Artigo Original

Medidas Acústicas para Detecção de Rouquidão em Crianças

Acoustic Measures for the Detection of Hoarseness in Children

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Resumo

Introdução: Muito freqüentemente, pais e professores não reconhecem a presença das alterações vocais na criança, podendo trazer conseqüências educacionais e sociais para o seu desenvolvimento.

Objetivo: O objetivo deste estudo foi o de descrever a configuração laríngea utilizando a videofibrolaringoscopia em um grupo de crianças órfãs, associando estes resultados com a análise computadorizada da voz, identificando parâmetros acústicos capazes de predizer alterações vocais e/ou estruturais das pregas vocais.

Métodos: Foram avaliados 50 meninos entre 3 e 10 anos de idade, sem história de patologia laríngea e, que viviam em um orfanato. As crianças foram divididas em 2 grupos: A: aquelas que apresentavam lesões (cistos e nódulos) nas pregas vocais (25 meninos); B: aquelas que não apresentavam lesões nas pregas vocais (25 meninos). Foram analisados 5 parâmetros acústicos da voz das crianças: freqüência fundamental, quociente de perturbação da freqüência, quociente de perturbação da amplitude, jitter e shimmer. A configuração glótica foi avaliada, sendo seus resultados analisados conjuntamente com a análise acústica.

Resultados: Os resultados indicaram a presença de nódulos vocais e de fenda triangular médio-posterior com diferença significante entre os dois grupos. A análise acústica computadorizada da voz não mostrou diferença significante entre os grupos estudados.

Conclusões: Nós não observamos diferença significante com relação ao tipo de fechamento glótico e constrição laríngea no grupo de crianças sem lesão estrutural das pregas vocais. Considerando a análise computadorizada da voz, não houve diferença significante entre os grupos com relação aos parâmetros estudados.

Palavras-chave: voz, qualidade vocal, rouquidão, masculino.

Summary

Introduction: Very often, parents and teachers do not recognize the presence of hoarseness in children, a fact which may have consequences for the child's social and educational development.

Objective: The objective of the present study was to assess laryngeal configuration using videofibrolaryngoscopy in a group of boys living in an orphanage, and to associate the results of this analysis with the results of computerized voice analysis, so as to identify acoustic parameters which may be used as predictors of vocal and/or structural alterations in the vocal fold.

Methods: We analyzed 50 boys between 3 and 10 years of age, without history of laryngeal pathology, living in a private orphanage. The children were divided into two groups: A) with lesions (unilateral vocal cyst or bilateral small nodules) in the vocal fold (25 subjects); and B) without lesions in the vocal fold (25 subjects). Five parameters were assessed: fundamental frequency, pitch period perturbation quotient, amplitude perturbation quotient, jitter, and shimmer. Glottic configuration was analyzed; results were compared with the results of acoustic analysis.

Results: The results indicate that the presence of vocal nodules and median posterior glottic chink was significantly different in the two groups. The computerized analysis results were not statistically different for the two groups. Conclusion: We did not observe a significant difference with respect to type of glottic closure and laryngeal constriction in the group of children without lesion. Regarding the computerized analysis of voice, there were no significant differences between the groups in terms of the parameters studied.

Key words: voice, vocal quality, hoarseness, male.

Introduction

The human voice is one of the most important ways of communicating with the world. The voice quality is defined at the level of the glottis, by a basic pattern of sound emission in association with the passage of air through the larynx and to the resonance system. Besides being influenced by anatomic alterations, the voice is also influenced by psychological and sociocultural factors.

An incomplete glottic closure produced by low abduction potency results in hypofunction, and in a breathy voice. In turn, a glottic closure with constriction, that is, with high abduction potency, may result in hyperfunction, and in a dysphonic voice.

Very often, parents and teachers do not recognize the presence of hoarseness in children, or do not recognize signs such as hoarseness as a symptom of deeper alterations, a fact which may have consequences for the child's social and educational development. The perception of vocal quality is important, since it may signal problems in the vocal fold that can be clinically or surgically treated.

