteria: bilingualism; hearing complaints or suspected hearing loss; self-reported neurological and/or psychological conditions; intellectual disability; a diagnosis of autism or Down's syndrome; previous speech therapy; anterior open bite; lisp; tongue-thrust; suspected language and/or vocabulary deficits. The presence of these conditions was determined based on parental and teacher questionnaires, as well as the speech assessment performed as part of the study. These criteria led to the exclusion of 210 children from the study.

The final sample therefore consisted of 866 children aged between 3 years, and 8 years 11 months. After the phonological assessment, participants were classified into typical and atypical acquisition groups, based on the presence of phonological disorders, and stratified by type of school (public and private) and gender (male and female). The selection of participants from different school types allowed for an analysis of performance across socioeconomic subgroups.

Instruments and procedures

An individual testing session was conducted with participants in a classroom at each of their schools. After a brief conversation with each participant, the children were administered the Phonological Assessment Instrument (*Instrumento de Avaliação Fonológica*; INFONO)[23].

The conversation and administration of the INFONO[23] were conducted by four speech therapists, three of whom were doctoral students, while the fourth was a speech pathologist

with over 10 years of experience in phonological assessment. All therapists had been previously trained in the administration of the assessment instruments.

The INFONO[23] is a software tool for phonological assessment which collects speech samples and provides immediate results, facilitating the evaluation of large numbers of children. Our reasons for selecting this particular instrument for the present study include its software format, which facilitates test administration and the analysis of task results, as well as the availability of normative data and validity indicators for the southern Brazilian population. Additionally, the INFONO[23] allows for the assessment of all consonant sounds in Brazilian Portuguese in different syllable and word positions.

The administered individually according to standardized procedures, in a session lasting approximately 15 to 20 minutes. Using the INFONO[23], an examiner can conduct the assessment through repetition, spontaneous naming or connected speech tasks. In the present study, the method selected was spontaneous naming.

Participants were asked to name 84 animated images, or GIFs. Each image was followed by a prompt from the examiner to facilitate the production of the associated target word. Examples include: "He uses the pencil to...?" (write), "What animal is this?" (dog), etc. If necessary, the examiner may ask additional questions to elicit the correct term. However, in the present study, such questions were rarely required, and participants were able to name all items in the INFONO[23].

Children's responses were audio recorded and transcribed using broad phonetic transcription with the help of the software itself, which allows the examiner to select the appropriate transcription units during the assessment. After the test is completed, the accuracy of the transcription can be verified by the examiner. The INFONO[23] provides possible transcriptions for each target word, and the examiner must select the one which corresponds to the response of the child, or complement the transcription if necessary.

The results of the assessment were given to the parents of every participating child, and referrals to public clinics for speech and language therapy were made whenever necessary.

After the assessment, the INFONO[23] provides information on phonological processes, as well as contrast analysis, in which the phonemes that are present or absent from the phonetic and phonological inventory are identified. After analyzing participants' phonological inventory, the sample was classified based on the presence of phonological disorders, resulting in two groups corresponding to typical and atypical phonological acquisition, respectively. The analysis of phonological processes was performed in order to identify and determine the age-appropriateness of syllable structure and substitution processes in the production of every phoneme in Brazilian Portuguese. This procedure was conducted with every process which occurred with a frequency of at least 15% in the sample. This value was selected based on the definition of phoneme acquisition adopted in the present study, which requires that a phoneme be produced correctly at least 85% of the time.

Phonological assessment findings were therefore analyzed and discussed for two distinct participant groups. Those with typical phonological acquisition were able to produce all phonemes expected of a child their age[24]. For instance, a child aged 4 years 7 months in the typical acquisition group must have acquired all phonemes in Brazilian Portuguese, and exhibit no phonological processes except for cluster reduction. Those in the atypical phonological acquisition (phonological disorder) group, on the other hand, showed substitution and deletion processes which were no longer expected to occur in a child their age.

Data analysis

Assessment results were stored electronically and entered into Excel and SPSS spreadsheets (version 22 for Windows). These data were used to calculate and compare the prevalence of phonological disorders by age group, school type and gender.

The frequency of phonological processes in typical and atypical acquisition was also calculated and compared. The prevalence of phonological impairments was compared between age groups, genders and school types using Chi-square tests. Results were considered significant at $p \leq 0.05$. The frequency of phonological processes was calculated as a percentage of each participant group.

