CHARACTERISTICS OF SPEECH AND VOICE AS PREDICTORS OF THE QUALITY OF COMMUNICATION IN ADULTS WITH HYPOKINETIC DYSARTHRIA

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KARAKTERISTIKE GOVORA I GLASA KAO PREDIKTORI KVALITETA KOMUNIKACIJE KOD ODRASLIH OSOBA SA HIPOKINETIČKOM DIZARTRIJOM

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Received/Primljen: 13.11.2018. Accepted/Prihvaćen: 21.12.2018.

ABSTRACT

Hypokinetic dysarthria is characterized by a speech that gradually becomes monotonous, poorly modulated, quiet and ultimately unintelligible. The goal of this research is to determine the acoustic characteristics of voice and speech in adults with hypokinetic dysarthria and the impact of the altered voice on the quality of communication. The sample consisted of 30 elderly respondents of both genders with Parkinson's disease and hypokinetic dysarthria. In order to conduct a spectral analysis, the voice of patients was recorded while they were reading phonetically balanced text. The respondents conducted a self-assessment of the degree of their own handicap caused by voice disorder and impact of the voice handicap by completing the Voice Handicap Index (VHI). Statistically significant differences were determined in the position of some formants in respondents compared to the values of formants in typical speakers for the following vowels: F1 of the vowel /I/ and F2 of the vowels /E/, /I/, /O/ and /U/. By examining the relation between the score achieved on the VHI instrument and the value of formants, the only statistically significant correlation was achieved between the formant F1 of the vowel /A/ and functional and emotional subscale. By regression analysis used to determine the predictor of the quality of communication, it was confirmed that F1 of the vowel /A/ has a statistically significant contribution to the explanation of the score achieved on functional and emotional subscale, by explaining 15% of the functional subscale (Beta=-0,393 (11,30 – 47,37)) and 10% of the emotional subscale (Beta=-0,363 (-0,052 – 0,000)).

Keywords: hypokinetic dysarthria, spectral analysis, quality of communication.

SAŽETAK

Hipokinetičku dizartriju karakteriše govor koji vremenom postaje monoton, slabo moduliran, tih i na kraju nerazumljiv. Cilj ovog istraživanja je utvrđivanje akustičkih karakteristika glasa i govora kod odraslih osoba sa hipokinetičkom dizartrijom i uticaja izmenjenog glasa na kvalitet komunikacije. Uzorak je činilo 30 odraslih ispitanika oba pola koji imaju Parkinsonovu bolest i hipokinetičku dizartriju. Kako bi se izvršila spektralna analiza glasa sniman je govor pacijenta tokom čitanja fonemski izbalansiranog teksta. Samoprocenu stepena sopstvenog hendikepa izazvanog poremećajem glasa i uticaja glasovnog oštećenja na kvalitet komunikacije ispitanici su vršili popunjava-njem Indeksa glasovnog oštećenja (VHI). Utvrđene su statistički značajne razlike u položaju pojedinih formanata kod ispitanika u odnosu na vrednosti formanata tipičnih govornika i to za sledeće glasove: F1 vokala /I/ i F2 vokala /E/, /I/, /O/ i /U/. Ispitivanjem veze između skora na VHI instrumentu i vrednosti formanata (F1 i F2) jedina statistički značajna pove-zanost ostvarena je između formanta F1 glasa A i funkcionalne i emocionalne supskale. Regresionom analizom korišćenom za utvrđivanje prediktora kvaliteta komunikacije potvrđeno je da F1 glasa A statistički značajno doprinosi objašnjenju skora dobijenom na funkcionalnoj i emocionalnoj supskali, objašnjavajući 15% funkcionalne supskale (Beta=-0,393 (11,30 – 47,37)) i 10% emocionalne supskale (Beta=-0,363 (-0,052 – 0,000)).