Even though subjective voice evaluation methods, such as perceptual auditory analysis, are widely used, methods that yield more concrete, quantifiable parameters, are needed. Historically, the acoustic analysis of voice was introduced in the 1920s, with the use of the oscillograph. In the 1940s, the sound spectrograph was introduced; and in the beginning of the 1970s, the first digital processors began to be used, yielding more accurate and clearer definitions. Modern acoustic analysis is computerized, and employs increasingly more sophisticated programs.

The objective of the present study was to assess laryngeal configuration using videofibrolaryngoscopy in a group of boys living in an orphanage, and to associate the results of this analysis with the results of computerized voice analysis, so as to identify acoustic parameters which may be used as predictors of vocal and/or structural alterations in the vocal fold.

Patients and Methods

We evaluated 50 boys between 3 and 10 years of age, all living in an orphanage (Lar da Criança Feliz), in Taboão da Serra, state of São Paulo, Brazil, with no complaints regarding voice ailments.

All children were otolaryngologically (GPJ) and phonoaudiologically (ECA) evaluated on the same day and during the same period of the day. Evaluations were blinded, that is, one investigator was not aware of the results of the other investigation. Laryngoscopy was carried out to determine the presence of lesions in the vocal fold using a MACHIDA ENT 30 S-III fibrolaryngoscope, and all examinations were video-recorded. Videofibrolaringoscopies were carried out following a standard procedure: the child was sitting; anesthesia was applied topically to the nasal cavity (lidocaine at 2%). Laryngeal configuration was assessed during a sustained emission of vowels /e/ and /i/ at normal intensity and tone. We looked to identify the presence of structural lesions in the vocal fold (unilateral vocal cyst and bilateral small nodules), type of glottic closure, and type of constriction of the laryngeal vestibule.

For the phonoaudiologic examination, the boys were tested using a computerized speech laboratory (CSL) type 4300 B with Kay Elemetrics Corporation multi-dimensional voice program (MDVP). Emissions were captured through a professional microphone (SHURE), placed 15 cm from the child's mouth.

Children were asked to emit the oral, central, low, open vowel /a/, isolated and sustained. They were instructed to breath deeply before each emission and to sustain the vowel as naturally as possible, and for as long as possible. For each child, stable emissions lasting 3 seconds were taken as samples. The beginning and the ending of all recordings were discarded. The inferior limit of vocal intensity was monitored by the closing of at least 60% of the window. The upper limit was monitored using the equipment's VU meter, according to the manufacturer's instructions.

The following acoustic measures were performed: fundamental frequency (F_o), jitter, pitch period perturbation quocient (PPQ), shimmer (in dB and %), and amplitude perturbation quocient (APQ).

The following tests were used for statistical analysis of the results:

1. Mann-Whitney's test for independent samples (1), for comparison of children with and without lesions of the vocal fold structure in terms of the variables under study. Due to the size of the sample, this test was applied only in some cases, and always with approximation to the normal curve (calculated Z);
2. Cochran´s G test (1), used to study the presence or absence of alterations in glottic closure. This analysis was carried out separately for children with or without lesions of vocal fold structure;
3. Chi-square (1) for contingency tables, with the aim of comparing the vocal quality of children with or without lesions of vocal fold structure;

Table 1. Videofibrolaryngoscopic findings for normal children and children presenting lesions of the vocal fold.

	Finding								
			Type of glottic closure[c]			Type of constriction[d]			
Presence of structural lesion of the vocal fold	Cyst	Nodule	Median posterior chink	Posterior chink	No chink	Antero-posterior constriction	Median constriction	Mixed	No constriction
Yes (n=25)[a]	8 (32%)	17 (68%)	22 (88%)	1 (4%)	2	7	7	4	15
No (n=25)[b]	-	-	7 (28%)	9 (36%)	9	10	8	7	14
Total (n=50)	8	17	29	10	11	29	10	15	17

Legenda: [a]Cochran´s test: calculated G = 43.86*; critical G = 11.07.
[b]Cochran´s test: calculated G = 1.0G; critical G = 7.82.
[c]Chi square: calculated c^2 = 18.61*; critical c^2 = 5.99. c^2 partition: critical c^2 = 3.84; first partition: (normal + posterior chink) x median posterior chink; calculated c^2 = 18.47*; second partition: normal x posterior chink; calculated c^2 = 0.14.
[d]Chi square: calculated c^2 = 1.85; critical c^2 = 7.82.

