

Original article

## Voice condition assessment and the effect of rehabilitation in vocal professionals

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### Summary

**Introduction.** The human voice is an important characteristic that enables the distinction of human from other living beings. Otherwise, it represents a picture of a person's personality, his health, mental and emotional state. The research aims are to determine the voice characteristics of vocal professionals with diagnosed vocal cord nodules by subjective voice assessment and objective voice measurement before and after vocal rehabilitation.

**Methods.** This study has involved 25 examinees, aged 23 to 56. The subjective voice assessment was conducted with the Voice Handicap Index - VHI questionnaire and the objective voice measurement by a computerized laboratory for voice analysis "Kay Elemetrics". The obtained data were processed using descriptive and analytical statistics.

**Results.** Before the vocal rehabilitation and the subjective and objective voice measurements, the examinees had greater psychosocial difficulties associated with their voice quality. After two months of vocal rehabilitation, there has been a significant improvement in the voice of all subjects on the VHI scale. A statistically significant and highly statistically significant improvement have been noticed in six out of seven analyzed parameters of vocal A, by the objective measurement of voice. Namely, the obtained values - the percentage of jitter Jitt (%), the percentage of shimmer Shim (%), the relative average perturbation value RAP (%) and the coefficient of fundamental frequency variation - vFo were highly statistically significant ( $p < 0.01$ ). The VTI - voice turbulence index and the SPI - soft phonation index also improved, the observed difference was statistically significant ( $p < 0.05$ ), while the observed difference in the FTRI parameter was not statistically significant ( $p > 0.05$ ).

**Conclusion.** Vocal rehabilitation has influenced the improvement of the voice quality, which means that the results obtained by objective voice measurements were more in accordance with the results of the subjective voice assessment.

**Key words:** voice, vocal rehabilitation, measurement, acoustic voice analysis, perceptual voice evaluation

### Introduction

Vocal professionals are individuals who use voice as the basic means of their professional activity. They use it on a much larger scale, longer duration, higher intensity and under various professional and microclimate conditions [1].

The voice of a human involves a variety of sounds produced in a human phonatory organ. A human voice is a portrayal of one's personality, their health, psychological and emotional

state [2]. The term vocal professional includes a range of occupations that require the successful use of voice and speech, such as singers, actors, teachers, radio and television presenters, priests, commanders, lawyers, street vendors and many others. For the vocal professionals, a healthy and pleasant voice is important, because with a disrupted speech and voice they would not be able to do their job successfully [3].

According to the recommendation of the Center for Voice Disorders at Wake Forest University, there are four levels of vocal use depending on the importance of the voice for the profession:

**Level I - Elite vocal professionals** (actors and singers) where even the slightest damage to the voice affects their professional activity.

**Level II - Vocal professionals** (educators, leaders, priests, lawyers, politicians...) where moderate voice impairment affects their profession.

**Level III - Non-vocal professionals** (doctors, judges, command staff in the army and politics...) where only severe voice impairment affects their profession.

**Level IV - Non-vocal nonprofessionals** (all other occupations) where voice quality does not affect a profession which is important for everyday communication [2].

Causes of voice damage in vocal professionals are the same as for nonprofessionals, although vocal professionals are more exposed to damage due to specific working conditions, vocal load and special psychological conditions. Vocal fatigue leads to a change in vocal quality and a reduction in voice control, which results in reduced durability. In such situations, vocal professionals have an unpleasant sensation in the throat and neck, feel pain when swallowing, and avoid talking due to consistent tiredness [4]. The most common problems of the vocal professionals are hoarseness, murmured voice, voice tension, weak voice and ultimately loss of voice [5]. Dysphonia is a voice disorder that denotes

any deviation from its normal features of pitch, intensity, and quality [6]. Vocal difficulties can also affect the psychological state of a patient and cause concern if and when the voice will function normally [5]. Hoarseness can affect communication and social integration, thereby deteriorating the quality of life of every human being [7].

The vocal cord nodules are limited calcules occurring on the free edge of the vocal cord, between the anterior and the middle third (the so-called Frenkel point) of both vocal cords and they are most often benign changes on the vocal cords.

The nodules may interfere with the professional activities of the patient and they should be treated, because any further strain on the voice organ of the patient with vocal cord nodules additionally damages the vocal cords [6].