Ključne reči: *hipokinetička dizartrija, spektralna analiza, kvalitet komunikacije.*

ABBREVIATIONS

VHI - Voice Handicap Index
F1, F2 - the first and the second vowel formants

sciendo
UDK: 616.89-008.434.37
Ser J Exp Clin Res 2021; 22 (2): 157-165
DOI: 10.2478/sjecr-2018-0081

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INRODUCTION

Acquired dysarthria is a neurologically conditioned motor speech disorder caused by abnormalities in power, strength, range, speed, control, precision of movement and tonus of muscles which are involved in the realization of respiration, phonation, resonance, articulation and prosody during the speech production (1). As such, dysarthria represents a multidimensional disorder which can affect all above stated aspects of speech or just some components of the speech production process (2). Dysarthria includes many voice, speech and speech fluency related problems, what undermines the intelligibility of speech and affects the success of communication, as well as psychosocial functioning of an individual (3, 4).

Hypokinetic dysarthria is present in individuals with Parkinson's disease, and it is believed that voice is most often the first affected speech component (5). Also, the prevalence of voice disorder in this population is very high (6). The main symptoms of hypokinetic dysarthria are: irregular breathing in speech, inadequate articulation, slow, slurred speech ending with unintelligible murmur, short phonation in which a person is not able to pronounce multisyllabic words and shorter sentences within one expiration without interruptions, as well as a sobbing, monotonous voice (7).

Graphic segmentation of speech into the basic acoustic elements is performed by a spectrographic analysis. The speech segment is parsed into different frequencies by a series of electronic filters and the intensity of each frequency is calculated. Formants represent an increased concentration of sound energy at certain frequencies. Those areas of increased frequencies reflect the main points of resonance in the vocal tract. All vowels and some consonants have formants. In speech, vowels show two, and more often three formants. Formant pattern (particularly F1 and F2) enables us to distinguish vowels or to recognize that some vowel is "the same" when repeated, even when produced by different speakers. This paper presents the results of a spectral analysis of all vowels, that is, the positions of the first and the second vowel formants, obtained from the processing of the recorded voice of speakers from the sample. In this way, it is determined whether there is a difference in the position of formants F1 and F2 in individuals without speech impairment and those with hypokinetic dysarthria.

It often happens that voice disorders resulting from the same impairments can result in different handicaps. Therefore, it is necessary to have standardized instruments for self-assessment of the voice disorder, which will be included in the clinical assessment and will influence the process of determining an adequate treatment and evaluation of the success of treatment. An increased interest in the quality of life of patients with voice and speech disorders and understanding of the importance of a human voice in social inclusion generated the questionnaires for assessing the subjective experience about the consequences of the voice disorder. Voice Handicap Index – VHI (8) used in this research has several potential applications in the clinical practice of the speech-language pathology. It is most often used for the assessment of a patients' experience about the impact of their own voice disorder on daily activities and quality of communication. It is also used as an instrument for measuring the efficiency of the outcome of voice therapy, as well as the assessment of the severity of a voice problem in an individual with speech pathology of different etiology. In this research, the respondents expressed their opinions on the impact of the characteristics of their voice and speech on their physical, emotional and functional condition, and consequently on the quality of daily communication, whereby the information about the degree of a voice handicap experienced by individuals with hypokinetic dysarthria were obtained.

The relation between the values obtained by a spectral analysis and the score achieved on the VHI instrument is being increasingly studied today, and it has been determined that these values can be strong predictors of the type and severity of dysphonia (9). The main goal of this research was to determine the acoustic characteristics of voice and speech by spectral analysis in adults with Parkinson's disease being diagnosed with hypokinetic dysarthria. The ultimate goal was to determine the relation between the characteristics of speech and voice and quality of communication of individuals with hypokinetic dysarthria. More precisely, testing was performed in order to determine whether the altered position of vowel formants can be a predictor of the quality of communication in these individuals.

MATERIALS AND METHODS

Sample

The testing was performed on the sample of 30 elderly respondents of both sexes with Parkinson's disease and hypokinetic dysarthria. The respondents were aged between 59 and 94 years, with an average age of Me=82, with 11 (36.7%) being men and 19 (63.3%) being women. Demographic characteristics, educational level and smoking status of the respondents, as well as the presence of vocal professionals in the sample are shown in the Table 1.

