EFFECT OF INHALANT ALLERGIES ON VOICE QUALITY IN WOMEN

ANA BONETTI[1], MATEJA VISKOVIĆ[2]

[1]Department of Speech and Language Pathology, Faculty of Education and Rehabilitation Sciences, University of Zagreb, ana.bonetti@erf.hr, [2]Specialist Hospital for Medical Rehabilitation Lipik, Lipik

Received: 26.10.2017.
Accepted: 16.01.2018.

Original scientific paper
UDK 616.211-002:81] (497.5)
612.784-055.2(497.5)
81'342.2:61-055.2] (497.5)

Abstract: *Reports of negative influence of inhalant allergies on voice quality in the world are increasingly frequent. In order to evaluate this impact using objective and subjective methods, women with allergies (n = 30) and women without allergies (n = 30) underwent multidimensional assessment consisting of perceptual assessment, Voice Handicap Index – HR (Bonetti and Bonetti, 2013) and acoustic analysis. The results indicate a negative effect of allergies on voice quality, which is measurable as significantly worse VHI-HR results and worse harmonics-to-noise ratio (HNR) in acoustic analysis.*

Key words: *inhalant allergies, perceptual assessment of voice, acoustic analysis of voice, Voice Handicap Index (VHI-HR)*

INTRODUCTION

Allergy is the overreaction of a person's immune system to substances that are usually harmless, such as pollen, food and medication (Aleraj and Tomić, 2011). The frequency of allergic illnesses has lately been increasing in the whole world (American Academy of Allergy, Asthma & Immunology, 2017), which is especially worrying because of the long-term consequences caused by allergies which had emerged in childhood. Bulat-Kardum (2013) states that, due to cigarette smoke, wide use of antibiotics, change of nutritional habits, climate changes with air pollution and the overall change of the way of life, we can expect increase in allergies.

Allergies affecting airways, i.e. *inhalant allergies*, refer to allergies to pets, dust, mould and trees (American Academy of Allergy, Asthma & Immunology, 2017). Inhalant allergies can be seasonal (e.g. to dust) or all year round (e.g. to dust and mites), causing irritation of upper airways, itching of nose and eye and excessive excretion of mucus, which can consequently affect voice quality (Ohlsson et al., 2015).

Studies have shown that allergens in allergic persons induce inflammatory changes in the throat that can be followed by vocal symptoms as the consequence of inflammations or independent activity of allergens (Asher, 2013; Ohlsson et al., 2015). A study conducted by Baker et al. (1982) showed that vocal symptoms such as weak voice, hoarseness and harshness in persons with allergies is up to eight times more common than in healthy persons. Perceptually, the voice in persons with allergies is described as quiet, nasal (Cvejić and Kosanović, 1982), soar and tense (Simberg et al, 2009) and some vocal symptoms are present outside allergy season, which can indicate that allergies may permanently affect voice quality (Ohlsson et al., 2015). It seems that mentioned perceptual voice characteristics of persons with inhalant allergies follow changes in acoustic voice parameters, since allergy symptoms are connected with the lowering of F0 (Jackson-Menaldi et al., 1999), increased values of jitter and shimmer (Niedzielska, 2005) and the decrease in the friction ratio of sounds /s/ and /z/ (Ozbal Koc et al., 2014). Also, in relation to healthy persons, allergic persons have more bio-psycho-social complaints connected to voice quality (Ozbal Koc et al., 214; Krouse et al., 2007;

Millqvist et al., 2006) indicating that voice handicaps they are exposed to are present even when basic symptoms are not, and that the effect of allergy can begin even when it is impossible to recognise it by means of clinical voice assessment tools.

Voice quality of persons with allergies can be damaged due to a particular therapy, i.e. taking medicines. Titze and Verdolini Abbot (2012) divide allergy medicines in five categories (decongestives, antihistamines, mucolytics, steroids and agents for stabilisation of mastocytes) and assert that some of them can have a damaging effect on voice: Oxymetazoline (active ingredient of Operil, for example) can lead to increased sneezing and irritation of nasal mucosa; antihistamines Loratidine (active ingredient of allergy medicines such as Claritine, Rinolan, Aerius) and Cetirizine (active ingredient of Xyzal) cause dryness of mouth which can result in hoarseness, sore throat and changes in voice; steroids Rhinocort (active ingredient is budesonide), Avamys (with fluticasone as the active ingredient), as well as Nasonex (Mometasone as the active ingredient), can cause irritation of throat, dryness, coughing, laryngeal edema, hoarseness and changes in voice (Ihre et al., 2003; Gallivan et al., 2005; Hellings and Fokkens, 2006, Titze and Verodlini Abbot, 2012).

