https://doi.org/10.23925/2176-2724.2021v33i2p257-264

Case series study on voice and transsexuality: acoustic characteristics of Brazilian trans men and women

Estudo de série de casos sobre voz e transexualidade: características acústicas de homens e mulheres trans brasileiras

Estudio de serie de casos sobre voz y transexualidad: características acústicas de hombres y mujeres trans brasileños

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Abstract

Objective: To describe the acoustic characteristics in the voice of trans men and women. Method: Six trans subjects, two men and four trans women, aged over 18 years participated in this study. The SoundForge 10.0® software was used to edit and select the vowel /a/, the Advanced Multi-Dimensional Voice Program (MDVP-Adv) for extraction of measurements from computerized acoustic analysis, and the Analysis Synthesis Laboratory program (Computerized Speech Lab - Kay Pentax®) for analysis of the vocal filter. **Results**: Formant values were lower when compared to national and international literature. The measures of f0 presented values below that expected for the female gender and increased to the

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RD: contibuted in the orientation of the study and original idea.
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Received: 07/24/2020
Accepted: 11/12/2020

male gender. Regarding the measures of the highest fundamental frequency (fhi) and the lowest (flo), the results showed great variability, suggesting phonatory instability. The results of jitter and shimmer and noise-related parameters, such as Voice Turbulence Index (VTI) and Soft Phonation Index (SPI), were incongruent when related to normality parameters. The noise / harmonic NHR measurement showed to be higher than the normal values, suggesting the presence of noise or hoarseness during the emission. Measurements of vocal tremor (Fatr and Ftri), presented an abnormal distribution when compared to the literature. It was not possible to observe relations in the analysis of the acoustic characteristics between the reference values and the people participating in this research. **Conclusion**: The acoustic measures of voices of trans people present different analysis when compared to the literature, evidencing the fragility of acoustic vocal analysis programs that do not contemplate the cultural heterogeneity and the varied gender identities.

Keywords: Voice; Voice Quality; Transsexuality; Formants; Speech, Language and Hearing Sciences; Dysphonia.

Resumo

Objetivo: Descrever as características acústicas na voz de homens e mulheres trans. **Método:** Participaram desta pesquisa seis pessoas trans, dois homens e quatro mulheres trans, com idade superior a 18 anos. Foram utilizados o *software SoundForge 10.0*®, o *Advanced Multi- Dimensional Voice Programm (MDVP-Adv)* para extração das medidas da análise acústica computadorizada e o programa *Analysis Synthesis Laboratory (Computerized Speech Lab – Kay Pentax®)* para análise do filtro vocal. **Resultados:** Os valores dos formantes se mostraram menores quando comparados à literatura nacional e internacional. As medidas de f_0 apresentaram valores abaixo do esperado ao gênero feminino e aumentados ao gênero masculino. Quanto às medidas de frequência fundamental máxima (fhi) e mínima (flo), os resultados apresentaram uma grande variabilidade, sugerindo instabilidade fonatória. Os resultados de jitter e shimmer e os parâmetros relacionados ao ruído, como o Índice de turbulência vocal (VTI) e Índice de fonação suave (SPI) mostraram-se incongruentes quando relacionados aos parâmetros de normalidade. A medida de ruído/harmônico NHR se mostrou maior que os valores de normalidade, sugerindo presença de ruído ou rouquidão durante a emissão. As medidas de tremor vocal (Fatr e Ftri) apresentaram distribuição anormal quando comparadas à literatura. Não foi possível observar relação nas análises das características acústicas entre os valores de referência e as pessoas participantes desta pesquisa. **Conclusão:** As medidas acústicas de vozes de homens e mulheres trans apresentam análises diferentes quando comparados à literatura, evidenciando fragilidade dos programas de análise vocal acústica que não contemplam a heterogeneidade cultural e as variadas identidades de gênero.

Palavras-chave: Voz; Qualidade da voz; Transexualidade; Fonoaudiologia; Disfonia.

