Original Article

Artigo Original

Auditory-perceptive, acoustic and vocal self-perception analyses in children

Análise perceptivo-auditiva, acústica e autopercepção vocal em crianças

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Keywords

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ABSTRACT

Purpose: To establish the occurrence of dysphonic children and to relate data from auditory-perceptive, acoustic and vocal self-perception analyses of dysphonic and non-dysphonic children. **Methods:** Participants were 70 children, 37 female and 33 male, with ages ranging from 6 to 10 years. The sustained emission of the vowel /a/ was recorded, and children replied to the question "*What do you think of your voice?*". After that, the auditory-perceptive analysis of their voices was carried out, based on the parameters of the GRBASI scale. The acoustic analysis was also conducted, considering the following measures: fundamental frequency, frequency and amplitude perturbation quotient, and harmonic-to-noise ratio. The self-perception analysis of the subjects' voices was based on content analysis. Data were statistically analyzed. **Results:** The occurrence of dysphonic children was 37.14%. Breathiness was the most common vocal quality among dysphonic children, followed by roughness, which was also common. The acoustic measures frequency and amplitude perturbation quotient and harmonic-to-noise ration were higher among dysphonic children. However, these measures were similar between children that had positive self-perception and those with negative self-perception. Negative self-perception was more frequent among dysphonic children. **Conclusion:** The occurrence of dysphonia in the studied group was 37.14%. Dysphonic children present negative self-perception of their voices, voice quality predominantly rough and/or breathy, and altered acoustic measures, when compared to non-dysphonic children.

Descritores

Voz
Distúrbios da voz
Disfonia/epidemiologia
Percepção auditiva
Criança

RESUMO

Objetivo: Estabelecer a ocorrência de crianças com disfonia e relacionar os dados das análises perceptivo-auditiva, acústica e de autopercepção vocal de crianças com e sem disfonia. **Métodos:** Participaram 70 crianças, na faixa etária entre 6 e 10 anos de idade, sendo 37 do gênero feminino e 33 do gênero masculino. Foi gravada a emissão sustentada da vogal /a/ e as crianças responderam à pergunta "*O que você acha da sua voz?*". Posteriormente, foi realizada a análise perceptivo-auditiva das vozes, com base nos parâmetros da escala GRBASI. Além disso, foi realizada a análise acústica, considerando as medidas de frequência fundamental, quociente de perturbação de frequência e amplitude e proporção harmônico-ruído. A análise da autopercepção vocal das crianças foi fundamentada em análise de conteúdo. Os dados foram submetidos à análise estatística pertinente. **Resultados:** A ocorrência de crianças com disfonia foi de 37,14%. A soprosidade foi a qualidade vocal mais comum entre as crianças disfônicas, seguida de rugosidade, que também foi frequente. As medidas acústicas de quociente de perturbação de frequência e amplitude e a proporção harmônico ruído foram mais elevadas entre as crianças disfônicas. Entretanto, tais medidas foram semelhantes entre as crianças que apresentaram percepção positiva e negativa em relação à voz. A autopercepção vocal negativa foi maior entre as crianças com disfonia. **Conclusão:** A ocorrência de disfonia no grupo de crianças estudado é de 37,14%. Crianças disfônicas apresentam autopercepção vocal negativa, voz predominantemente soprosa e/ou rugosa, além de medidas acústicas alteradas, quando comparadas a crianças não disfônicas.

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INTRODUCTION

Over life, vocal changes will happen and follow an individual's development, from the physical, psychological and social points of view. The development of the larynx happens in an intense and continuous way since the baby's birth[1,2].

Until the age between 6 and 7 years, the voices of boys and girls are very close regarding fundamental frequency. Differences in vocal quality may be attributed to divergent vocal models, based on what girls seek a typical female voice with more breathy vocal quality, and the boys, a more hyperfunctional vocal quality[3].

In childhood, dysphonia cases occur as a result of phonation disorders, which may be related to inappropriate vocal behavior or to an imbalance of anatomical, physiological, social, emotional and/or environmental factors. Many times dysphonia is associated with other etiologies, ranging from self-limiting diseases such as acute viral laryngitis to life-threatening disabling injuries, such as tumors or laryngeal stenosis of varying degrees[4,5].