AIM OF THE STUDY

The above mentioned indicates the influence of allergies on perceptual and objective characteristics of voice quality, as well as the influence of changes in voice quality due to the emergence of symptoms or treatment of allergies on the quality of life of allergic persons. However, studies so far have not clearly illustrated the influence of the duration of allergic symptoms on subjective and objective voice quality, nor the relationship between allergy duration and potential associated vocal handicaps on the quality of life of allergic persons. Therefore, the aim of this research was to examine voice quality in women without allergies and in women with inhalant allergies by means of subjective and objective methods during allergy season (during allergy symptoms) via self-assessment method in order to examine the influence of participants' voice quality on their everyday life and examine the relationship between the duration of allergy symptoms and the results of subjective and objective voice quality assessment.

HYPOTHESES OF THE STUDY

In line with the proposed aim, the following hypotheses of the study have been defined:

H: There is a significant difference in the results of self-assessment of the influence of voice on everyday life and perceptual and objective voice assessment between research participants with and without allergies.

H2: There is a significant connection between the duration of allergy symptoms and findings of self-assessment of the influence of voice quality on everyday life and the results of subjective and objective voice quality assessment.

RESEARCH METHODS

Research participants

The total of 30 women with allergies aged 20 to 36 (mean age 25,66, with standard deviation of 5,83 years) participated in the study, as well as 30 women without allergies aged 20 to 37 (mean age 25,76, with standard deviation of 5,44 years). Apart from age and gender, data regarding allergies (how long has the person been suffering from allergies and the type of allergens), medication used by participants and their occupation were also collected.

Participants with allergies stated that they have been suffering from allergies between 2 and 35 years (mean age 14,5, with standard deviation of 9,02 years). Most participants (26) are allergic to pollen (86,1%), 3 participants are allergic to ambrosia (10%) and, finally, one participant is allergic to dust (3,3%).

Most of the participants use antihistamines in the form of pills to alleviate allergy symptoms and smaller number of them uses steroids in the form of nasal sprays, while inhalers (corticosteroids and β2-agonists) are used in the smallest number of cases (5 participants or 20% of cases), those intended for bronchodilation, i.e. easing of breathing. Data on the use of pills, sprays and inhalers is illustrated in Table 1.

Table 1. *Data on the use of pills, sprays and inhalers for alleviating allergy symptoms (N=30).*

Method of treating allergy symptoms	Name of medication	Frequency	Percentage
Pills (antihistamines)	None	8	26.7
	Claritine	7	23.3
	Rinolan	5	16.5
	Telfast	1	3.3
	Aerius	3	10
	Xyzal	2	6.7
	Daselta	2	6.7
	Nixar	2	6.7
Nasal sprays (steroids)	None	22	73.3
	Tafen	3	10
	Rhinocort aqua	1	3.3
	Nasonex	1	3.3
	Avamys	3	10
Inhalers (corticosteroids and β2-agonists)	None	24	80
	Alvesco	2	6.7
	Servente diskus	1	3.3
	Ventolin	3	10

Study variables

Set hypotheses of the study were analysed by means of selecting three types of variables: variable self-assessment of the influence of vocal handicaps on everyday activities, variable objective voice assessment, variable perceptual voice assessment and variable duration of allergy symptoms.

The first group of variables consisted of 4 variables obtained through the use of Voice Handicap Index questionnaire (VHI-HR, Bonetti and Bonetti, 2013), representing Croatian adaptation of the Voice Handicap Index questionnaire (Jacobson et al., 1997). This instrument of Likert type consisting of 30 questions is one of the most commonly used measures for self-assessment of the influence of vocal handicaps on voice quality (Bouwers and Dikkers, 2009) with certified psychometric characteristics (Franic et al., 2004), with which it is possible to quantify functional (10 questions), physical (10 questions) and emotional (10 questions) effects of vocal handicaps on individual's quality of life (T VHI-HR) and the results of its 3 subscales: functional (F VHI-HR), physical (P VHI-HR) and emotional (E VHI-HR).