Resumen

Objetivo: describir las características acústicas en la voz de hombres y mujeres trans. **Metodos**: Seis personas trans, dos hombres y cuatro mujeres trans, mayores de 18 años participaron en esta investigación. El *software SoundForge* 10.0®, Programa de voz multidimensional avanzado (MDVP-Adv) se utilizaron para extraer las mediciones del análisis acústico computarizado y el programa del Laboratorio de síntesis de análisis (Laboratorio de habla computarizada - Kay Pentax®) para analizar el filtro vocal. **Resultados**: Los valores de los formantes demostraron ser más bajos en comparación con la literatura nacional e internacional. Las mediciones de f0 mostraron valores inferiores al esperado para el género femenino y aumentaron para el género masculino. En cuanto a las medidas de frecuencia fundamental máxima (fhi) y mínima (flo), los resultados mostraron una gran variabilidad, lo que sugiere inestabilidad fonatoria. Los resultados de *jitter* y *shimmer* y los parámetros relacionados con el ruido, como el índice de turbulencia vocal (VTI) y el índice de fonación suave (SPI) fueron incongruentes cuando se relacionaron con los parámetros de normalidad. La medida de ruido / armónicos NHR fue más alta que los valores normales, lo que sugiere la presencia de ruido o ronquera durante la emisión. Las mediciones del temblor vocal (Fatr y Ftri) mostraron una distribución anormal en comparación con

la literatura. No fue posible observar una relación en el análisis de las características acústicas entre los valores de referencia y las personas que participan en esta investigación. **Conclusión**: Las medidas acústicas de las voces de las personas trans presentan diferentes análisis en comparación con la literatura, mostrando la fragilidad de los programas de análisis acústico vocal que no contemplan la heterogeneidad cultural y las diferentes identidades de género.

Palabras clave: Voz; Calidad de la Voz; Transexualidad; Disfonía; Fonoaudiología

Introduction

Among the demands of trans people (women and men, transsexuals, transvestites, and transgender people) in the process of sexual reassignment, voice is one of the aspects that is rarely addressed both in clinical practice and in research regarding this topic. Speech, Language and Hearing Sciences is a science that studies human communication, with special regard to its development, improvement, and changes [1], including vocal production. However, it has not profoundly dealt with studies related to voice and transsexuality in the last ten years. The voice is constituted in the subject's history, revealing individual marks and characteristics that arise from subjective experiences [2]. Thus, in transsexuality, vocal quality must accompany the desire for sexual reassignment, either through the therapeutic process that includes the recognition of one's voice or even that of vocal identification.

Characterizing the human voice is an arduous process, in which it is necessary to be very careful about the countless processes for extracting the results. On the other hand, appropriating the longing and glimpsing the scarcity of studies regarding the voice of trans people, and after an accurate suggestion, the need to start the study on the vocal characterization of trans people was observed, which will be built through analysis of formants, vocal acoustic analysis, and their measurement extraction through the Multi Dimensional Voice Program (MDVP).

The acoustic vocal analysis [3,4] consists of the non-invasive process of extracting objective measures of the signal. Such evaluation allows the capture of vocal changes and the comparison of therapeutic voice procedures. Thus, the objective of the research is to describe the acoustic parameters of the source and vocal filter of trans men and women.

Method

The research was approved by the Universidade Federal de Sergipe Research Ethics Committee, under the CAAE number 48581715.3.0000.5546. All the participants agreed to participate in this work, signing the Free and Informed Consent form, according to the rules established in the Resolution of the National Health Council CONEP 466/2012.

Eight trans people participated in this research, however, two of them were excluded due to noise and impossibility of analysis. The others were henceforth named from P1 to P6, where P3 and P4 are trans men, and P1, P2, P5 and P6, trans women, over 18 years old, users of the Trans Ambulatory of Sergipe. The study included trans people aged 18 years or over who participated in all stages of the data collection.