RESULTS

The sample consisted of 866 children, 84.6% (n = 733) of whom exhibited typical phonological acquisition, while the remaining 15.4% (n = 133) presented with phonological disorders. A total of 44.6% (n = 386) of the sample attended public schools while 55.4% (n = 480) attended a private institution. Most participants were female (52.6%; n = 455), while 47.4% (n = 411) of the sample was male. Children ranged in age from 3 years, to 8 years 11 months. Phonological disorders, that is, phoneme substitution and deletion errors, were identified in 15.4% of the sample (n = 133). Participants who showed phonetic and phonetic-phonological impairments were excluded from the analysis. The prevalence of phonological disorders by school type and age group is shown in Table 1. Overall, the frequency of these impairments in the sample was considered quite high.

As can be seen in Figure 1, phonological impairments were more frequent in public school students across all age groups (X^2 = 8.883; p = 0.003). The highest prevalence rates for phonological disorders were observed at ages 4, 5 and 6, respectively. Among 6-year-olds, phonological disorders were twice as frequent in public school relative to private school students (X^2 = 8.935, p = 0.003). These impairments were also more prevalent in public schools at age 8 (X^2 = 6.076, p = 0.016).

The occurrence of phonological disorders by gender and age group is shown in Table 2. Prevalence rates were higher for males than females (X^2 = 8.982, p = 0.003) across all age groups except for the youngest (Figure 2).

At ages 7 and 8, phonological disorders were significantly more frequent in males than females (X^2 = 8.224, p = 0.004, and X^2 = 6.984, p = 0.012, respectively). At age 3, although females showed a much higher prevalence of phonological disorders than males, this difference was not statistically significant.

Table 1. Prevalence of phonological impairments by school type and age group

Age (years old)	Type of school								Total			
	Public				Private							
	N	n	n¹	P¹	N	n	n¹	P¹	N	n	n¹	P1
3;0	45	39	6	13.33	61	58	3	4.92	106	97	9	8.49
4;0	57	44	13	22.80	70	56	14	20.00	127	100	27	21.26
5;0	95	75	20	21.05	75	60	15	20.00	170	135	35	20.59
6;0	75	53	22	29.33	135	118	17	12.59	210	171	39	18.57
7;0	60	54	6	10.00	84	76	8	9.52	144	130	14	9.72
8;0	54	46	8	14.81	55	54	1	1.82	109	100	9	8.26
Total	386	311	75	19.43	480	422	58	12.08	866	733	133	15.36

Caption: N = Total number of participants; n = number of participants with typical phonological acquisition; n¹ = Number of participants with phonological disorders; P¹ = Frequency of phonological disorders

Table 2. Prevalence of phonological impairments by gender and age group

Age (years old)	Gender								Total			
	Male				Female							
	N	n	n¹	P¹	N	n	n¹	P¹	N	n	n¹	P¹
3;0	49	47	2	4.08	57	50	7	12.28	106	97	9	8.49
4;0	61	47	14	22.95	66	53	13	19.70	127	100	27	21.26
5;0	78	58	20	25.64	92	77	15	16.30	170	135	35	20.59
6;0	101	78	23	22.77	108	92	16	14.81	209	171	39	18.66
7;0	71	59	12	16.90	74	72	2	2.70	145	130	14	9.66
8;0	51	43	8	15.69	58	57	1	1.72	109	100	9	8.26
Total	411	332	79	19.22	455	401	54	11.87	866	733	133	15.36

Caption: N = Total number of participants; n = number of participants with typical phonological acquisition; n¹ = Number of participants with phonological disorders; P¹ = Frequency of phonological disorders