The vocal rehabilitation is an effective method that applies to voice disorders and tends to change the way of vocal production. It reduces the unnecessary tension of the larynx and neck muscles and the proper flow of air through the glottis. In addition to the techniques of correct vocal production, vocal hygiene is also performed [8, 9].

The research aim is to determine the voice characteristics of vocal professionals with diagnosed vocal cord nodules by the subjective voice assessment and objective voice measurement before and after vocal rehabilitation.

## Methods

In this study, 25 examinees participated, aged 23 to 56, with mean age 40.05. All the subjects were first examined by an otorhinolaryngologist, by indirect laryngoscopy, and after the diagnosis was established, they were referred to a logopedic outpatient clinic where vocal rehabilitation was performed, twice a week for 30 to 45 minutes.

In this research, the subjective voice assessment and objective voice measurement have been performed.

The subjective voice assessment has been performed using the Voice Handicap Index – VHI [10] questionnaire, which covers three areas: functional, emotional and physical. Each area contains ten questions. This questionnaire demonstrates the effectiveness of vocal rehabilitation and evaluates the extent of the voice problem experienced by a patient. All examinees filled out the VHI questionnaire for the first time they reported to the logopedic outpatient clinic and after two months they filled it for the second time. There was no time limit for completing the questionnaire.

The objective voice measurement has been conducted by the computerized laboratory for the voice analysis of the company “Kay Elemetrics”. In all examinees, the vocal A was recorded and analyzed. The acoustic structure of vocal A was analyzed for at least three seconds, from three attempts, in a room isolated from the noise, in a comfortable sitting position, with the usual voice pitch and intensity of the speaking voice. Seven parameters of multidimensional voice analysis were analyzed: the parametric signal (percentage of jitter (%)), the relative average perturbation value - RAP (%), the coefficient of fundamental frequency variation - vFo, the percentage of shimmer Shim (%), the voice turbulence index - VTI, the soft phonation index – SPI and the tremor analysis (frequency tremor intensity index- FTRI %). This method of assessment (acoustic analysis) is non-invasive and gives objective data on voice quality and allows monitoring of changes in voice over a longer period [11].

The subjective voice assessment and objective voice measurement were performed twice - before the beginning of vocal rehabilitation and two months later, after its completion.

Methods of descriptive and analytical statistics have been used in describing and analyzing the obtained data. From the methods

of descriptive statistics, the arithmetic mean with the corresponding standard deviation was used, as well as the minimum and maximum frequency and percentage were used, and everything was presented in tabular form. In analytical statistics, the Student’s t-test for parametric data and the Wilcoxon test of equivalent pairs for non-parametric data were used to assess the significance of the difference. Since the sample size was 25 subjects, the significance of the difference in the Wilcoxon test was determined by the Zed-Z test, because the data behaved according to the normal distribution. Statistical processing and analysis were done in the computer program SPSS ver. 20 (Statistical Package for the Social Sciences).

## Results

Structure of the examinees in relation to gender, shown in Table 1.

**Table 1.** Sample structure with respect to gender

Gender	Frequency	Percentage
Female	16	82.0
Male	9	18.0
Total	25	100

f - frequency; p - percentage

The average age of the examinees is 40.05 years. Vocal professionals, whose voice use causes vocal strain, were represented in the study (Table 2).

**Table 2.** Sample structure with respect to occupation

Occupation	Frequency	Percentage
Teachers	10	49.0
Professors	7	35.0
Singers	4	8.0
Educators	4	8.0
Total	25	100

f - frequency; p - percentage

Table 3 shows the results on the VHI scale before vocal rehabilitation. Based on the results obtained before vocal rehabilitation, the examinees had greater psychosocial difficulties related to their voice quality. Since they were not able to use their voice adequately for professional and social needs, it also had a negative effect on their emotional state.

Table 4 shows the results obtained by the VHI scale after vocal rehabilitation. After vocal rehabilitation, there has been an improvement in the voice of all examinees (100%) on all the subscales, which has positively affected their voice as well as the quality of life.