The data were collected through recording in a unidirectional condenser microphone, positioned in a 6 cm distance and at an angle of 45º regarding the mouth of the participants. People performed three repetitions of the vowel [a] in a sustained manner and repeated the sentence extracted from the CAPE-V protocol "*Agora é hora de acabar*" (Now it's time to end). From this sample, the vowel [a] of the stressed syllable of the word / *agora* / (now) was selected to extract the formants' measurements. All the sentences were recorded using a digital recorder of the Lucky brand, model K-70. Recordings were made in a single session and a quiet environment. In the end, the voices were transferred to a Dell® brand notebook, Intel Core 2 Duo processor in WAV format.

For editing the samples, the vowel / a / sustained for at least 1 second using the SoundForge 10.0® software was selected. The same software was used to extract the acoustic parameters, with a sampling rate of 44,100 Hz, 16 bit.

The acoustic analysis was performed at Voice and Speech Lab from the Departamento de Oftalmologia, Otorrinolaringologia e Cirurgia de Cabeça e Pescoço da Universidade de São Paulo – Ribeirão

Preto, Brazil.A Dell® computer was used, with the Computerized Speech Lab (CSL) / Model 6103 vocal analysis package software by Kay Pentax®.

The extraction of the measurements from the computerized acoustic analysis was performed using the Advanced Multi-Dimensional Voice Program (MDVP-Adv). The following parameters were extracted: fundamental frequency, acute frequency, low frequency, percentage jitter, percentage shimmer, tremor amplitude, frequency amplitude, noise harmonic ratio - NHR, harmonic energy ratio - SPI and Voice Turbulence Index - VTI.

For the analysis of the formants, the program Analysis Synthesis Laboratory (Computerized Speech Lab - Kay Pentax®) was used. It can present the mean and the absolute data of each formant analyzed using the Linear Predictive Coding (LPC) method. For the present study, the means of the first four formants were used.

Results

The population participating in the research consists of 2 trans men and 4 trans women. No participant underwent a surgical procedure on the vocal folds or vocal tract to modify the voice. All participants are regulars at the outpatient speech therapy service with biweekly sessions. The number of sessions held until data collection is estimated at 15 sessions, except for absences or reappointments. All of them underwent a video laryngoscopy exam before the start of consultations and no structural changes were identified. Table 1 shows data on the characterization of the population participating in the study.

Table 2 shows the individual values of the acoustic measurements extracted by the MDVP.

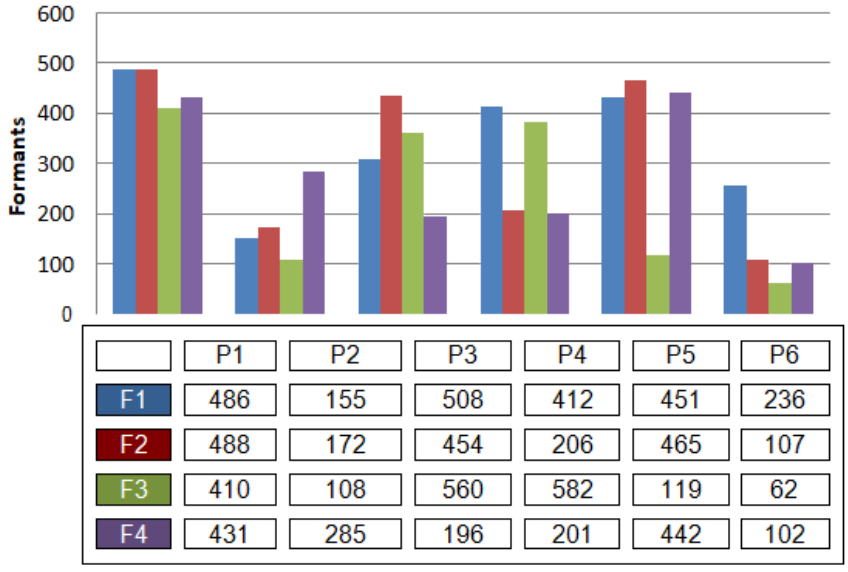
Table 1. Individual values of the acoustic measurements extracted by the MDVP