Recent epidemiological studies show that dysphonia in childhood affects from 6% to 38% of children. Hoarseness and breathiness are the most frequent vocal alterations[6-9].

Historically, childhood dysphonia is described more frequently in boys due to personality differences and the practice of physical and social activities that require excessive vocal use[10,11]. However, currently there is a growing increase in number of cases of vocal dysphonia in girls, younger and younger. According to the literature, the increasingly early socialization, greater exposure to noisy environments and the participation of both genders in sports and singing activities are factors that might have contributed to these changes[12].

Childhood dysphonia must be investigated very early, because the sooner the diagnosis is established and the treatment begins, the lower the impact on communication will be.

To enable the evaluation and treatment of the dysphonia cases, the speech therapy clinic has a range of possibilities for analysis of production and perception of voice signal. Some analyses are based on the auditory perception method of the trained therapist and have standardized scales of evaluation, such as GRBASI[13]. This is a subjective method of voice analysis, because it depends on the judgment(s) of the evaluator(s). Therefore it raises questions among professionals working in the area of voice. However, its contribution is undeniable in clinical practice[14].

The acoustic analysis, another method for voice assessment, is objective, noninvasive and provides the integration of data from auditory-perceptive assessment with the physiological level. It details the process of generating the sound signal and provides an indirect estimate of the vocal fold vibratory patterns as well as the shapes of the vocal tract and its changes[15].

Beyond these evaluations, the protocols that investigate the individual's self perception on the quality of life and voice, when associated with the other several forms of assessments, contribute to reasoning about the diagnosis of the patient with dysphonia[13]. It is noteworthy that in cases of childhood dysphonia the difficulty with the diagnosis is higher, as children without voice problem may have a mild degree of nasality, hoarseness and breathiness[1].

Whereas voice disorders in childhood can impair the development of effective communication in the social environment[5], it is appropriate to conduct researches outlining the peculiarities of childhood dysphonia. We believe that this study further underpins the speech therapy clinical work, in the perspective that emphasizes the importance of the correlation between the auditory-perceptive, acoustic and vocal self-perception analysis of children for the understanding of children's voice.

The aim of this study was to establish the occurrence of children with dysphonia and relate the obtained data in the auditory-perceptive, acoustic and vocal self-perception analysis of dysphonic and non-dysphonic children.

METHODS

This research consists of a random sample transversal study, approved by the Research Ethics Committee of Universidade Federal de Minas Gerais (UFMG), under number 676/08. The sample was comprised of 70 children, aged between 6 and 10 years old, 37 females (mean age 8.35 years, SD=1.29), and 33 males (mean age 7.7 years, SD=1.44). The children were students from first to fifth grade of fundamental school of the Pedagogic Center of UFMG, Belo Horizonte (MG), Brazil.

The Pedagogic Centre is a public school and it is incorporated to the University campus. The selection of the children has been made by raffle since the 1990s. Parents register their children and monitor the process. Thus, the school includes children of all social classes.

All children were authorized by their parents (or by the responsible people for them), by signing the Free and Informed Consent (FIC). Exclusion criteria were: children aged less than 6 years or more than 10 years and 11 months (excluding thus the period of vocal change), non Pedagogic Center students, the ones suffering from neurological disorder or diagnosed auditory loss and the ones that could not understand the questions or requests made by the researcher.