**Table 3.** Results on the VHI scale before vocal rehabilitation

VHI subscale		Frequency	Percentage
Physical subscale	Mild	0	0
	Moderate	0	0
	Heavy	25	100.0
Emotional subscale	Mild	4	20.0
	Moderate	2	10.0
	Heavy	19	70.0
Functional subscale	Mild	0	0
	Moderate	6	30.0
	Heavy	19	70.0
Total score	Mild	0	0
	Moderate	1	5.0
	Heavy	24	95.5

**Table 4.** Results on the VHI scale after vocal rehabilitation

VHI subscale		Frequency	Percentage
Physical subscale	Mild	25	100.0
	Moderate	0	0
	Heavy	0	0
Emotional subscale	Mild	25	100.0
	Moderate	0	0
	Heavy	0	0
Functional subscale	Mild	25	100.0
	Moderate	0	0
	Heavy	0	0
Total score	Mild	25	100.0
	Moderate	0	0
	Heavy	0	0

f - frequency; p - percentage

**Table 5.** Values of vocal parameters before and after vocal rehabilitation

Vocal parameters	Middle value (MV)		p
	Before vocal rehabilitation	After vocal rehabilitation	
Jitter (%)	2.396±1.053	0.200±0.100	p<0.01
Shimmer (%)	5.056±1.657	1.896±0.122	p<0.01
RAP	1.890±1.602	0.200±0.114	p<0.01
vFo	2.810±1.430	0.579±0.268	p<0.01
VTI	0.179±0.227	0.089±0.151	p<0.05
SPI	20.822±11.009	4.901±1.767	p<0.05
FTRI	1.006±0.461	0.671±0.658	p>0.05

The data are presented as an arithmetic mean ± standard deviation and as range (min - max). Jitt (%) - jitter percentage; Shim (%) - shimmer percentage; RAP - relative mean perturbation value; vFo - coefficient of variation of the fundamental frequency; VTI - voice turbulence index; SPI - attenuated phonation index; FTRI - frequency tremor intensity index

Table 5 shows the values of acoustic parameters before and after vocal rehabilitation. The results of acoustic parameters of the vocal A before and after vocal rehabilitation differed significantly. The observed difference in the parameters: Percentage of jitter Jitt (%), percentage of shimmer Shim (%), the relative average perturbation value RAP (%) and the coefficient of fundamental frequency variation - vFo were highly statistically significant. The obtained values of the parameters were as follows: Jitter (%)  $W = 456$ ,  $Z = -4.761$ ,  $p < 0.01$ ; Shimmer (%)  $W = 440$ ,  $Z = -4.871$ ,  $p < 0.01$ ; RAP  $W = 389$ ,  $Z = -4.461$ ,  $p < 0.01$ ; vFo  $W = 424$ ,  $Z = -4.661$ ,  $p < 0.01$ .

The voice turbulence index - VTI and the soft phonation index - SPI have also improved, the observed difference was statistically significant ( $W = 129.4$ ,  $Z = -2.158$ ,  $p < 0.05$ ,  $W = 465$ ,  $Z = -4.781$ ,  $p < 0.01$ ). Tremor analysed by the frequency tremor intensity index - FTRI did not show significant improvement, the observed difference was not statistically significant ( $W = 168$ ,  $Z = -1.263$ ,  $p > 0.05$ ).

## Discussion

Vocal cord nodules most often occur in vocal professionals, individuals whose primary occupation is based on their voice, but also in children. They cause the hoarseness of voice of varying intensity. The hoarseness of the voice caused by vocal cord nodules in vocal professionals can affect physiological functioning, social adaptability and emotional state and cause psychological and emotional problems and thus impact their quality of life [7, 11, 12, 13].

The goal of vocal rehabilitation is to restore the voice of patients so that they will be able to use it adequately for their professional and social needs, which will improve their quality of life.

Before the beginning of vocal rehabilitation, an objective voice measurement showed that all the analyzed parameters were distorted, which inadequately reflected on their professional activity and thus the quality of life. After the completion of the vocal rehabilitation, a statistically significant and highly statistically significant improvement has been observed in six out of seven analyzed parameters of the vocal A: Jitter - Jitt (%), the relative average perturbation value - RAP, the coefficient of fundamental frequency variation - vFo, the percentage of shimmer Shim (%), the voice turbulence index - VTI, the soft phonation index - SPI, which is in accordance with other studies [13, 14, 15, 16, 17]. There was no significant improvement in the frequency tremor intensity index - FTRI, which can be explained by the short duration of vocal rehabilitation, which lasted two months. A large number of examinees in this study simultaneously attended vocal rehabilitation and completed their professional duties, not preserving their voice, which further slowed down their recovery.