4. Kruskal-Wallis variance analysis (1), with the aim of comparing normal children with the groups of boys presenting cysts or nodules in terms of the values observed in the vocal evaluation tests. If a significant difference was observed, a multiple comparison test was also performed (2).

The level of significance was 5%. The study was approved by the Ethics Committee at Hospital de São Paulo, Universidade Federal de São Paulo - Escola Paulista de Medicina (UNIFESP - EPM), Brazil.

RESULTS

According to the otolaryngologic examination, 25 children presented lesions of vocal fold structure (bilateral small nodule or unilateral vocal cyst) and 25 did not. Children were then divided into two groups, according to presence (group A) or not (group B) of lesion of vocal fold structure.

Table 1 presents the videofibrolaryngoscopic findings for the two groups. Table 2 presents the results of the computerized analysis in the two groups in terms of the variables under study (F_o, jitter, shimmer, PPQ, APQ) and in relation to age. Table 3 compares the computerized values for children with cysts and nodules in relation to children with no lesion of vocal fold.

DISCUSSION

The study of voice among children living in institutions supports the idea of a high incidence of structural alterations in the vocal fold in this population, as well as the idea that the social organization in which these children live strongly influences them. Many times, these children have to "yell to conquer their space," a fact which may result in structural alterations in the vocal fold. DANOY et al. (3) have reported that numerous cases of hoarseness during childhood are a consequence of congenital lesions in the vocal folds, and that personality development is one of the factors that might influence the voice. However, we consider others risk factors to justified hoarseness in childhood.

Hoarseness may have negative consequences for a child. For example, a child may suffer discrimination from peers in school, or may lose interest in careers that require intensive use of the voice. As a result, many authors have become interested in the study of vocal alterations during childhood (3-9).

In 1968, SENTURIA & WILSON estimated that hoarseness affected up to 1.5 million children, or 6% of school-age children in the U.S. at the time. The estimated incidence of hoarseness among school-age children has been increasing to the point that certain studies have reported an incidence as high as 23.4% (5).

Hoarseness is the vocal quality most often associated to laryngeal disorders. Many times, hoarseness results from vocal abuse, although the causal factors have been described as being divided into physical and psychological factors, including personality structure, poor phonic adjustment, and allergic factors (10). In special education classes, voice, speech, and language alterations are common. The prevalence of such alterations is around 50% in school-age mentally challenged children in the UK (11). The fact that

Table 2. Results of the computerized analysis for the variables under study according to age distribution for children with and without lesions of the vocal fold structure[a].