The research was conducted in four stages:

- First stage – recording the voices of children. The vocal registers were individually collected, using a professional digital recorder (DAT-Digital Audio Tape) by Sony®, equipped with a unidirectional microphone. The microphone was positioned 10 cm away from the mouth of the speaker and directional pickup angle of 90º to avoid picking up noise environment. The recording sessions lasted approximately 10 minutes and occurred at previously scheduled times with the coordinator of the school. For the recording, it was used a quiet room, with a noise level below 50 dB SPL (sound pressure level), as measured by a digital sound pressure level meter. The child was asked to perform two basic tasks for voice recording: make the issue of sustained vowel /a/ in maximum phonation time, and answer the question "What do you think about your voice?". The understanding the child was assured by the observation of the answer, following the criteria of exclusion of the study.
- Second stage – auditory-perceptive analysis of the children

voices based on parameters established by GRBASI scale. The judges assessed the overall degree of change (G), which was divided into: G0 (absence of dysphonia), G1 (mild dysphonia), G2 (moderate dysphonia) and G3 (intense dysphonia) and the predominance of vocal quality, divided into: roughness (R), breathiness (B), asthenia (A), tension (T) and vocal instability (I).

Three voice expert speech therapists collaborated for this assessment. The speech therapists heard the recording of the sustained vowel /a/, defined for reporting information of the sound source[16]. Analyses were performed separately. The examiners used headphones and listened to each sample three times, in a quiet place. Then they filled out the report of the auditory-perceptive assessment concerning each child. All the evaluators that participated in the study had prior training in auditory-perceptive analysis of children's voices and with the use of the GRBASI scale.

For the analysis of the intra-evaluator agreement, 14 samples (20%) were repeated randomly selected among those presented in random order. The three evaluators presented more than 75% of reliability, calculated using the Kappa statistic test. The voices of children were considered altered (G greater than or equal to 1) when there was agreement between at least two evaluators. The analysis results of the other parameters of vocal quality were determined by the more prevalent result among the assessments. In no time there was a discordant assessment between the three evaluators, i.e., at least two of them examined the same way an auditory-perceptive parameter of the same voice. The agreement of at least two evaluators was the criterion used to increase the reliability of the auditory-perceptive analysis and, consequently, the sample selection.

- Third stage – the acoustic analysis of the children's voices using the sustained issue of vowel /a/. The following parameters were evaluated: fundamental frequency (F_0), amplitude perturbation quotient (APQ%), frequency perturbation quotient (FPQ%), harmonic-noise ratio (HNR dB). The recording of the sustained vowel /a/ was transferred to the Dell® Pentium PC (R), the Sound Blaster Live 24-bit Soundboard, Behringer MIC200 preamp, and the sound wave was recorded at MDVP module (Multi-Dimensional Voice Program Advanced) of the Multi-speech model 3700 program of Kay Elemetrics®. The beginning and end of the emission were eliminated due to their irregular feature. There are no reference values as the data base for the acoustic analysis of children's voices in the program MDVP. Thus the comparative analysis was performed among the dysphonic and non-dysphonic children. To identify dysphonic and non-dysphonic children the G values of the auditory-perceptive analysis were considered, and the values of G equal to or greater than 1 indicated the presence of dysphonia.
- Fourth stage – qualitative analysis of the self-perception of children about their voices using the speech sample. The data analysis was based on the content analysis proposed by Bardin[17], in which the central ideas of the answers of the same question were identified for further comparison of the group and the synthesizing of the general knowledge. After selecting the categories to be analyzed, their frequency of occurrence (arising) was verified in the speeches. For this assessment, the vocal self-perception of the children was considered positive or negative. The self-perception was considered positive when the child reported that the voice was "beautiful, nice, good", it "transmitted joy" or he/she "liked the voice". The negative self-perception was considered when the child reported that the voice was "bad, ugly", it "transmitted anger" or he/she "didn't like the voice."

The data were stored and tabulated. For statistical analysis, we used specific software, SPSS, version 15. Initially, descriptive analyses were performed on the data, calculating averages, standard deviations (SD), as median, minimum and maximum for continuous variables. For categorical variables, this analysis consisted in determining the frequency and respective percentage of each class.

Hypothesis tests *t* of Student were performed to compare the means of parameters of the acoustic analysis in dysphonic and non-dysphonic children, and tests of association between the presence or absence of dysphonia and the gender and vocal self-perception variables. We adopted the 5% level of significance. In the specific case of the association test, we used the Chi-square one when all the intersections had five or more observations or the Fisher exact one when all the crossings had less than five observations.