The respondents did not have any associated disabilities that can affect the characteristics of speech and voice. The sample consisted inclusively of the respondents whose native language is Serbian so that voice characteristics of the respondents with hypokinetic dysarthria could be compared to the existing standards for adult typical speakers of the Serbian language.

Table 1. Structure of the sample

	N=30
Gender, n (%)	
Male	11 (36.7%)
Female	19 (63.3%)
Educational level, n (%)	
without school and primary school	10 (33.3%)
secondary school	10 (33.3%)
high and higher school	10 (33.3%)
Smoking status, n (%)	
Smoker	7 (23.3%)
Non-smoker	23 (76.7%)
Vocal professional, n (%)	
Yes	3 (10.0%)
No	27 (90.0%)
Average age, Median (min-max)	82.00 (59-94)

n – number of respondents, % - percentage

Instruments and procedure

The respondents which made the sample in the research are beneficiaries of several care homes for elderly and sick persons in Belgrade. Data about the type of pathology and dysarthria of respondents were obtained by an insight into their medical and logopedic documentation, and data about age, education, smoking status and profession were received from the respondents themselves. The consent to participate in the research was given by respondents and members of their families. The adults with Parkinson's disease and hypokinetic dysarthria answered the questions from the VHI instrument, thus evaluating the quality of their own communication. Recording of the voice and speech was performed individually, in a quiet room isolated from noise. Processing and analysis of data obtained by recording of the voice and speech of respondents were performed at the Department of Otorhinolaryngology at Medical Center „Zvezdara".

The computerized laboratory of *"Kay Elemetrics"* corporation, model 4300, was used for an acoustic analysis of voice and speech, to determine parameters of the spectral analysis of speech – formant structure of vowels. While the voice and speech were recorded, the respondents were reading "Balanced text" (10), which represents an instrument designed specifically for the analysis of voice and speech. The text represents a coherent semantic whole and contains complex utterances that are useful for speech analysis. The presence of all speech sounds is balanced in the text as in an everyday speech. The balance of the text refers to natural distribution of the frequency of syllables in semantic units of the Serbian language, as well as to the inclusion of all speech sounds in the Serbian language in the initial and medial articulation position and 14 most frequent speech sounds in the final position. The natural distribution of one-syllable, two-syllable and three-syllable words was also respected, as well as the distribution by types of words (10).

Voice Handicap Index (VHI) (8) is an instrument used in the research, and thus adults with hypokinetic dysarthria could conduct a subjective assessment of the degree of handicap they experienced because of the voice disorder and evaluate the quality of communication they achieved. The VHI instrument includes 3 subscales with 10 items each, physical which represents a patients' perception of their own voice, emotional which represents the emotional experience of a patient about the problem they have with their own voice, and functional which indicates patient's problems that occur during the communication. The results obtained in all three subscales indicate the possible problems which individuals with voice pathology have during communication. The VHI instrument indicates the level of self-assessed problem which a patient has with voice, which does not have to be in correlation with the objective measures of the voice. Each subscale contains 10 questions with 5 answer options of Likert scale type (0-4).

Statistical data analysis

As for descriptive statistics measures, a median with minimum and maximum for numerical variables was used, while the overview of categorical variables was given through frequencies and percentages. Differences between groups on numerical variables were tested by Mann-Whitney and Kruskal Wallis Tests. The relation of two categorical variables was tested by Chi square test. Spearman's correlation coefficient was used to test two numerical variables, while predictor features of the variables were tested by univariate linear regression analysis. Deviation of the values obtained by the analysis of the samples from normal values was tested by t test for one sample. Nonparametric tests were used given that deviation of distribution from the normal one was statistically significant.

Statistical significance was defined at the probability level of zero hypothesis of $p \leq 0,05$. Statistical analysis was done in the computer programme SPSS ver. 24 (Statistical Package for the Social Sciences).

RESULTS AND DISCUSSION

The Table 2 shows average values of formants of analysed vowels in the respondents with hypokinetic dysarthria, as well as results of testing of the difference between the achieved values on the sample and normal values of formants.