Age		Fo (Hz)		Jitter (%)		Shimmer (dB)		Shimmer (%)		PPQ (%)		APQ (%)	
Yes[b]	No[b]	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
3	3	363,68	244,72	0,50	2,76	0,27	0,88	3,18	10,35	0,28	1,71	2,44	6,90
3	4	275,67	265,47	18,60	2,11	1,29	0,44	13,63	5,13	11,86	1,25	10,76	3,34
3	4	293,55	238,57	3,34	0,85	0,80	0,78	9,02	8,89	2,06	0,53	5,93	7,10
3	5	315,26	211,70	4,96	1,46	0,74	0,96	8,89	10,56	3,02	0,88	5,96	6,90
4	5	266,60	291,46	7,14	2,86	1,16	1,03	12,14	11,52	4,46	1,72	9,58	7,73
5	5	228,30	188,11	0,77	3,17	0,37	0,46	4,24	5,31	0,43	1,88	3,27	3,70
5	5	208,32	147,32	2,56	8,37	0,45	1,11	5,24	12,70	1,48	6,57	3,70	8,25
6	6	233,14	256,74	0,32	4,27	0,28	1,01	3,35	11,68	0,18	2,78	2,36	7,68
6	6	234,38	264,22	1,05	0,55	0,57	0,73	6,64	8,44	0,53	0,32	4,15	5,52
6	6	261,32	222,40	3,69	5,44	0,56	1,04	6,46	11,39	2,20	3,18	4,57	7,68
6	6	219,91	277,84	5,44	2,35	1,03	0,74	11,74	8,45	3,22	1,36	8,13	5,78
6	7	259,41	254,67	2,79	3,07	0,83	0,65	8,65	7,54	1,71	1,89	5,94	5,36
6	7	300,33	239,24	0,51	0,41	0,61	0,39	6,92	4,54	0,30	0,26	4,74	3,33
8	7	208,07	214,54	3,06	3,22	0,83	0,69	9,93	7,97	1,89	1,88	7,92	6,23
8	7	233,66	277,48	0,78	1,95	0,51	0,52	5,88	6,06	0,47	1,13	4,24	4,25
8	8	265,23	277,84	0,47	0,89	0,28	0,37	3,31	4,19	0,26	0,52	2,79	2,95
9	8	248,49	160,75	0,87	4,44	0,32	0,97	3,63	10,90	0,50	2,92	2,62	7,61
9	9	208,07	220,21	2,31	0,76	0,68	0,44	7,86	4,99	1,35	0,44	5,03	3,62
9	9	205,23	202,44	3,30	0,65	0,77	0,34	8,77	3,92	1,99	0,38	5,98	2,63
10	9	207,33	270,19	1,07	3,94	0,60	1,04	6,90	11,00	0,65	2,32	4,73	7,27
10	9	118,97	233,46	2,31	6,58	0,62	1,49	7,22	15,74	1,48	4,35	5,44	11,69
10	9	241,42	239,38	0,57	0,42	0,18	0,40	2,12	4,67	0,33	0,25	1,50	3,30
10	10	247,95	195,91	1,76	4,39	0,54	1,12	6,26	12,92	1,03	3,03	4,23	9,04
10	10	262,53	240,82	0,84	1,78	0,46	0,57	5,29	6,59	0,50	1,03	3,67	4,47
10	10	238,77	250,16	0,73	1,60	0,38	0,67	4,28	7,47	0,42	1,19	3,11	5,14
Average													
6,92	6,96	245,82	235,42	2,79	2,73	0,60	0,75	6,86	8,51	1,70	1,75	4,91	5,89

[a] Mann-Whitney test (without or with lesion): critical Z = 1.96. Calculated Z: 0.58 (age); 0.51 (Fo/Hz); 0.81 (jitter/%); 1.68 (shimmer/dB); 0.83 (PPQ/%); 1.61 (APQ (%).

[b] Yes = With lesion of vocal fold structure; No = Without lesion of vocal fold structure.

the children in our study live in an orphanage increases their chance of presenting structural alterations in the vocal fold, since space is many times secured through a loud voice, a fact that was also observed by Carlin & Saniga (6) and Andrews (7).

Baynes (12) and Shearer (13) reported that a large number of school-age children, especially in elementary school, presented a chronically hoarse vocal type. Senturia & Wilson (4) and Hersan (14) reported that up to 70% of school-age children presenting a hoarse voice had vocal nodules.

Videofibrolaryngoscopy is a test commonly performed in children. In the present study, we did not experience any technical complications or difficulties. Differently from us, Senturia & Wilson (4) reported that they were able to perform the videofibrolaryngoscopic examination in only 62.2% of the cases studied.

The presence of a median posterior chink and of vocal nodule was significantly more common (Cochran´s test) in the group of children with structural lesions of the vocal folds in relation to the other characteristics studied (table 1). Senturia & Wilson (4) reported that almost 70%

Table 3. Results of computerized analysis for the variables under study according for normal children and for children with cysts and nodules.