The results obtained by the subjective voice assessment before vocal rehabilitation indicated a severe voice disorder. These results are in accordance with previous studies where it has been confirmed that dysphonia can cause psychological and emotional problems, which negatively affected their social integration [7, 9, 12, 14, 18, 19].

After the vocal rehabilitation, the voice of each examinee has improved, which means that the vocal rehabilitation produced positive results. Mathur et al. [20] had a positive outcome of vocal therapy on voice quality in vocal professionals. Other authors had a positive impact on the implementation of educational guidelines for vocal hygiene and vocal rehabilitation in patients with dysphonia in their studies [21, 22]. Many studies have shown that vocal rehabilitation can lead to improved voice quality [13, 14, 23].



## Conclusion

Vocal professionals are people who are most susceptible to the development of all types of laryngeal pathology, but also functional pathologies that occur mainly due to improper and excessive use of voice. Vocal cord nodules represent one of the most serious laryngeal problems for vocal professionals. Vocal rehabilitation based on giving guidelines on

voice hygiene, mastering the technique of proper breathing, eliminating hard attacks and tension in the neck and shoulders has a significant role in the treatment of vocal cord nodules. Vocal rehabilitation is of great importance for vocal professionals, primarily by achieving aesthetically high quality and good voice, and at the same time it is strongly focused on improving their quality of life.

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**Ethical approval.** The Ethics Committee of the Public Health Hospital "Sveti Vračevi" in Bijeljina approved the study and informed consent was obtained from all individ-

ual respondents. The research was conducted according to the Declaration of Helsinki.

**Conflicts of interest.** The authors declare no conflict of interest.

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## Procena stanja glasa i efekat rehabilitacije kod vokalnih profesionalaca

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**Uvod.** Ljudski glas je važna karakteristika koja omogućava razlikovanje čoveka od drugih živih bića. Inače, predstavlja sliku ličnosti jedne osobe, njenog zdravstvenog, psihičkog i emotivnog stanja. Cilj istraživanja je da se subjektivnom procenom i objektivnim merenjem utvrde glasovne karakteristike vokalnih profesionalaca sa čvorićima na glasnicama pre i nakon vokalne rehabilitacije.

**Metod.** Ova studija obuhvatila je 25 ispitanika starosne dobi od 23 do 56 godina. Subjektivna procena glasa sprovedena je pomoću Indeksa glasovnog oštećenja (Voice Handicap Index - VHI scale) i objektivnog merenja glasa kompjuterizovanom laboratorijom za analizu glasa „Kay Elemetrics“. U opisivanju i analiziranju dobijenih podataka korišćene su metode deskriptivne i analitičke statistike.

**Rezultati.** Pre vokalne rehabilitacije subjektivnim i objektivnim merenjem ispitanici su imali izražene psihosocijalne poteškoće koje su se odražavale na kvalitet glasa. Nakon dvomesečne vokalne rehabilitacije na VHI skali došlo je do značajnog poboljšanja glasa kod svih ispitanika. Objektivnom analizom glasa, visoko statistički značajno i statistički značajno poboljšanje primećeno je kod šest od sedam analiziranih parametara vokala A. Odnosno, dobijene vrednosti - procenat jitter-a Jitt (%), procenata shimmer-a Shimm (%), relativna srednja vrednost perturbacije RAP (%) i koeficijent varijacije osnovne frekvencije - vFo su bile veoma statistički značajne ( $p < 0,01$ ). Poboljšali su se i indeks turbulencije glasa VTI i indeks prigušene fonacije SPI, uočena razlika je bila statistički značajna ( $p < 0,05$ ), dok uočena razlika parametra FTRI nije bila statistički značajna ( $p > 0,05$ ).

**Zaključak.** Vokalna rehabilitacija je značajno uticala na poboljšanje kvaliteta glasa, odnosno rezultati dobijeni objektivnim merenjem bili su u skladu sa rezultatima subjektivne procene glasa.

**Ključne reči:** glas, vokalna rehabilitacija, merenje, akustička analiza glasa, perceptivna analiza glasa