Table 2. Average values of formants and differences compared to normal values

	N	Min	Max	Median	T	df	p
F1 of vowel A	30	269	896	642,00	-1,933	29	0,221
F2 of vowel A	30	747	1554	1300,00	1,018	29	0,317
F1 of vowel E	29	269	687	508,00	-0,513	28	0,612
F2 of vowel E	29	867	2242	1674,00	-3,855	28	***0,001***
F1 of vowel I	30	179	717	328,00	4,619	29	***0,000***
F2 of vowel I	30	926	2682	1974,00	-4,638	29	***0,000***
F1 of vowel O	29	298	687	448,00	-1,523	28	0,139
F2 of vowel O	29	538	1225	1016,00	3,357	28	***0,002***
F1 of vowel U	30	209	538	358,00	-0,964	29	0,343
F2 of vowel U	29	508	1195	837,00	2,643	28	***0,013***

N-number of respondents, Mim – minimum value on the sample, Max – maximum value on the sample, t – t test, df – degrees of freedom, p – statistical significance

Differences were tested by t test for one sample. There is a statistically significant difference between normal values on the formant F2 of vowel /E/ (t=-3,855, p=0,001). The value of this formant on the sample (Me=1674) is lower than normal values (1720-2000 Hz). There is also a statistically significant difference compared to normal value on the formant F1 of vowel /I/ (t=4,169, p=0,000). Compared to normal values (170 – 300 Hz), higher average values (Me=328) were received on the sample. Lower average values on the sample (Me=1974) were calculated on the sample for the formant F2 of vowel /I/ compared to normal values (2100 - 2500 Hz). This difference is statistically significant (t=-4,638, p=0,000). The formant F2 of vowel /O/ is statistically significantly higher (Me=1016) than normal values (780 – 1000 Hz). The same applies to the formant F2 of vowel /U/ (t=2,643, p=0,013). The average values of this parameter are also higher (Me=837) than normal values (650-800 Hz).

Voice Handicap Index consists of three subscales: physical, emotional and functional. The scores on subscales are obtained by summing up the values achieved on items they consist of. Also, it is possible to have the total score for the whole scale measuring the impact of speech handicap on psychosocial functioning.

By processing the results, it was determined that theoretical range between the minimum and maximum is from Min=0 to Max=40. All three subscales have an average value which is close to the maximum: physical subscale (Me=6.50), emotional subscale (Me=8.50) and functional subscale (Me=2.00). Such low average values show the presence of minimum difficulties in all aspects of functioning that are assessed by the scale. Theoretical range on the score for the whole scale is from Min=0 to Max=120. The values achieved on the samples range from Min=0 to Max=94. The average is also very low (M=16.50), which indicates good psychosocial functioning and relatively good quality of communication.

The values achieved on the VHI instrument can be divided into three categories: mild, moderate and severe disorder in psychosocial functioning. When achieved values were divided into three categories in accordance with the instructions given by the scale constructor, the following results were received: 60% of the respondents belonged to the group of mild disorders, 13.3% to the group of moderate and 26.7% to the group of severe disorders on the functional scale. Mild disorder in emotional functioning was detected in 73.3% of respondents, moderate in 6.7% and severe in 20% of respondents. On the overall scale of psychosocial functioning, mild disorder was detected in 73.3% of respondents, moderate in 6.7% and severe in 20% of respondents.

Spearman's correlation coefficient was used to examine whether the score on the VHI instrument correlated with the value of formants (F1 and F2) of vowels (Table 3). The only statistically significant correlation was achieved between the formant F1 of vowel /A/ and functional subscale (rho=-0,393, p=0,032), as well as emotional subscale (rho=-0,363, p=0,049). Both correlations were statistically significant on the level p<0,05 and had negative values. So, the lower the values of formants, the higher the scores on functional and emotional subscales.