Fo (Hz)			Jitter (%)			Shimmer (dB)			Shimmer (%)			PPQ (%)			APQ (%)		
Normal	Cyst	Nodule	Normal	Cyst	Nodule	Normal	Cyst	Nodule	Normal	Cyst	Nodule	Normal	Cyst	Nodule	Normal	Cyst	Nodule
363,68	211,70	244,72	0,50	1,46	2,76	0,27	0,96	0,88	3,18	10,56	10,35	0,28	0,88	1,71	2,44	6,90	6,90
275,67	291,46	265,47	18,60	2,86	2,11	1,29	1,03	0,44	13,63	11,52	5,13	11,86	1,72	1,25	10,76	7,73	3,34
293,55	188,11	238,57	3,34	3,17	0,85	0,80	0,46	0,78	9,02	5,31	8,89	2,06	1,88	0,53	5,93	3,70	7,10
315,26	147,32	256,74	4,96	8,37	4,27	0,74	1,11	1,01	8,89	12,70	11,68	3,02	6,57	2,78	5,96	8,25	7,68
266,60	239,24	264,22	7,14	0,41	0,55	1,16	0,39	0,73	12,14	4,54	8,44	4,46	0,26	0,32	9,58	3,33	5,52
228,30	277,48	222,40	0,77	1,95	5,44	0,37	0,52	1,04	4,24	6,06	11,39	0,43	1,13	3,18	3,27	4,25	7,68
208,32	202,44	277,84	2,56	0,65	2,35	0,45	0,34	0,74	5,24	3,92	8,45	1,48	0,38	1,36	3,70	2,63	5,78
233,14	240,82	254,67	0,32	1,78	3,07	0,28	0,57	0,65	3,35	6,59	7,54	0,18	1,03	1,89	2,36	4,47	5,36
234,38		214,54	1,05		3,22	0,57		0,69	6,64		7,97	0,53		1,88	4,15		6,23
261,32		277,84	3,69		0,89	0,56		0,37	6,46		4,19	2,20		0,52	4,57		2,95
219,91		160,75	5,44		4,44	1,03		0,97	11,74		10,90	3,22		2,92	8,13		7,61
259,41		220,21	2,79		0,76	0,83		0,44	8,65		4,99	1,71		0,44	5,94		3,62
300,33		270,19	0,51		3,94	0,61		1,04	6,92		11,00	0,30		2,32	4,74		7,27
208,07		233,46	3,06		6,58	0,83		1,49	9,93		15,74	1,89		4,35	7,92		11,69
233,66		239,38	0,78		0,42	0,51		0,40	5,88		4,67	0,47		0,25	4,24		3,30
265,23		195,91	0,47		4,39	0,28		1,12	3,31		12,92	0,26		3,03	2,79		9,04
248,49		250,16	0,87		1,60	0,32		0,67	3,63		7,47	0,50		1,19	2,62		5,14
208,07			2,31			0,68			7,86			1,35			5,03		
205,23			3,30			0,77			8,77			1,99			5,98		
207,33			1,07			0,60			6,90			0,65			4,73		
118,97			2,31			0,62			7,22			1,48			5,44		
241,42			0,57			0,18			2,12			0,33			1,50		
247,95			1,76			0,54			6,26			1,03			4,23		
262,53			0,84			0,46			5,29			0,50			3,67		
238,77			0,73			0,38			4,28			0,42			3,11		
245,82	224,82	235,43	2,79	2,58	2,80	0,60	0,67	0,79	6,86	7,65	8,92	1,70	1,73	1,76	4,91	5,16	6,25

[a]Kruskal-Wallis variance analysis (normal vs. cyst vs. nodule): critical H = 5.99. Calculated H: 1.17 (Fo/Hz); 1.70 (jitter/%); 3.81 (shimmer/dB); 3.64 (shimmer/%); 1.29 (PPQ/%); 3.51 (APQ (%).

of the children submitted to videfibrolaryngoscopy presented vocal nodules. In the present study, one child with normal vocal quality and no glottic chink presented a vocal nodule, a finding which differs slightly from what is expected.

The group without structural lesions upon videofibrolaryngoscopic examination did not present a significant difference in terms of Cochran´s G test (Table 1) in relation to the characteristics under study, although it has been reported by Södersten & Lindestad (15) that among women a posterior glottic closure is normal. Morrison et al. (16) reported that laryngeal constriction is also a condition frequently found among young women.

The antero-posterior constriction was the most frequent type of constriction in our population (Table 1). We observed a normal vocal quality even in the presence of a posterior chink, an observation reported by other authors as well (17). Södersten (18) reported that a posterior chink did not necessarily correspond to a breathy voice quality, and that this alteration was commonly found among women. In the present study, 78% of the children had some kind of glottic chink (Table 1), whereas McAllister et al. (19) observed the chink in 36.4% of their population.

In terms of structural lesions (Table 1), the chi-square test revealed that the presence of these lesions in the group with a median posterior chink was significantly more frequent than in the normal group and in the group with a posterior chink (with no difference between the normal and posterior chink groups).