Second group of variables consisted of 4 variables obtained through the use of acoustic analysis of participants' voice samples and 2 aerodynamic variables. Observed acoustic variables were the height of the average base voice frequency (f0), shimmer (SHIMM), jitter (JITT) and the acoustic parameter harmonics to noise ratio (HNR), as the common acoustic parameters in measuring voice quality (Awan, 2006). Observed aerodynamic variables were the maximum phonation time of /a/ (MPT) and the phonation time ratio of sounds /s/ and /z/ (S/Z) as joined indicators of laryngeal dysfunction (Eckel and Boone, 1981), i.e. the coordination of breathing out and the vibration of vocal chords or the efficiency of active structures in glottis (Gelfer and Pazera, 1997).

Variable perceptual voice assessment consisted of grade of dysphonia (GD), obtained as the audio assessment of the impression of exposure to deviations in participants' voice quality and variable duration of allergy symptoms made up a time frame within which allergy symptoms could affect voice quality and quality of life of particular participants.

Data collection method

Participants whose voices and allergies were observed in this study all volunteered to participate in the study between May and August 2017, when the activity of allergens was expected to be higher, based on a question on the message board of the Faculty of Education and Rehabilitation Sciences, University of Zagreb. The criteria for choosing participants were female gender, due to a greater risk of occurring changes in voice quality (Lauriello et al., 2011) and the doctor's diagnosis of inhalant allergy.

For each participant, data on age, type and – depending on the existence/non-existence of a diagnosis – on the duration of allergy and type of therapy were recorded. Personal and all subsequently collected data were analysed after oral permission of each participant.

After forming two groups of participants, each had to complete the VHI-HR questionnaire. This was preceded by short instructions on the purpose and way of completing the questionnaire. Participants were told that the degree of their agree-

ment with each statement in the questionnaire, presented with numbers 0-4, should be rounded with a pen. The questionnaire was not timed.

After the questionnaire, participants' voice samples were recorded for the purpose of acoustic and perceptual analysis of their voices. Voice samples consisted of three maximum phonation times of sustained /a/ and of reading a connected text 10 sentences long. Recording of voice samples for acoustic and perceptual analysis was done separately, in a quiet room with a digital portable recorder TASCAM, on a 20 cm distance from participant's mouth and the participant was asked to sit straight. After recording three maximum phonation times and reading a short paragraph, friction time of sounds S and Z was measured, in one trial.

Data processing methods

For the purpose of a possible psychosocial influence of vocal handicaps on the quality of life, the overall number of points on the VHI-HR questionnaire subscales was calculated for each participant, as well as the overall result on the questionnaire by adding points to all three questionnaire subscales.

Recorded phonation times were, for the purpose of further acoustic and perceptual analysis, edited via computer program Adobe Audition 1.5 (default recording was 44100 Hz and the dynamic scale 16 bits). Acoustic analysis of individual voice recordings was done via program PRAAT (Boersma and Weenink, 2017) and it consisted of the recording of the vowel /a/ in its middle, for the duration of 5 seconds. The best of three trials of held phonation was taken into consideration as the maximum phonation time.

Collected participants' reading samples were switched to a digital audio media (CD) and presented to one assessor with experience in perceptual voice assessment in the same order they were recorded. Voice quality on the recordings, which followed one another in the original duration, was rated from 0 (no dysphonia) to 4 (severe dysphonia), to get the perceptual assessment of possible discrepancies in participants' voice quality. Each following reading sample was presented after the assessor had rated the previous sample.

The friction of sounds S and Z was measured with a stopwatch and their ratio was calculated. Data was statistically analysed via SPSS software. Descriptive analysis was done first and it included the verification of the normality of distribution on dependent variables via Kolmogorov-Smirnov test. Testing the normality of distribution displayed the necessity of the application of non-parametric Mann-Whitney test in testing the significance of differences between participants with and without allergies on dependent variables. Finally, non-parametric Spearman correlation coefficient was calculated to determine the relationship between the duration of allergy symptoms and the results of self-assessment of the influence of voice quality on everyday life, i.e. the results of subjective and objective voice quality assessment.