Subject	Gender	Age in Years	Time of hormonal treatment with medical monitoring	Period of hormonal treatment without medical supervision
P1	Woman	41	2 years	19 years
P2	Woman	44	2 years	17 years
P3	Man	27	2 years	-
P4	Man	19	2 years	-
P5	Woman	23	2 years	6 years
P6	Woman	45	2 years	30 years

Table 2. Individual values of acoustic measurements extracted by the MDVP

	MDVP										
	Gender	F0 (Hz)	Flo (Hz)	Fhi (Hz)	Jitt (%)	Shim (%)	NHR	VTI	SPI	Fatr (Hz)	Ftri (%)
P1	Woman	193.339	155.706	233.943	0.880	10.132	0.112	0.046	7.534	2.759	0.372
P2	Woman	119.935	115.634	124.924	0.800	8.428	0.167	0.034	21.579	6.349	0.262
P3	Man	148.922	130.998	173.388	1.211	11.005	0.209	0.080	3.982	2.312	0.628
P4	Man	199.964	168.163	240.568	3.227	9.173	0.174	0.064	1.935	4.082	0.727
P5	Woman	167.372	164.621	171.348	0.282	2.117	0.136	0.012	15.957	2.051	0.505
P6	Woman	141.710	134.968	147.659	0.520	6.535	0.162	0.056	4.746	3.279	0.431

Figure 1 presents a graph that illustrates the individual comparison between Formants F1, F2, F3, and F4.



	P1	P2	P3	P4	P5	P6
F1	486	155	508	412	451	236
F2	488	172	454	206	465	107
F3	410	108	560	582	119	62
F4	431	285	196	201	442	102

Figure 1. Individual comparison chart between Formants: F1, F2, F3, and F4.

Discussion

The voice depends on a complex and interdependent activity of all the muscles that produce it, in addition to the integrity of the tissues of the speaking apparatus. Although phonation is an innate neurophysiological function, the voice develops in parallel with the individual's organic and psychic process. The individual's psychic construction is also expressed by the voice, being one of the most striking extensions of the personality. Currently, there is a notable lack of research regarding the vocal characteristics of the trans person; a factor that corroborated significantly for the construction of this study. Therefore, it should be noted that to start a discussion about the values and comparison between this population and their vocal needs, results of studies with cisgender people will be used.

The acoustic identification of speech sounds occurs due to the different resonance properties of the vocal tract, which together with the sound filters, interact and modify the acoustic content of the sound produced by the larynx. The vowels are defined by the amplification regions inserted in the glottal energy [5]. These regions represent groups of harmonics amplified in the vocal tract, which are called sound formants. Although they have many definitions, in summary, the values of the formants represent the natural frequencies of resonance of the vocal tract, varying according to the articulatory position of the emitted vowel. In this study, the F1 values of trans women ranged between 153 and 486 Hz, lower than the study by Lima et al., (2007) [6] that presented values for the same formant and gender between 973 and 1001 Hz.

The degree of opening of a vowel, that is, the lowering of the mandible and, consequently, of the tongue, is directly related to the first formant, which is more acute when the mouth opening is greater; also, the degree of vowel anteriorization, that is, how much the pharynx is free, due to the displacement of the tongue, has a direct relationship with the second formant, being higher when the pharyngeal space is greater. The production of the third and fourth formants, on the other hand, demonstrates more particular aspects of the vocal tract, directly related to individual aspects of vocal quality, and is still widely discussed [5].

Some authors [7] state that the first, second, and third formants - F1, F2, and F3 - are related to the

quality of a vowel and the fourth and fifth formants - F4 and F5 - to the quality of the voice. The first formants - F1, F2, and F3 - are more unstable, while F4 and F5 are more stable. In this study, the means of the first four formants were used.

The results differ systematically in all formants, with lower values in formants F1, F2, and F3 when related to a study [8]. The findings of this study regarding F3, F4, and F5 are not close to the values found in the literature published in Sundberg's studies [9,10], which proposes the grouping of formants between 2,800-3,400 Hz and 3,500 Hz, respectively. In male voices, f0 and lower formants are expected [11].

