

Original article

Comparison of Voice Acoustic Parameters in Persons with Organic Voice Disorders

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SUMMARY

Introduction/Aim. Voice is an acoustic phenomenon that must be viewed multidimensionally. In the quantitative assessment of voice characteristics, the use of acoustic parameters becomes a necessary method of analysis. The aim of the paper is to examine whether there are differences in the acoustic parameters of the voice (the average value of the fundamental frequency - F_0 , variations in the height of the fundamental frequency – Jita, and variations in the intensity of the fundamental tone of the larynx - ShdB in people with organic voice disorders with reference to gender and age).

Methods. The research included 30 subjects with organic voice disorders (inflammatory processes in the larynx and various allergic diseases), of both sexes (female $n = 13$, male $n = 17$), aged from 13 to 85 years. The first age group consisted of respondents aged 13 – 40 years, and the second age group consisted of respondents aged 41 - 85 years. The acoustic parameters of the voice were processed with a computer program for multidimensional vocal analysis model 4300 of the "Kay Elemetrics" voice laboratory.

Results. The results of the analyzed parameters (F_0 , Jita, ShdB) show that the mentioned parameters deviate from the reference values in women. Analyzing the acoustic parameters of the voice in older and younger subjects with organic voice disorders, it can be seen that there are significant differences between the two groups of subjects in the acoustic parameters of the voice in older subjects.

Conclusion. Considering the importance of voice and speech for social development, these research findings imply the need to describe the quantitative and microstructural characteristics of the voice in individuals with organic voice disorders, thereby providing vocal pathologists with a better understanding of the relationship between the investigated independent factors of sex, age, smoking status, and voice, improving their ability in the process of diagnosis, therapy and rehabilitation of organic voice disorders.

Keywords: voice, disorders, analysis, gender, age

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INTRODUCTION

Voice is an acoustic phenomenon that must be viewed multidimensionally (1). We analyse voice quality from the aspect of acoustic, perceptual and aerodynamic nature (2). In the quantitative assessment of voice characteristics, the use of acoustic parameters becomes a necessary method of analysis (3).

Analysis of the acoustic parameters of the voice allows easier and faster identification of voice pathology. By comparing the algorithms, a graphical and numerical representation of the pathological and healthy voice is obtained, which is necessary for establishing a precise and good prognosis (4). The advantages of acoustic voice analysis are reflected in its objectivity and non-invasive character, enabling the detection of voice pathology at an early stage (5).

The results of recent research (6 - 8) have shown that deviations in the values of acoustic parameters in organic voice disorders are the result of changes in anatomical structures that prevent the normal functioning of the vocal cords. Changes in vocal fold mass, length, and tension modify the fundamental frequency of Fo (8). Variations in Shimmer occur when there are mass lesions in the vocal folds such as edema, polyps, or carcinoma (7). The change of Shimmer determines the variation of the Jitter value, that is, the frequency of the voice, which becomes lower during phonation, impairing the quality of the voice (6). As the values of frequency and intensity variability parameters decrease, changes in voice quality (hoarseness, tension and weakness in the voice) worsen (9).

Comparing the acoustic correlates of the vocal quality of patients with vocal polyps and patients without any pathological changes on the vocal cords, the results showed that Jitter (%), Shimmer (%), fundamental frequency variation (vFo), voice turbulence index (VTI), frequency perturbation coefficient (PPK), perturbation coefficient amplitude (APK), and noise to harmonic ratio (NHR) significantly differ in patients with polyps on the vocal cords compared to patients without any pathological changes on the vocal cords (10).

Investigating the influence of factors (age, gender, smoking, enjoyment of alcohol, level of education, occupation and social status) in subjects with functional and organic voice disorders, it was concluded that smokers, compared to independent non-smokers, have organic voice disorders more often (internus) as well as transverse paresis, vocal fold

sulcus and malignant changes in the larynx), while smoking is not associated with functional voice disorders (11). Many studies have dealt with understanding the relationship between smoking intensity and the development of voice disorders, pointing out that there are acoustic differences between smokers and non-smokers (12 - 15). Research conducted in Korea shows that smokers have a 77% higher chance of voice disorders, highlighting the consistency of the relationship between smoking intensity and laryngeal disease. These authors point out that smoking causes gradual changes in voice quality that are often not recognized by the smoker (16). Analysing the acoustic parameters of frequency and intensity in smokers and non-smokers, Tuhanioglu and colleagues point out that the value of frequency parameters is lower in smokers, and the intensity parameter is higher. They also emphasize that there are differences in the effects of cigarette type on voice, emphasizing that electronic cigarettes have a milder impact compared to conventional cigarettes (14).

Physiological changes in the larynx occur with age, including laryngeal muscle atrophy (17), disorganization of collagen fibrils (18), reduced synthesis of hyaluronic acid and other components of the extracellular matrix (19). These aberrations often result in changes in the vocal folds, deformation of the glottic gap and narrowing of the laryngeal opening, which can lead to the appearance of dysphonia, impairing the quality of the individual's voice and his overall ability to use the voice to express wishes and needs (17). Research shows that voice disorders are more common in the elderly, linking this frequency to poor perception in the elderly due to hearing loss with age (19). It is estimated that 6.6% of the general population under the age of 65 have a voice disorder (20), while the percentage is much higher in those over 65, as much as 20% - 29% (21). Voice disorders in young adulthood are commonly associated with hypertension, tinnitus, and anxiety (22).