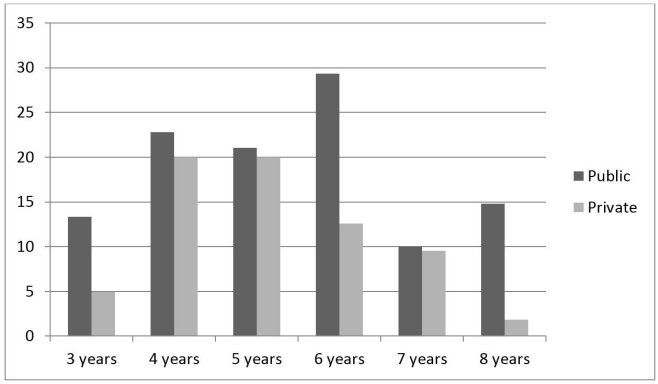


Figure 1. Frequency of phonological disorders in public and private schools

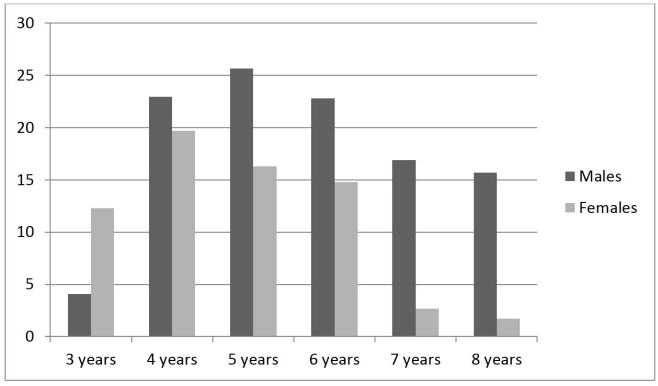


Figure 2. Frequency of phonological disorders in males and females

Overall, the occurrence of phonological processes in the typical acquisition group decreased with age (Table 3). The most common phonological processes other than cluster reduction in 3- and 4-year-olds were: nonlateral liquid deletion in word-final position; nonlateral liquid substitution in onset; semivocalization of nonlateral liquid in coda; and unstressed, pre-stress syllable deletion. At age 5, cluster reduction and nonlateral liquid substitution in onset position were especially frequent. From this age onward, a drastic reduction in the prevalence of phonological processes was observed.

In typical phonological acquisition, nonlateral liquid substitution in onset position was especially frequent, and showed high prevalence rates until the age of 8. However, this may be attributable to a population-specific language variation, since this process was mostly observed in a single word: /ko'λɛr/ (*colher*; spoon) which was pronounced /ko'lɛr/. This substitution error did not occur in other words containing this phoneme.

Unstressed, pre-stress syllable deletion was also quite frequent between the ages of 3 and 5. However, this process was only observed in a single target word, "*biblioteca*" (library), which is also the only five-syllable word in the instrument. This type of error was much less frequent in four-syllable target words ("*bicicleta*"/bicycle, "*travesseiro*"/pillow, "*ventilador*"/fan, "*passarinho*"/bird, "*microfone*"/microphone), and even then, was mostly limited to younger age groups.

The occurrence of phonological processes in children with phonological disorders did not decrease with age (Table 4). Overall, the prevalence of these errors remained high among

older children. The most common phonological processes other than cluster reduction in this participant group were: lateral and nonlateral liquid substitution in onset position; nonlateral liquid deletion; fronting of fricatives in onset position; unstressed, pre-stress syllable deletion; semivocalization of nonlateral liquid in coda; and nonlateral liquid deletion in coda position.

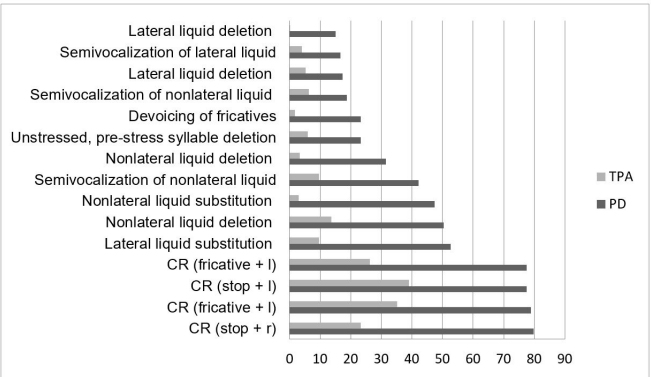
Some of the phonological processes displayed by participants with phonological disorders, such as the fronting and backing of plosive sounds, assimilation and affrication, were not observed in typical phonological acquisition.

The frequency of phonological processes exhibited by over 15% of children with phonological impairments was also compared to their prevalence in participants with typical phonological acquisition (Figure 3). Participants with phonological disorders showed a significantly higher prevalence of phonological processes than the remainder of the sample.