After analyzing the data, the obtained results were passed for the school and the people responsible for the children. Children with dysphonia received guidance about vocal health, as well as their parents (or other people responsible for them). The ones that showed interest were indicated to the Basic Health Unit.

RESULTS

The occurrence of children with dysphonia found in this study was 37.14% (n=26), considering the analysis of the sustained vowel /a/. Moreover, the number of cases of dysphonia was similar between the female and male genders (Table 1).

Among the 26 dysphonic children, 84.60% (n=22) presented mild alteration (G1), 7.80% (n=2), moderate one (G2) and 7.80% (n=2) intense degree of alteration (G3).

In relation to the auditory-perceptive characteristics, breathiness (B) was the most common vocal quality (n=25) among the 26 dysphonic children, then roughness (R), which was also frequent (n=18). The other auditory-perceptive parameters of the GRBASI scale were not observed by the evaluators (Table 2).

Table 1. Occurrence of dysphonia in children, according to gender

Vowel	Gender				Total	p-value
	Female		Male			
	n	%	n	%		
Non-dysphonic	23	32.86	21	30.00	44	1.0
Dysphonic	14	20.00	12	17.14	26	
Total	37	52.86	33	47.14	70	

Chi-square test ($p \leq 0.05$)

Table 2. Results of the GRBASI scale for the dysphonic children

	n	%
(G) Grade≥1	26	100.00
(R) Roughness	18	69.23
(B) Breathiness	25	96,15
(A) Asthenia	0	00.00
(S) Strain	0	00.00
(I) Instability	0	00.00

As for the acoustic measurements, considering the total sample, the obtained averages were: F_0=240.17 Hz, FPQ%=1.12%, APQ=2.26% and HNR dB=0.1dB. The was difference in the comparison of dysphonic and non-dysphonic children with respect to: frequency perturbation quotient (FPQ%), amplitude perturbation quotient (APQ%) and harmonic-noise ratio (HNR dB) (Table 3).

The FPQ% average was higher in dysphonic children. The average obtained value for non-dysphonic children was 0.82% and for dysphonic children was 1.34%. The APQ% average was lower in non-dysphonic children. Regarding the values of HNR dB average, they were higher among dysphonic children (Table 3).

Most children showed positive vocal self-perception. The negative self-perception was higher among dysphonic children, with significant differences when compared to the non-dysphonic ones. Among the 26 dysphonic children, 9 (34.61%) presented negative perceptions about their own voices (Table 4).

The mean acoustic measures (F_0, APQ, FPQ and HNR) were similar between children who presented positive and negative self-perception in relation to the voice, with no differences among the groups (Table 5).

DISCUSSION

Childhood dysphonia has a negative impact on the child's general health as well as the development of adequate communication. Specifically, the dysphonic children are more negatively judged by their mates than non-dysphonic children in relation to bipolar characteristics, both physical and about personality, as dirty/clean, bad/good, sick/healthy, sad/happy, and wrong/right[5].

Epidemiological studies show that the prevalence of vocal alterations in childhood varies from 6% to 38%[6-8]. These data are corroborated by the indices obtained in this study. However, the results of this study differ from those that were obtained in research with children from 6 to 10 years old, in which the prevalence of vocal alterations ranged from 59% to 64%[9].

By linking the variable gender with the presence or absence of dysphonia, researchers emphasize that the childhood dysphonia occurs more frequently in boys. This is because they have a risk factor for the development of dysphonia due to personality differences and the practice of physical and social activities that require excessive vocal use[10,11,18]. However, both in this study

Tabela 3. Acoustic analysis for dysphonic and non-dysphonic children

Variables	Mean		SD		Median		Minimum		Maximum		PPMCC		p-value
	D	ND	D	ND	D	ND	D	ND	D	ND	D%	ND%	
F_0 (Hz)	230.30	244.69	39.63	28.04	228.67	243.92	121.70	187.07	323.07	312.08	17.21	11.46	0.321
FPQ%	1.34	0.82	0.68	0.6	1.20	0.63	0.49	0.13	2.96	2.24	50.61	73.72	0.001*
APQ%	2.70	1.72	1.20	0.48	2.37	1.64	1.05	1.00	5.59	2.76	44.47	27.91	0.001*
HNR (dB)	0.14	0.11	0.03	0.03	0.14	0.11	0.06	0.04	0.22	0.15	24.29	24.84	0.001*