AIM

The aim of the paper was to examine whether there were differences in the acoustic parameters of the voice (average value of the fundamental frequency - Fo, variations in the height of the fundamental frequency - Jita, and variations in the intensity of the basic laryngeal tone - ShdB in persons with organic voice disorders with reference to gender and age).

A SAMPLE

The research included 30 subjects with organic voice disorders (inflammatory processes in the larynx and various allergic diseases), of both sexes (female N = 13, male N = 17), aged from 13 to 85 years.

The first age group consisted of respondents aged 13 – 40 years, and the second age group consisted of respondents aged 41 – 85 years. The average length of smoking experience for both research groups was 10 years (Table 1).

Table 1. *Distribution of the sample in relation to gender, age and smoking status*

Gender		Age		Smoking status	
Male	17 (56.60%)	Younger	15 (50%)	Smoker	18 (60%)
Female	13 (43.33%)	Older	15 (50%)	Non-smoking	12 (40%)

Note: N - number of respondents

Research instruments and procedures

Research, analysis, and data processing was carried out at the Ear, Throat and Nose Clinic in the "Zvezdara" Clinical Hospital Center in Belgrade. Basic demographic data were collected from the anamnestic data of the respondents. Only respondents who signed the informed consent for the research were included in the research. It was explained to the respondents that they could withdraw from the research at any time during its implementation.

The acoustic parameters of the voice were processed by a computer program for multidimensional vocal analysis model 4300 of the "Kay Elemetrics" voice laboratory. A Sony ECM-T150 microphone was placed at a distance of 5 cm from the subject's mouth. The signal was recorded directly on the computer. The examination was carried out individually, in conditions of minimal background noise, while the comfort and privacy of the subjects were ensured. Each subject repeated the prolonged vowel /a/ for several seconds, and the mean produced value was taken for analysis.

In this research, the acoustic parameters of the voice were analyzed: the average value of the fundamental frequency F_0 /Hz/, variations in the height of the fundamental frequency (percentage of jitter) Jitt /%/, and variations in the intensity of the basic laryngeal tone (percentage of shimmer) Shim /%/.

Data processing

Descriptive and inferential statistical analysis was used in statistical processing. The results obtained from the research were statistically processed

with an adequate selection of statistical methods (one-factor multivariate ANOVA) in order to provide an optimal model for understanding the dependence and differences between the analyzed data obtained in the research.

Statistical data processing was carried out using the package for statistical data processing in social sciences SPSS (SPSS, version 21.0). The results are tabulated.

RESULTS

Table 2 shows descriptive data and comparative values of parameters of acoustic voice analysis in persons with organic voice disorders in relation to gender.

By applying one-factor multivariate ANOVA, statistically significant differences ($p < 0.05$) were obtained in the values of the analysed voice parameters between persons with organic voice disorders in relation to gender, parameter F_0 : [$F(1,29) = 17.126$, $p = 0.002$]; Jita: [$F(1,29) = 21.425$, $p = 0.000$]; ShdB: [$F(1,29) = 36.598$, $p = 0.003$]. Analysing the average of the arithmetic means of all the analyzed parameters of the two groups of respondents and the results of the Scheffe post-hoc test (F_0 , Jita, ShdB), we came to the conclusion that the mentioned parameters deviated from the reference values in women.

Table 3 shows descriptive data and comparative values of parameters of acoustic voice analysis in persons with organic voice disorders in relation to the age of the subjects.

By applying one-factor multivariate ANOVA, a statistically significant differences ($p < 0.05$) were

Table 2. Descriptive values and comparison of voice acoustic parameters in persons with organic voice disorders in relation to gender

Acoustic parametric	Group	M	(n)	rcX ²	df	F	p
Fo	Male	2,63	(17)	69,789	1	17,126	,002
	Female	4,32	(13)				
Jita	Male	18,25	(17)	1208338,052	1	21,425	,000
	Female	102,28	(13)				
ShdB	Male	,09	(17)	1,248	1	36,598	,003
	Female	,43	(13)				

Note: Fo - average value of the fundamental frequency /Hz/, Jita - variations in the height of the fundamental frequency /%/, ShdB - variation of the sound signal amplitude /dB/, M - arithmetic mean, (n) - number of respondents, rcX² - value of the given statistic, df - number of degrees of freedom, F - statistic, p - significance level.