Table 3. Prevalence of phonological impairments by age group in typical phonological acquisition

Age (years old)	3;0 (n=97)		4;0 (n=100)		5;0 (n=135)		6;0 (n=170)		7;0 (n=131)		8;0 (n=100)		Total (n=733)	
Phonological Process	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Onset														
CR (stop + l)	87	89.80	63	63.00	66	48.89	32	18.82	27	20.61	11	11.00	286	39.02
CR (stop + r)	86	88.78	56	56.00	26	19.26	1	0.59	1	0.76	-	-	170	23.19
CR (fricative + l)	85	87.76	69	69.00	60	44.44	31	18.24	8	6.11	5	5.00	258	35.20
CR (fricative + r)	83	85.71	50	50.00	40	29.63	10	5.88	7	5.34	2	2.00	192	26.19
Lateral liquid substitution	46	46.94	50	50.00	66	48.89	49	28.82	23	17.56	11	11.00	245	33.42
Nonlateral liquid substitution	53	55.10	15	15.00	2	1.48	-	-	-	-	-	-	70	9.55
Semivocalization of lateral liquid	19	19.39	2	2.00	1	0.74	-	-	-	-	-	-	22	3.00
Semivocalization of nonlateral liquid	25	25.51	4	4.00	-	-	-	-	-	-	-	-	29	3.96
Nonlateral liquid deletion	37	37.76	8	8.00	-	-	1	0.59	-	-	-	-	46	6.28
Lateral liquid deletion	21	21.43	2	2.00	1	0.74	-	-	-	-	-	-	24	3.27
	2	2.04	-	-	-	-	-	-	-	-	-	-	2	0.27
Unstressed, pre-stress syllable deletion	50	52.04	22	22.00	15	11.11	5	2.94	2	1.53	-	-	94	12.82
Coda														
Semivocalization of nonlateral liquid	50	52.04	15	15.00	3	2.22	1	0.59	1	0.76	1	1.00	71	9.69
Nonlateral liquid deletion	66	68.37	23	23.00	6	4.44	3	1.76	1	0.76	1	1.00	100	13.64
Lateral liquid deletion	11	11.22	4	4.00	1	0.74	2	1.18	-	-	-	-	18	2.46
Nasal deletion	5	5.10	2	2.00	-	-	-	-	-	-	-	-	7	0.95
Fricative deletion	32	32.65	5	5.00	1	0.74	-	-	-	-	-	-	38	5.18
Frication	1	1.02	-	-	-	-	-	-	-	-	-	-	1	0.14
Devoicing of stops	3	3.06	-	-	1	0.74	-	-	-	-	-	-	4	0.55
Devoicing of fricatives	5	5.10	2	2.00	1	0.74	1	0.59	2	1.53	2	2.00	13	1.77

Caption: n = number of participants; CR = cluster reduction



Caption: CR = cluster reduction

Figure 3. Frequency of phonological processes in participants with typical phonological acquisition (TPA) and phonological disorders (PD)

Table 4. Prevalence of phonological impairments by age group in atypical phonological acquisition (phonological disorders)