Table 3. Correlation between the values of formants with the results on VHI

		Functional subscale	Physical subscale	Emotional subscale	Total score
F1 of vowel A	Rho	***-,393****	-,254	***-,363****	-,346
	P	***,032***	,175	***,049***	,061

		Functional subscale	Physical subscale	Emotional subscale	Total score
F2 of vowel A	Rho	-,155	-,042	-,169	-,122
	P	,412	,826	,371	,519
F1 of vowel E	Rho	-,197	-,239	-,215	-,227
	P	,306	,211	,262	,236
F2 of vowel E	Rho	-,105	-,089	-,075	-,094
	P	,586	,646	,698	,627
F1 of vowel I	Rho	-,215	-,178	-,150	-,189
	P	,254	,347	,430	,318
F2 of vowel I	Rho	-,006	-,012	,122	,032
	P	,973	,951	,520	,868
F1 of vowel O	Rho	-,132	-,119	-,051	-,107
	P	,495	,539	,793	,581
F2 of vowel O	Rho	-,040	,134	,048	,052
	P	,839	,488	,805	,789
F1 of vowel U	Rho	-,034	,190	,077	,085
	P	,859	,316	,687	,654
F2 of vowel U	Rho	,261	,385*	,390*	,359
	P	,172	,039	,037	,055

rho-Spearman's correlation coefficient, p-statistical significance

Since the ultimate goal of the research was to determine the impact of the voice and speech characteristics on the quality of communication of adult respondents with hypokinetic dysarthria, it was also examined whether sociodemographic variables as control variables of the research were in a statistically significant correlation with the VHI instrument.

The correlation of the VHI instrument with the following variables was also tested: gender, educational level, smoking status and vocal professional, and it was determined that none of the variables was in a statistically significant correlation with subscales and total score of the VHI instrument (Table 4).

Table 4. Differences between patients of different characteristics on dimensions of the VHI instrument

	Functional subscale	p	Physical subscale	p	Emotional subscale	p	Total score	p
Gender								
Male	7,00 (0 – 33)	0,525[a]	15,00 (0 – 32)	0,232[a]	2,00 (0 – 24)	0,611[a]	26,00 (0 – 89)	0,395[a]
Female	6,00 (0 – 31)		15,00 (0 – 33)		2,00 (0 – 30)		15,00 (0 – 94)	
Educational level								
without school and primary school	5,00 (0 – 12)	0,154[b]	2,00 (0 – 14)	0,091[b]	0,00 (0 – 6)	0,125[b]	13,00 (0 – 27)	0,111[b]
secondary school	5,00 (0 – 22)		10,50 (0 – 29)		2,00 (0 – 24)		16,00 (0 – 74)	
high and higher school	13,00 (0 – 33)		16,50 (0 – 33)		7,00 (0 – 30)		33,00 (0 – 94)	
Smoking status								
Smoker	5,00 (0 – 33)	0,774[a]	12,00 (2 – 32)	0,061[a]	3,00 (0 – 24)	0,360[a]	18,00 (2 – 89)	0,245[a]
Non-smoker	7,00 (0 – 31)		5,00 (0 – 33)		2,00 (0 – 30)		15,00 (0 – 94)	
Vocal professional								
Yes	31,00 (0 – 33)	0,315[a]	32,00 (0 – 33)	0,283[a]	24,00 (0 – 30)	0,226[a]	89,00 (0 – 94)	0,315[a]
No	6,00 (0 – 29)		8,00 (0 – 29)		2,00 (0 – 24)		16,00 (0 – 74)	

[a]Mann-Whitney test; [b] Kruskal Wallis Test; p- statistical significance;
Medians (min – max) are shown in the table.

The initial goal of the research was to determine the predictors of the quality of communication. First, the univariate analyses were conducted. These analyses were conducted in order to determine which variables make a regression model. Specifically, only the variables which are in a statistically significant correlation with the dependant variable make a regression model. The only statistically significant correlation was identified between the formant F1 of vowel /A/ (independent variables) and functional and emotional scales (dependent variables). Regression analysis confirmed the previous findings. The first formant of the vowel /A/ has a statistically significant contribution to the explanation of the score achieved on the functional subscale, by explaining 15% of the functional subscale (Adjusted R Square=0,155), (-0,393 (11.30 – 47.37)). The same formant explains 10% of the emotional scale (Adjusted R Square=0,100), (-0,363 (-0,052 – 0,000)) (Table 5).