* Significant values (p≤0.05) – Test *t* of Student

Note: F_0 = fundamental frequency; APQ% = amplitude perturbation quotient in the short term; FPQ% = frequency perturbation quotient in the short term; HNR = harmonic-noise ratio; D = dysphonic individual; ND = non-dysphonic individual; SD = standard deviation; PPMCC = Pearson product-moment correlation coefficient

Table 4. Vocal self-perception of dysphonic and non-dysphonic children

Fala	Dysphonic		Non-dysphonic		p-value
	n	%	N	%	
Negative	9	34.61	2	4.55	0.001*
Positive	17	65.38	42	95.54	
Total	26	99.99	44	99.99	

* Significant values (p≤0.05) – Fisher's Exact test

Table 5. Relation between the data of acoustic analysis and vocal self-perception of the children

Variáveis	Positive self-perception			Negative self-perception			p-value
	n	Mean	SD	n	Mean	SD	
F_0 (Hz)	59	241.79	29.66	11	231.49	43.26	0.331
FPQ%	59	1.09	0.57	11	1.30	0.89	0.317
APQ%	59	2.15	0.86	11	2.81	1.33	0.138
HNR (dB)	59	0.12	0.03	11	0.14	0.04	0.098

Test t for equality of averages (p≤0,05)

Note: F_0 = fundamental frequency; APQ% = amplitude perturbation quotient in the short term; FPQ% = frequency perturbation quotient in the short term; HNR = harmonic-noise ratio; SD = standard deviation

and in another similar one[8] this difference was not observed.

It's important to highlight that the laryngeal settings of girls and boys are similar[3]. Moreover, now the girls have shown greater interest for rough and aggressive plays, which were more frequent among boys in the past. These activities require sound competition in addition to misused and abused use of voice, attitudes that may cause hyperfunctioning and laryngeal disorders[13,19].

In schools, in general, children have many opportunities to abuse the voice, because they participate in outdoor activities, where the vocal self-control is difficult. Another consideration is that children often have oral breathing cases, respiratory allergies and infections of the upper airways. These factors, when articulated, provoke the use of voice in inadequate conditions, in the presence of dried mucous membranes, swelling and irritation of the vocal tract[5].

The GRBASI scale is one of the instruments of vocal assessment[13]. Authors[20] observed that this instrument is valid for the assessment of children's voices, although one must consider the importance of trained evaluators, given the high level of subjectivity involved in the process.

In this study, the selection of three judges with an index of intra-evaluator agreement over than 75% for the auditory-perceptive analysis of the GRBASI scale decreased the subjectivity of the process. It's important to highlight that the security test-retest of the GRBASI scale is moderate[13].

With regard to the auditory-perceptive characteristics, breathiness (B) was the most observed vocal quality in this study. Other authors also concluded that this is the most common vocal quality in children[3,9]. Future studies are needed to better understand which anatomic and/or functional factors may be related to the presence of breathiness in the voice of dysphonic children.

The roughness (R) was also a frequent vocal alteration among dysphonic children. This finding is expected, since it is favored by vocal abuse or misuse, especially when it refers to the child's larynx[1]. In addition, in many childhood laryngeal diseases, hoarseness is their main indicator[1].

Regarding the acoustic analysis, after conducting a review study, researchers found that many studies recognize little differentiation between normal and dysphonic voices[20]. There is a need for more research on the subject, with greater standardization and normalization of measures[13,21].

It's important to highlight that the average values obtained in the acoustic measures (F_0, APQ, FPQ and HNR) disagreed with the values reported in other studies[21-23]. Probably this is related to differences in the recording procedures and mathematical calculations used for the analysis. The acoustic measures vary according to the program used, limiting the direct comparison between studies using different programs[1,17].