Age (years old)	3;0 (n=9)		4;0 (n=27)		5;0 (n=35)		6;0 (n=39)		7;0 (n=14)		8;0 (n=9)		Total (n=133)	
Phonological Process	n	%	n	%	n	%	n	n	%	n	%	n	%	n
Onset														
CR (stop + l)	8	88.89	25	92.59	26	74.29	29	74.36	9	64.29	6	66.67	103	77.44
CR (stop + r)	9	100	24	88.89	28	80.00	28	71.79	11	78.57	6	66.67	106	79.70
CR (fricative + l)	9	100	26	96.30	28	80.00	30	76.92	8	57.14	4	44.44	105	78.95
CR (fricative + l)	9	100	24	88.89	31	88.57	24	61.54	8	57.14	7	77.78	103	77.44
Nasal substitution	-	-	1	3.7	-	-	1	2.56	-	-	-	-	2	1.50
Lateral liquid substitution	6	66.67	13	48.15	17	48.57	22	56.41	6	42.86	6	66.67	70	52.63
Nonlateral liquid substitution	9	100	19	70.37	17	48.57	13	33.33	3	21.43	2	22.22	63	47.37
Semivocalization of lateral liquid	4	44.44	7	25.93	6	17.14	5	12.82	-	-	-	-	22	16.54
Semivocalization of nonlateral liquid	5	55.56	6	22.22	7	20.00	6	15.00	1	7.14	-	-	25	18.80
Nonlateral liquid deletion	7	77.78	12	46.15	11	31.43	8	20.51	3	21.43	1	11.11	42	31.58
Lateral liquid deletion	4	44.44	9	33.33	4	11.43	3	7.69	-	-	-	-	20	15.04
Nasal deletion	1	11.11	1	3.70	2	5.71	1	2.56	-	-	-	-	5	3.75
Unstressed, pre-stress syllable deletion	6	66.67	7	25.93	5	14.29	11	28.21	-	-	2	22.22	31	23.31
Stops backing	2	22.22	1	3.70	-	-	-	-	-	-	-	-	3	2.25
Fricatives backing	2	22.22	7	25.93	3	8.57	5	12.50	-	-	1	11.11	18	13.53
Stops fronting	7	77.78	3	11.11	1	2.86	2	5.13	-	-	-	-	13	9.77
Fricatives fronting	7	77.78	12	44.44	17	48.57	10	25.64	3	21.43	4	44.44	53	39.84
Stopping	2	22.22	2	7.41	2	5.71	1	2.56	-	-	1	11.11	8	6.01
Frication	-	-	2	7.41	-	-	-	-	-	-	-	-	2	1.50
Devoicing of stops	2	22.22	1	3.70	3	8.57	2	5.13	1	7.14	3	33.33	12	9.02
Devoicing of fricatives	3	33.33	5	18.52	10	28.57	6	15.38	3	21.43	4	44.44	31	23.31
Assimilation	1	11.11	-	-	-	-	1	2.56	-	-	-	-	2	1.50
Affrication	1	11.11	2	7.41	-	-	2	5.13	-	-	-	-	5	3.76
Coda														
Semivocalization of nonlateral liquid	8	88.89	14	53.85	18	51.43	13	33.33	2	14.29	1	11.11	56	42.10
Nonlateral liquid deletion	8	88.89	17	62.96	20	57.14	18	46.15	3	21.43	1	11.11	67	50.37
Lateral liquid deletion	4	44.44	3	11.11	4	11.43	1	2.56	-	-	1	11.11	13	9.77
	3	33.33	-	-	1	2.86	-	-	-	-	-	-	4	3.01
	5	55.56	9	33.33	6	17.14	3	7.69	-	-	-	-	23	17.29

Caption: n = number of participants; CR = cluster reduction

DISCUSSION

The prevalence of speech impairments, especially phonological disorders, has been discussed by several studies[8,17-20,25-27] in the national and international literature. In Australia, phonological disorders affect approximately 13%[27] of children, while in the United States, this figure is somewhat lower, and ranges from 3.8% to 7.5%[25].

In the present study, the mean frequency of phonological impairments was 15.26%, with a range of 8.26% to 20.63%. These findings were similar to those obtained by other studies[17,18,26] conducted in Brazil. In 2006, an investigation[17] performed in the same city as the present study reported a prevalence of 18.55% for phonological impairments in children aged 5 years 7 months to 7 years 5 months. Another study[26] conducted in the city of Porto Alegre (RS) in southern Brazil identified phonological alterations in 10% of a sample of children aged 5 years 4 months to 6 years 11 months. However, a study performed in the city of Canoas (RS)[19], also in southern Brazil, obtained a much higher prevalence estimate for phonological disorders in the population studied (55%). Lastly, a study[18] performed in the city of Salvador (BA)

reported a prevalence of 9.17% for phonological impairments in children aged 4:7 to 6:11 years.

The present findings were similar to those of other studies conducted in Brazil, except for one particular investigation[19] which produced a much higher estimate for the prevalence of phonological impairments. These variations may be attributed to differences between the age of participants, methods and sample sizes involved in each study, which may result in higher or lower estimates for the prevalence of phonological disorders.

The estimated prevalence of phonological impairments in Brazil is significantly higher than that seen in the United States. This discrepancy may be attributable to differences in public policy between the two countries[28]. In the United States, speech pathologists play an active role in school activities, conducting screenings and implementing interventions. This is not a common practice in Brazilian schools, where speech pathologists are rarely present, and no public policies have been implemented to encourage screenings and early intervention for phonological impairments in school.

It is also important to note that some studies[8,20,28] suggest that the prevalence of speech impairments may exceed 20%. However, this figure also includes alterations such as phonetic and fluency disorders in addition to phonological impairments. Since phonetic impairment is more likely than phonological disorder to occur as an isolated condition[8] its inclusion in frequency calculations may inflate prevalence rates.