Fant[12] states that, in men, formants present lower values than in women, in which the values are lower than in children. There is a study [13] that further suggests that the vowel identification is based on F1 and F2, however, they recommend the association with f0 and F3 to identify the gender, thus enabling better assimilation of the vocal parameter in the trans person.

The fundamental frequency (f0) is one of the most used measures in clinical practice to characterize the human voice [14], as it provides clues about aspects such as the individual's age, sex, and height. The f0 corresponds to the number of glottic cycles performed per second, relating aspects such as length, mass, and the tension of the vocal folds. Therefore, the more the vocal folds are stretched, the faster the glottic cycles will be performed and the higher the frequency produced [15].

The f0 measures of this study showed values below the expected for the female gender and increased for the male gender when compared with the Software Instruction Manual - MDVP - (KAYPENTAX, 2007). The average for adult men and women (18 to 45 years) is 113 and 204 Hz, respectively [16]. This contributes to substantiate the need for speech therapy and hormonal therapy follow up so that the voice adapts to the desire of people who seek the transsexual process, and that acoustic analysis programs can contemplate the population according to gender identity and that is not based only on cisgender people.

Regarding the measures of the highest fundamental frequency (fhi) and lowest fundamental frequency (flo), the results obtained show great variability during sustaining f0, suggesting phonatory instability. This variability can be justified by the subjects presenting untrained voices, because, if there is greater pneumophonoarticulatory coordination, there is, consequently, a more stable emission [17].

The jitter refers to the disturbance cycle by cycle of the voice frequency. It is an objective and repeatable measure, which evaluates small irregularities of the glottic pulses. The shimmer reflects on the disturbance of the amplitude cycle by cycle and its increase is related to the decrease or inconsistency of the contact coefficient of the vocal folds [14,18]. Besides, it is believed that it may also be related to the presence of breathiness in the voice or noise [18].

Also, according to the Software Instruction Manual - MDVP, the measurements of jitter and percentage shimmer are the result of the mean absolute difference between consecutive periods divided by the average period, and, when altered, they can be associated with hoarse and muffled voices.

Although scarce, some studies assess other parameters related to noise, such as the VTI - Voice Turbulence Index and the SPI - Soft Phonation Index.

The VTI indicates the level of relative energy in high-frequency noises. It is the ratio of the high-frequency non-harmonic spectral energy in the range from 1800 to 5800 Hz to the harmonic spectral energy in the range from 70 to 4200 Hz. According to the manufacturer of the MDVP software, VTI is related to the turbulence caused by incomplete closure of the vocal folds and by analyzing the high-frequency components. It is correlated with breathiness [19]. Researchers studied the reliability of the acoustic parameters of the voice of young adults of both genders and found that the noise parameter VTI has moderate reliability [20]. In a study, which assessed dysphonic voices in men and women aged between 38 and 87 years old and sought to determine the relationship between elements of vocal analysis, the authors correlated the NHR parameter with the general degree of vocal deviation and with roughness. The VTI correlated significantly only with the degree of vocal deviation [21]. The data found in this study are incongruous when compared with those found in the aforementioned manual. Thus, possible incomplete closure of the vocal folds is hypothesized, mainly in the female population, in which the reference value is 0.046, with greater adduction in the male population, with a reference value of 0.052.

The SPI, however, is given by the mean ratio of the low-frequency harmonic energy between 70 and 1550 Hz to the high-frequency harmonic energy between 1600 and 4500 Hz. This is a parameter indicating how smooth or compressed the glottic closure is during phonation [19]. A study sought to determine the sensitivity of RLS with an indicator of incomplete glottic closure in men diagnosed with vocal nodules and voices assessed as breathy and found that it is a reliable parameter to indicate the approximation of the vocal folds [22]. Roussel and Lobdell [23] investigated the clinical application of the SPI and found slightly elevated values for breathy voices compared to normal and strained voices. This corroborates the results found in the study group, whose SPI values were different from the parameters established by the Software Instruction Manual - MDVP [19], in which the normative values are 7,534 for women and 6,770 for men, which can be justified by the vocal adaptations that people made during the moment of the evaluation.