Significance level for all performed analyses was $p<0,05$.

RESULTS AND DISCUSSION

Descriptive data on both groups of participants for observed acoustic and aerodynamic variables, variable perceptual assessment and four variables self-assessment of the influence of voice quality on the quality of life are illustrated in Table 2.

By looking at the values in Table 2, we can see that both groups of participants demonstrate lower mean values on variables maximum phonation time (14.0 and 15.7 s) in relation to referential values of 20 s that were reported (Fernand, 2012 according to Botha et al., 2017). Friction ratio of sounds /s/ and /z/ in both groups of participants was within expected parameters, 1.00-1.40 (Fernand, 2012, according to Botha et al., 2017).

If we look at values of acoustic measures illustrated in Table 2, we will see that values of variable jitter in both groups of participants fall within expected parameters (Fernand, 2012, according to Botha et al., 2017). Participants with allergies in relation to referential values show slight increase of the mean value of shimmer indicating a slightly hoarseness voice, while results of participants without allergies on the same variable fall within referential values of Praat program. It is visible that the average HNR in participants with allergies is slightly below the recommended value of 20 dB

Table 2. *Values of aerodynamic and acoustic variables, variable perceptual assessment and four variables self-assessment of voice quality on the quality of life for participants with and without allergies*

Variables		Participants with allergies (N=30)				Participants without allergies (N=30)			
		Min	Max	M	SD	Min	Max	M	SD
Aerodynamic	MPT	6	43	14.6	7.35	8	25	15.07	4.16
	S/Z	0.59	2.14	1.03	0.35	0.60	1.46	0.94	0.26
Acoustic	F0	145.54	240.12	195.12	21.57	164	279.65	205.38	25.92
	JITT	0.17	1	0.43	0.17	0,16	0.67	0.37	0.13
	SHIMM	0.17	1.47	0.37	0.24	0.15	0.63	0.32	0.13
	HNR	8.39	24.17	18.81	2.88	15.60	27.56	20.82	3.15
Perceptual	GD	0	2	0.30	0.53	0	1	0.10	0.31
Self-assessments	F VHI-HR	0	23	7	5.34	0	8	1.77	2.1
	P VHI-HR	0	27	10.87	7.74	0	11	3.13	3
	E VHI-HR	0	25	4.47	6.2	0	5	0.83	1.37
	T VHI-HR	1	71	22.3	16.88	0	16	5.73	4.89

Legend:
Min – minimum result
Max – maximum result
M – average result
SD – standard deviation

(18.81 dB), while in participants without allergies that average is 20.82 dB.

Mean value of the grade of dysphonia in group of participants with allergies is not high and it is 0.3, with standard deviation of 0.53, while in group of participants without allergies that mean is even lower (0.1), with a lower standard deviation (0.31), indicating somewhat better perceptual assessment of voice quality.

Looking at results of self-assessment of the influence of voice quality on the quality of life, illustrated in Table 2, it is clear that participants with allergies have the highest average number of points on the P VHI-HR (10.87 points) with the maximum result of 27 points. If we look at the average number of points, functional subscale follows (7 points) with 23 as the maximum number of points and emotional subscale (7 points) with 25 as the maximum number of points. The overall average result of participants with allergies is 22,3 points, with standard deviation of 16.8 points. These results can indicate that participants with allergies in average do not express psycho-social difficulties as the result of change in voice quality, i.e. they do not consider that these voice handicaps are expressed in such way that they affect their everyday activities. However, high standard deviation values on the T VHI-HR and high maximum result of 71 points indicate that there are significant individual differences between them in terms of self-assessment of voice quality on the quality of life, i.e. some participants have reported a significant psycho-social influence of their own voice quality. Participants without allergies have also had the highest average number of points on a physical subscale (3.13 points), then on the functional subscale (1.77) and the lowest on emotional subscale (0.83). However, the average result on the T VHI-HR, as well as standard deviations and maximum results on all four observed self-assessment variables indicate that participants without allergies have homogeneously reported insignificant influence of voice quality on the quality of life.