The average F_0 (240.17 Hz) obtained in this study was similar to those obtained in most studies[24,25]. The average of 230.30 Hz, obtained in dysphonic children and 244.69 Hz, obtained in non-dysphonic ones, also corroborate the literature data[22].

The measure of the jitter is frequency perturbation quotient (FPQ%) that relates to the disturbance of vibration frequency of the vocal folds in the short term[1,22]. Shimmer is the measure of the amplitude perturbation quotient (APQ%) calculated from the average of the disturbance amplitude, cycle by cycle, throughout the vocal sample[1,11].

The large variations of jitter and shimmer measures in children are suggestive of anatomophysiological changes of the laryngeal structures and lack of laryngeal control[20]. It is noteworthy that children's vocal fold has not undergone the differentiation process of the intermediate and deep layers of the own lamina yet[3]. In this study, the value of the averages found for FPQ% and APQ% measures were higher in dysphonic children. These findings corroborate the results of most studies in the area[23,26].

With regard to the FPQ%, authors found significantly elevation of the perturbation frequency values in the voice of children with vocal nodules[23]. This shows that the changes in the structure of the mucosa affect the regularity of vibration through the cycles of the vocal fold, resulting in the jitter values increase[1]. On the contrary, another study showed values of jitter that revealed no differences between normal and dysphonic voices[21].

For the acoustic measure APQ%, a study found increase in the values of shimmer in a group of subjects with papillomatosis and vocal nodules[26]. In other experiments, the shimmer value showed no difference between groups of children with normal and dysphonic voices[21,22]. It is noteworthy that the literature is not unanimous as to the power of shimmer differentiation.

The harmonic-noise ratio (HNR dB) is one of the best parameters for clinical application, both in quantification of vocal deviations and in the evaluation of procedures for dysphonia treatment, with direct relation to the vocal quality[1]. It is considered one of the noise perturbation measures that quantify the amount of noise in relation to the amount of harmonics in a vocal sample, which may be of great value in the differentiation between normal and dysphonic voices[1,20].

Regarding the HNR dB averages, higher values were observed between the dysphonic children. These results disagree with the study[23] which showed no significant increase in HNR dB when comparing groups of children with normal and altered voices.

Although the results of auditory-perceptive and acoustic analysis are not directly proportional[15], this study found that children classified as dysphonic ones showed higher mean values of acoustic measures. This shows that the greater the presence of noise at emission, the higher the frequency and amplitude periodicity at the acoustic signal.

Considering the multidimensional nature of the dysphonia, the joint use of protocols of auditory-perceptive, acoustic and self-perception evaluation of the person helps in understanding the cases[27]. In relation to the vocal self-perception, the results found in this study reinforce the idea that dysphonia is a poorly perceived symptom by the children[28,29]. This could be seen as very few children were negatively self-rated. However, it's necessary to highlight that this negative self-perception was higher in dysphonic children. Such evidence is in favor of studies about the creation of protocols for quality of life in voice, specific for children, which seek to study more deeply this impact.

The acoustic measures were similar between children who

presented positive and negative vocal self-perception. In the compiled literature no data were found that compare the vocal self-perception of the children with the objective measures. When considering the opinion of the parents regarding the voice of their children, most of them believe that the children do not realize the voice problems because they do not complain about it. However, they mention that children reduce the use of voice before any vocal alteration[28].

The relationship between the data of the different analysis helps to better understand the case of dysphonia in children and to define the clinical approach to be adopted. It must be highlighted that the data from this research reinforce the findings of the literature and contribute to the speech therapy practical clinic with children with vocal alterations. Under a more comprehensive and multifactorial look at childhood dysphonia, it encourages further researches to investigate the environmental conditions of the schools, in order to assess how much they interfere with voice production of children. Also, it is considered important the construction of projects for the awareness and clarification to the parents, educators and to the children themselves about the importance of the voice in children's communication.

CONCLUSION

The reported occurrence in the studied group of children is 37.14%. Dysphonic children present negative vocal self-perception, predominantly breathy and/or rough voice, besides altered acoustic measures, when compared to non-dysphonic children.

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