Regarding laryngeal constriction (Table 1), the chi-square test did not reveal any significant difference between the normal group in comparison to the groups with median constriction, antero-posterior constriction or mixed (median and antero-posterior) constriction in relation to the presence or absence of vocal fold structural lesion, a fact that was also observed by CERVANTES (20). MORRISON et al. (16) reported that laryngeal constriction was commonly observed among women and that 20% of the adult individuals assessed presented this condition, independently of the presence of structural alterations in the vocal folds. In our population, constriction was present in 42% of all cases.

We observed hoarseness as the most frequent symptom (61.9%) in the group with structural lesions of the vocal fold, a finding that was also reported by SILVERMAN & ZIMMER (5), who described a hoarse voice as the quality most frequently associated to vocal nodules in boys (50%). In the present study, the phonoaudiologic examination was carried out blinded to the results of the otorhinolaryngological examination and vice-versa, and 88% of the children presenting lesions presented a description of the vocal quality that was different from normal.

In our culture, we observe that in general people do not recognize hoarseness as a symptom of laryngeal alterations; in addition, hoarseness is many times seen as a "charming" trait in children.

We observed that the children with and without alterations in the vocal folds did not differ significantly in terms of age (Table 2), a finding which is different from that of SILVERMAN & ZIMMER (5), who observed that the incidence of these lesions peaked at 9 years.

In terms of the parameters analyzed in our study, fundamental frequency was not significantly different when the groups with and without lesion were compared. Therefore, we believe that fundamental frequency is not a good parameter for screening childhood hoarseness, as pointed out by GLAZE et al. (21) and MCALLISTER et al. (19). The fundamental frequency in our children varied from 224.82 to 245.82 Hz (Tables 2 and 3). These values are compatible with those described by MCALLISTER et al. (19). In the group with no lesions of the vocal fold fundamental frequency ranged from 118.97 to 363.68 Hz; in the group with lesions this parameter ranged from 147.32 to 291.46 Hz (Tables 2 and 3).

The increase in fundamental frequency values accompanied the increase in jitter values (Table 2), a finding which is compatible with the findings reported by HOLLIEN et al. (22). However, in the present study, when the group of children with lesions was divided into two groups (cysts and nodules), this correlation was no longer observed (Table 3).

The average shimmer value in the present study was 0.60 dB (with structural lesion) and 0.75 dB (without structural lesion) (table 2) and ranged from 0.60 to 0.79 (Table 3).

JOTZ (23) reported that jitter and shimmer are poor parameters, both for quantifying hoarseness and for therapeutic follow-up in children, possibly as a result of the anatomical and functional characteristics of the vocal fold (amount of lose conjunctive tissue and incipient development of the vocal muscle) in this age group.

In relation to PPQ and APQ, we did not observe any significant differences when comparing children with or without structural lesions of the vocal fold (tables 2 and 3). KOIKE et al. (24) had different results, but pointed out that a larger sample would be necessary to evaluate the true efficacy of these parameters for detection of vocal disorders. PINTO & TITZE (25) reported that PPQ and APQ are useful for detecting neurologic, biomechanical, or aerodynamic voice abnormalities.

In the present study, we observed that it is indeed difficult to establish parameters for vocal analysis in children. It is not possible to affirm that the computerized analysis was useful for establishing a distinction between the presence or absence of structural lesions in the study group. In turn, we do not expect any method to be 100% accurate, since Medicine is not an exact science; therefore, we still believe that computerized analysis is useful in children.

CONCLUSIONS

The study of laryngeal configuration, the perceptual auditory analysis, and the computerized analysis of voice in children living in an orphanage led us to conclude that there were no significant differences in the age of children with or without structural lesions of the vocal fold. In addition, in the group of children with lesions, the presence of a median posterior chink and of vocal nodules was significantly more frequent than in children without lesions.

We did not observe a significant difference with respect to type of glottic closure and laryngeal constriction in the group of children without structural lesion of the vocal fold. Regarding the computerized analysis of voice, there were no significant differences between the groups in terms of the parameters studied. Therefore, we conclude that these parameters are not adequate either for assessment of structural lesions of the vocal fold or for therapeutic follow-up in children.

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