Table 3. illustrates the results of Mann-Whitney U test, which tested the significance of differences between participants with and without allergies on aerodynamic and acoustic variables, perceptual variable and variable self-assessment of the influence of voice quality on everyday life. Values in Table 3 indicate that there are no significant differences in average values of observed aerodynamic variables, but that they are present for one acoustic variable and for all observed self-assessment variables. In other words, U values and levels of reliability illustrated in Table 3 clearly highlight differences between participants with and without

allergies in average harmonics to noise ratio and in the average number of points on three subscales of the VHI-HR, as well as in the overall average number of points on the questionnaire, that were statistically significant on the significance level p<0,05.

Table 3. *Results of testing the significance of differences between groups of participants with and without allergies on aerodynamic and acoustic variables, perceptual variable and variables self-assessment of voice quality on everyday life by means of Mann-Whitney U test*

Variables		U value	p value
Aerodynamic	MPT	382.000	0.313
	SZ	385.000	0.336
Acoustic	F0	348.000	0.132
	JITT	361.500	0.191
	SHIMM	407.000	0.530
	HNR	**296.000**	0.023*
Perceptual	GD	159.000	0.092
Self-assessments	F VHI-HR	**148.000**	0.000*
	P VHI-HR	**227.000**	0.000*
	E VHI-HR	**111.000**	0.001*
	T VHI-HR	**373.500**	0.000*

Legend:
*significant on significance level p<0,05

Test results of the relationship between the duration of allergy symptoms and self-assessment of the influence of voice quality on everyday life, i.e. results of subjective and objective assessment of voice quality by means of correlation analysis (Spearman correlation coefficient) are illustrated in Table 4. From the results of correlation analysis, it is possible to see a statistically significant low negative correlation between variables HNR and allergy duration (ρ=-0.281, p=0.030) and a moderate positive correlation on functional (ρ=0.582, p=0.000), physical subscale of the VHI-HR (ρ=0.545, p=0.000) and emotional (ρ=0.447, p=0.000) subscale of the VHI-HR (ρ=0.640, p=0.000) between allergy duration and self-assessment of the influence of voice qualiry on everyday life. Mentioned results indicate that higher self-assessment results, representing higher bio-psycho-social influence of voice quality, are followed by longer allergy duration.

Inhalant allergies affect airways, causing irritation of upper airways, nose and eye itching and excessive excretion of mucus (Ohlsson et. al., 2015). Allergic reactions in upper airways can have different manifestations of symptoms in different parts of a year and influence social aspects of life, quality of rest, productivity and the quality of life in general (Bousquet et al., 2008). Having in mind that allergic reaction in inhalant allergies is directly linked to structures participating in voice production and that voice quality is also directly linked to the quality of life (American Speech-Language-Hearing Association, 2016), it can be expected that inflammatory processes will affect voice production and its quality (Krouse and Altman, 2010; Ohlsson et al., 2015).

This study analysed possible influence of inhalant allergy on perceptually and acoustically assessed voice quality in young women and possible influence of the change in their voice quality on their socio-emotional perception of their own voice. Given that earlier studies on the effects of allergies on larynx indicated a possible influence of the duration of allergy symptoms on the manifestation of the reaction of structures participating in voice production (Reidi et al., 2003), this study also analysed the relationship between participants' voice quality assessment and their socio-emotional perception of voice with allergy duration.

Table 4. *Results of correlation analysis between the duration of allergy symptoms (in years) and aerodynamic and acoustic variables, perceptual variable and variables self-assessment of the influence of voice quality on everyday life*

Variables		Aerodynamic		Acoustic				Perceptual	Self-assessments			
		MPT	SZ	F0	JITT	SHIMM	HNR	GD	F VHI-HR	P VHI-HR	E VHI-HR	T VHI-HR
Duration of allergy symptoms	ρ	-0.114	0.135	-0.252	0.154	0.050	-0.281*	0.178	0.582*	0.545*	0.447*	0.640*
	p	0.386	0.302	0.052	0.239	0.706	0.030	0.173	0.000	0.000	0.000	0.000

Legend:
P – Spearman correlation coefficient
*significant on significance level p<0,05