Studying VTI and SPI parameters is important, as it is possible to obtain an overview of the vocal function. Besides, it is known that variations in acoustic parameters can influence changes in vocal quality [24].

The NHR measure (noise / harmonic ratio) has a direct relationship with the vocal quality. Therefore, the lower the NHR, the better the vocal quality. This measure reflects the general assessment of noise in the analyzed signal and is not specific for particular cycles, including contributions to both the amplitude and frequency disturbances and aiding in the general perception of noise and hoarseness in the vocal signal [25]. The noise-harmonic ratio (NHR) remains stable during youth and adulthood and starts to reduce the harmonics during old age [26]. In evaluating this parameter, all people presented values higher than the normal values for the MDVP program, which is 0.112, suggesting the presence of noise or hoarseness during the vowel's emission.

Among the measures of vocal tremor, the severity index of the tremor frequency (Ftri) and the mean frequency of the tremor amplitude (Fatr) are frequently analyzed by several studies. However, such measures may vary according to the time of issue or the section analyzed. Vocal tremor is seen as a manifestation of neurological changes in the voice [27]. However, authors describe that vocal tremor may also be present in individuals with vocal polyps [28]. Therefore, such irregular characteristics of the vibration of the vocal fold can lead to a tremulous voice of non-neurological origin. The vocal tremor comes from one or more speech components, at the respiratory, phonatory, or articulatory level [15]. The results obtained by the study have a different distribution when compared to another study [20] and did not present the standard proposed by the program.

It was not possible to observe a relationship in the analysis of the acoustic characteristics between the reference values and the findings of this research. This situation is justified by the fact that the instrument (software) makes a linear analysis of the signal, inevitably excluding relevant aspects of the voices of trans people, a factor that may justify the difference between the analysis and incongruity between the results.

Conclusion

The acoustic measurements of the voices of trans people present different analysis when compared to national and international literature; the fragility of the acoustic vocal analysis programs is evidenced by not considering the cultural heterogeneity and diversity of gender identities of the subjects.

More detailed studies are suggested about the vocal characteristics of the trans person and mechanisms that make it possible to perform acoustic analysis of people in different socio-cultural contexts and of varying gender identities so that effective evaluations can be carried out regarding vocal therapeutic planning according to the person's demand and desire.

Speech, Language and Hearing Sciences must appropriate gender identity discussions so that it can perform a unique service according to the self-designation of the users who seek a process of vocal reassignment.

References

1. Conselho Federal de Fonoaudiologia - CFFa. O que faz o fonoaudiólogo? [homepage na Internet]. Distrito Federal: Conselho Federal de Fonoaudiologia; 2015 [acesso em 5 out. 2018].Disponível em: http://www.fonoaudiologia.org/.

2. Dornelas R. Cunha, MC, Ghirardi ACAM. Voz e psiquismo: efeitos recíprocos em um paciente laringectomizado total. Distúrb da Comun. 2010; 22: 61-7.

3. Finger LS, Cielo CA, Schwarz K. Acoustic vocal measures in women without voice complaints and with normal larynxes. Braz J Otorhinolaryngol. 2009; 75(3): 432-40.

4. Mora R, Crippa B, Dellepiane A, Jankowski B. Effects of adenotonsillectomy on speech spectrum in children. Inter J of Pediatric Otorhinolaryngol. 2007; 71(8): 1299-304.

5. BRASIL. Conselho Nacional de Pesquisa. Portaria CONEP/ MS nº 465 de 2012. Brasília, DF.

6. Behlau, M, Madazio G,Feijó D, Pontes P. Avaliação de Voz. In: Behlau, M. Voz: o livro do especialista.Vol 1. Rio de Janeiro: Revinter, 2001. p.85-180.

7. Lima MFB, Camargo ZA, Ferreira LP. Qualidade vocal e formantes das vogais de falantes adultos da cidade de João Pessoa. Rev. CEFAC. 2007; 9(1): 99-109.