Table 3. Descriptive values and comparison of voice acoustic parameters in persons with organic voice disorders in relation to age

Acoustic parametric	Age	M	(n)	rcX ²	df	F	p
Fo	Younger	,36	(15)	6,896	1	16,748	,000
	Older	,94	(15)				
Jita	Younger	32,47	(15)	154596,763	1	14,289	,001
	Older	138,24	(15)				
ShdB	Younger	,18	(15)	1,259	1	22,448	,001
	Older	,46	(15)				

Note: Fo - average value of the fundamental frequency /Hz/, Jita - variations in the height of the fundamental frequency /%/, ShdB - variation of the sound signal amplitude /dB/, M - arithmetic mean, (n) - number of respondents, rcX² - value of the given statistic, df - number of degrees of freedom, F - statistic, p - significance level.

obtained in the values of the analyzed voice parameters in the "experimental" and control groups in relation to age, parameter Fo: [F(1,29) = 16.748, p = 0.000]; Jita: [F(1,29) = 14.289, p = 0.001]; ShdB: [F(1,29) = 22.448, p = 0.001]. Analyzing the average of the arithmetic means of all the analyzed parameters of the two groups of subjects and the results of the Scheffe post-hoc test (Fo, Jita, ShdB), we came to the conclusion that the mentioned parameters deviated from the reference values in older subjects.

DISCUSSION

Considering the importance of the acoustic assessment of the voice, as pointed out by many authors in this field, this paper aimed to examine whether there were differences in the acoustic para-

meters of the voice (average value of the fundamental frequency (Fo), variations in the height of the fundamental frequency (Jita) and variations in the intensity of the basic laryngeal tone (ShdB)) in persons with organic voice disorders in relation to gender and age.

By investigating the relationship between the acoustic parameters of the voice and gender, the research results show that the analyzed parameters deviated from the reference values in women. The frequency of voice disorders in women is associated with physiological differences in the phonatory apparatus, respiratory and digestive systems (23, 24), as well as with a higher degree of vocal self-assessment (24) which is why women present more often for counselling and vocal assessment (25).

By comparing the values of the analyzed voice parameters of younger and old people with organic voice disorders, we came to the conclusion that elderly people with organic voice disorders had deviations in all the analyzed voice parameters (Fo, Jita and ShdB). The obtained results are in accordance with the results of some authors (17) who point out that physiological changes in the larynx occur with age, including atrophy of the laryngeal muscles. This frequency is also associated with poor perception in the elderly (26). Based on these findings, the importance of providing unique health care to the elderly population is highlighted due to the high prevalence of chronic conditions that indirectly affect voice quality (27).

CONCLUSION

A complete voice assessment includes an in-depth understanding of how a voice disorder can af-

fect an individual's social participation and quality of life. Considering the importance of voice and speech for social development, these research findings imply the need to describe the quantitative and microstructural characteristics of the voice in individuals with organic voice disorders, thereby providing vocal pathologists with a better understanding of the relationship between the investigated independent factors of gender and age, improving their ability in the process of diagnosis, therapy and rehabilitation of organic voice disorders.

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Poređenje akustičkih parametara glasa kod osoba sa organskim poremećajima glasa

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SAŽETAK

Uvod/Cilj. Glas je akustički fenomen koji se mora sagledati iz više uglova. U kvantitativnoj proceni karakteristika glasa upotreba akustičkih parametara postaje neophodan metod analize. Cilj našeg rada je ispitati da li postoje razlike u akustičkim parametrima glasa (prosečna vrednost osnovne frekvencije – *Fo*, varijacije u visini osnovne frekvencije – *Jita* i varijacije u intenzitetu osnovnog tona larinksa – *ShdB* kod osoba sa organskim poremećajima glasa) u odnosu na pol i starost.

Metode. Istraživanjem je obuhvaćeno 30 ispitanika sa organskim poremećajima glasa (zapaljenski procesi u larinksu i različita alergijska oboljenja), oba pola (žena $n = 13$, muškarac $n = 17$), starosti od 13 do 85 godina. Prvu grupu činili su ispitanici stari od 13 do 40 godina, a drugu grupu ispitanici stari od 41 godine do 85 godina.

Istraživanje, analiza i obrada podataka obavljani su na Klinici za uho, grlo i nos u Kliničko-bolničkom centru „Zvezdara“ u Beogradu. Akustički parametri glasa obrađeni su kompjuterskim programom za višedimenzionalnu analizu vokala, model 4300 glasovne laboratorije *Kay Elemetrics*.

Rezultati. Rezultati analiziranih parametara (*Fo*, *Jita*, *ShdB*) pokazuju da navedeni parametri odstupaju od referentnih vrednosti kod žena. Analizirajući akustičke parametre glasa kod starijih i mladih ispitanika sa organskim poremećajima glasa, uvideli smo da postoje značajne razlike kod starijih ispitanika.

Zaključak. Uzimajući u obzir važnost glasa i govora za društveni razvoj, ovi istraživački nalazi impliciraju potrebu za opisom kvantitativnih i mikrostrukturnih karakteristika glasa kod osoba sa organskim poremećajima glasa, čime se vokalnim patolozima pruža bolje razumevanje odnosa istraženih nezavisnih faktora pola, godina starosti, pušačkog statusa i glasa; tako bi se poboljšala njihova sposobnost u procesu dijagnostikovanja, terapije i rehabilitacije organskih poremećaja glasa.

Ključne reči: glas, poremećaj, analiza, pol, starost