Two studies performed in the Brazilian state of Minas Gerais reported prevalence rates of 31.9%[8] and 33.7%[20] for phonological impairments in the cities of Belo Horizonte and Montes Claros, respectively. In municipal primary schools in the city of Santa Maria, the prevalence of speech impairments has been estimated to be 21.37%[25].

The comparison of prevalence rates between school types revealed that phonological disorders were more frequent among public school students across all age groups in the sample. Social factors can influence the acquisition of phonological skills, and as such, preventive measures and interventions to identify and treat phonological disorders must consider the effects of socioeconomic differences[19]. All aforementioned studies recruited participants from public schools only[8,14,16-20,25].

In the present study, phonological impairments were more frequent in males than females. This finding corroborates those of previous studies[14,17-20]. Only among 3-year-olds did girls have a higher prevalence of phonological impairment than boys. This may be explained by the fact that girls begin to speak earlier than boys; as a result, they acquire a larger vocabulary and, by the same token, become more susceptible to pronunciation errors.

A previous study[29] of the influence of gender on language acquisition revealed a female advantage in language ability which persists until 36 months of age. The present findings might also be explained by gender differences in language acquisition and development, as well as a slower maturation of the male brain[19].

Although phonological processes were observed in both typical and atypical language acquisition, they followed different chronological patterns in each of these participant groups. In typical phonological acquisition, phonological processes decreased with age. This is explained by the gradual acquisition of speech sounds, which ultimately results in the suppression of phonological processes, eliminating deletion and/or substitution errors (complete acquisition). However, children with phonological impairments did not show a reduction in phonological processes over time. The prevalence of these alterations remained high, even in older age groups.

The reason for this is the continued use of substitution and/or deletion as strategies to handle the complexity of phonemes or syllable structures which are unfamiliar or have not been mastered by children with phonological impairment. In children with these conditions, phonological processes continue to occur far beyond the expected age of suppression[26].

The most common phonological processes in both typical and atypical phonological acquisition were: cluster reduction; nonlateral liquid deletion in coda; nonlateral liquid substitution in onset; semivocalization of nonlateral liquid in coda; and unstressed, pre-stress syllable deletion. According to the literature, cluster reduction, together with liquid deletion and substitution, are the most common alterations in children with phonological disorders[14,19]. In a previous study[8] which also identified cluster reduction as the most prevalent phonological process in children, its occurrence was identified in 38.5% of the sample.

After age 5, children with typical phonological acquisition showed a drastic reduction in the frequency of phonological processes. These findings are in agreement with previous studies[24,30] which identify the age of 5 as a significant milestone in phoneme acquisition, and consequently, in the suppression of phonological processes.

Interestingly, in the present study, the occurrence of lateral liquid substitution in onset position remained high in the typical acquisition group until the age of 8. This may represent a population-specific linguistic feature, since it was only observed in a single target word in the assessment instrument. Linguistic variations are individual differences in speech production which do not compromise its intelligibility and are generally culturally accepted, though they vary from region to region. These variations may affect both adults and children[8].

Lastly, some of the phonological processes exhibited by children with phonological disorders were not present in those with typical phonological acquisition, such as the fronting and backing of plosive sounds, assimilation and affrication.

CONCLUSION

The present study found a mean prevalence of 15.26% for phonological processes, though values ranged from 8.26 to 20.63% depending on the age group. Younger age groups showed a higher prevalence of phonological impairments, since participants were still in the period of phonological

acquisition. Boys showed a higher prevalence of phonological impairments in all but the youngest age group, in which girls were more likely to present with these alterations.

The phonological processes exhibited by children with phonological impairments were more numerous and persistent than those observed in typical phonological acquisition. Additionally, some of the processes shown by participants with phonological disorders were not observed in children with typical phonological acquisition. In conclusion, information regarding the type and frequency of phonological processes in both typical phonological acquisition and phonological disorders may contribute to early diagnosis and increase the efficiency of treatment planning.

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Author contributions

MIC was responsible for writing the project proposal, data collection, data entry, study design and manuscript drafting; Marileda BG was responsible for data collection and manuscript drafting; Marieli BG was responsible for data cleaning and manuscript drafting; CRO contributed to data entry and manuscript drafting, and was responsible for statistical analysis; MKS was responsible for the project proposal, study design and revision of the manuscript.