Obtained statistically significant differences in the VHI-HR questionnaire and its subscales are in line with previous reports (Ozbal Koc et al., 2014; Radhawa et al., 2010; Millqvist et al., 2006) which observed a higher influence of vocal symptoms on the quality of life during allergy season. The absence of statistically significant difference in average results on particular acoustic variables (F0, jitter, shimmer), and on variable representing perceptual assessment of voice quality, is in line with the study conducted by Verguts et al. (2011), in which the results demonstrated that allergens do not have any influence on acoustic or perceptual level of voice assessment. However, opposite results were obtained by Ohlsson et al. (2015) and Jackson-Menaldi et al. (1999), who noticed lower F0 connected with allergies and mentioned vocal chords' edema as the result of allergens' activity as the possible conclusion. In this study, the influence of allergies on average voice height, jitter or shimmer was not found.

Statistically significant lower average harmonics to noise ratio in participants with allergies in relation to participants without allergies corresponds to the results of a study conducted by Develioglu et al. (2013), who also highlighted the differences in this acoustic parameter of voice in persons with and without allergies, as well as in all other acoustic parameters observed in this study.

CONCLUSION

In this study, with the observed values of aerodynamic and other acoustic variables, we cannot categorically claim that the significant difference in average harmonics to noise ratio in participants with and without allergies can indicate a higher presence of noise in voice of participants diagnosed with allergies. Based on significantly higher results of self-assessment of vocal handicap in relation to healthy participants and based on the significant connection of these results with allergy duration, and given the predominantly normal values of aerodynamic, acoustic and perceptual characteristics of their voice, it can be noted that participants suffering from allergies feel vocal symptoms during duration of allergy which do not have acoustic or perceptual, but a subjective effect. The presence of vocal symptoms such as exaggerated swallowing of excessive excretion, frequent clearing of throat, coughing, tension in larynx and neck area, weakness, breaking and losing voice and higher sensitivity or feeling of pain in larynx area during voice production, is more frequent in persons suffering from allergies than in persons without allergic reactions (Simberg et al., 2009). Given that results of this study indicate that mentioned vocal symptoms influence everyday life of persons with allergies, even without the presence of aerodynamic, acoustic and perceptual consequences, the question of the use of vocal handicap self-assessment questionnaire can be posed, as a screening measure for patients who could develop voice handicap due to inhalant allergy diagnosis. Corresponding to the mentioned is the significant connection of longer allergy duration and stronger manifestation of vocal handicap, i.e. the presence of higher quantity of noise in voice, suggesting the necessity of the application of self-assessment measures for voice quality and its psycho-social influence in persons suffering from inhalant allergies. Namely, even though this was not the case in this study, taking into consideration the young age of participants, it can be thought that their worse voice self-assessment due to the emergence of allergy symptoms could in the future be followed by changes visible on acoustic measures of voice which could be heard by listeners. The mentioned opens a new question of voice handicaps' prevention in persons with allergies that is, regarding content (e.g. consultation on implementation of vocal hygiene and vocal training) and efficiency assessment, also connected to vocal handicap self-assessment measures.

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UTJECAJ INHALACIJSKIH ALERGIJA NA KVALITETU GLASA KOD ŽENA

Sažetak: *U svijetu se sve češće govori o negativnom utjecaju inhalacijskih alergija na kvalitetu glasa. Kako bi se taj utjecaj ispitao objektivnim i subjektivnim metodama, na ispitanicama ženskog spola s alergijama (n=30) te na ispitanicama bez poznatih alergija (n=30) učinjena je multidimenzionalna procjene kvalitete glasa koja se sastojala od perceptivne procjene, rezultata Indeksa vokalnih teškoća (VHI-HR) (Bonetti i Bonetti, 2013) i akustičke analize. Dobiveni rezultati upućuju na negativan utjecaj alergija na kvalitetu glasa, vidljiv u statistički značajno lošijim rezultatima upitnika VHI-HR te na akustičkom parametru omjera šumnog i harmoničnog dijela spektra (HNR).*

Ključne riječi: *inhalacijske alergije, perceptivna procjena glasa, akustička analiza glasa, Indeks vokalnih teškoća (VHI-HR)*