8. Borden GJ, Harris KS, Raphael LJ. Speech Science Primer. 4.ed.Baltimore (Maryland): Williams & Wilkins; 2002.

9. Monteiro MC. Uma análise computadorizada espectrográfica dos formantes das vogais orais do português brasileiro falado em São Paulo. 1995. Monografia (Especialização) - Universidade Federal de São Paulo, São Paulo.

10. Sundberg J. The science of the singing voice. Illinois: Northern Illinois University Press, 1987.

11. Leino T. Long-term average spectrum study on speaking voice quality in male actors. In: STOCKHOLM MUSIC ACOUSTICS CONFERENCE, 1993, Stockholm. Proceedings of the Stockholm Music Acoustics Conference. Stockholm: Royal Swedish Academy of Music, 1993: 206-210.

12. Beber BC, Cielo CA. Medidas acústicas de fonte glótica de vozes masculinas Normais. Pró-Fono R Atual Cient. 2010; 22(3): 299-304.

13. Kazi RA, Prasad VM, Kanakalingam J, Nutting CM, Clarke P, Rhys-Evans P, Harrington KJ. Assesment of the formant frequencies in normal and laryngectomized individuals using Linear Predictive Coding. J Voice. 2007; 21(6): 661-8.

14. Fant G. Speech sounds and features. Cambridge: MIT Press, 1973.

15. Hillenbrand J, Clark M. The role of f0 and formant frequencies in distinguishing the voices of men and women. Attention, perception&Psychophysics. 2009; 71(5): 1150-66.

16. Santos IR. Análise acústica da voz de indivíduos na terceira idade. 2005. 189fl. Dissertação (Mestrado) - Escola de Engenharia de São Carlos - Faculdade de Medicina de Ribeirão Preto - Universidade de São Paulo.

17. Barros APB, Carrara AE. Análise acústica da voz. In: Deviditis RA, Barros APB. Métodos de avaliação e diagnóstico de laringe e voz. São Paulo: Lovise; 2002. p. 201-21.

18. KAYPENTAX CORPORATION. Multi-Dimensional Voice Program Model 5105. Software Instructions Manual. Lincoln Park, New Jersey: 2007, p.169-81.

19. Behlau MS, Tosi O, Pontes P. Determinação da frequência fundamental e suas variações em altura (Jitter) e intensidade (Shimmer) para falantes do português brasileiro. Acta AWHO. 1985; 4: 5-9.

20. Saxon KG, Schneider CM. Vocal exercise physiology. California: singular Publishing group, 1995. p. 69-71.

21. Oguz H, Demirci M, Safak MA, Arslan N, Islam A, Kargin S. Effects of unilateral vocal cord paralysis on objective voice measures obtained by Praat. Eur Arch Otorhinolaryngol. 2007; 264(3): 257-61.

22. Oguz H, Tarhan E, Korkmaz M, Yilmaz U, Safak MA, Dermici M, Ozluoglu LN. Acoustic analysis findings in objective laryngopharyngeal reflux patients. J Voice. 2007; 21(2): 203-10.

23. González J, Cervera T, Miralles JL. Análisis acústico de La voz. Fiabilidade de um conjunto de parâmetros multidimensionales. Acta Otorrinolaringol Esp. 2002; 53: 256-68.

24. Bhuta T, Patrick L, Garnett JD. Perceptual Evaluation of voice quality and its correlation with acoustic measurements. J Voice. 2004; 18(3): 299-304,2004.

25. Mathew MM, Bhat JS. Soft phonation index – a sensitive parameter? Indian J Otolaryngol Head NeckSurg. 2009; 61: 127-30.

26. Roussel NC, Lobdell M. The clinical utility of the soft phonation index. Clinic Linguist Phon. 2006; 20(2-3): 181-6.

27. Ferrand CT. Harmonics-to-noise ratio: an index of vocal aging. J Voice. 2002;16(4): 480-87.

28. Silveira DN, Brasolotto AG. Reabilitação vocal em pacientes com doença de Parkinson: fatores interferentes. Pró-Fono Revista de Atualização Científica. 2005; 17(2): 241-50.