Table 5. Predictors of the quality of communication

Dependent variables	Independent Variables	Univariate linear regression analysis		
		Beta (95%CI)	p	Adjusted R Square
Functional subscale	F1 of vowel A	-0,393 (11,30 – 47,37)	***0,032***	0,155
Emotional subscale	F1 of vowel A	-0,363 (-0,052 – 0,000)	***0,049***	0,100

DISCUSSION

An acoustic analysis of the frequency of formants provided the values of formants of vowels (F1 and F2) in respondents with hypokinetic dysarthria. The first three formants carry the main features of vowels. However, the first two formants, which are the strongest in terms of energy, are enough to recognize the vowels, while the third formant F3 provides clarity and improves the quality of voice. In addition, the positions of the third formant for all vowels in the Serbian language are very close to each other, and they can be disregarded when it comes to discrimination against vowels (11). The results obtained in this research indicate the presence of statistically significant differences between the positions of formants (F1 and F2) for most of the vowels in the Serbian language in adult respondents with hypokinetic dysarthria compared to the position of the formants that are characteristic for typical speakers. Such differences indicate the presence of a pathological voice which occurs as a consequence of a speech disorder. Given that changes in the concentration of acoustic energy were determined for four vowels (/E/,/I/,/O/,/U/) out of five, the intelligibility of these respondents was significantly impaired. The change in the position of the first format (F1) was determined just for the vowel /I/, while changes were particularly identified in the position of the second formant (F2) for four stated vowels, and it is known that the second formant has the greatest dynamics at vowels.

Other studies also show that there is a reduction in the degree of articulation movement in individuals with Parkinson's disease, what disturbs the production of vowels which results in the change of the position of formants or it being noticed with a difficulty (12). The position of articulators defines three-dimensional characteristics of the vocal tract and affects the frequencies of formants, particularly the first (F1) and the second (F2) formant. As a result of limited articulator movements, an inadequate formation of vowels and restriction of normal formant production, which leads to lowering of typically high frequency of formants or to increasing of typically low frequency of formant, occur in these individuals (13). The results of our research show lower average values for the second formant of vowels /O/ and /I/ compared to the existing standards for typical speakers, and higher average values of the first formant of the vowel /I/, and the second formant of vowels /O/ and /U/. The research which examined the production of vowels in individuals with Parkinson's disease (14) showed the reduced transition of formants and limited acoustic space of vowels caused by hyperkinesia of articulators, which together lead to significant disruption of the intelligibility of speech. However, these authors also proved that speech intelligibility can be relatively preserved at mild forms of dysarthria which are characterized by monotonous speech, without the change in pitch.

Based on received results and a large amount of previous research, it has been noticed that communication changes in individuals with Parkinson's disease are almost inevitable (15). More precisely, about 80-90% of these individuals experience changes in voice, and 45-50% changes during the articulation (16). This paper shows changes in the position of formants of vowels determined by spectral analysis based on the speech of individuals with hypokinetic dysarthria caused by Parkinson's disease. However, in addition to these changes, hypokinetic dysarthria implies significant perceptual, acoustic and kinematic changes resulting from the deterioration of voice and speech (16, 17). The voice usually has monotonous pitch and volume, it is imprecise and dysfluent, with many acoustic changes that are exactly the result of the reduction of strength, amplitude, durability and intensity of the movement of speech apparatus. The intelligibility of an individual's speech becomes worse with time, speech production slows down, clarity is lost and murmur occurs, with long breaks and efforts at speech. Changes and variations in

speech are great even in the course of a day, which is very demoralizing for a speaker (15). However, some authors state that degradation during the production of vowels in individuals with dysarthria is more a consequence of the severity of a motor speech disorder than the fact that in overall it contributes to intelligibility deficits (12).

In the earlier studies, the individuals with a speech disorder were mainly neglected. More precisely, the focus of research was just a speech pathology and not a person. The research focused on the identification of dynamic or statistical acoustic values correlating with perceptual characteristics, i.e. the level of intelligibility. For instance, determination of the correlation between the speech intelligibility and dynamic measures, which indicate the instability of formants of vowels and reduced F2 slope (18). Since it was determined that there is a correlation between the position of the second formant of vowels and perceptual characteristics, it was started with examining the impacts of inadequate values of formants on the speech intelligibility in individuals with dysarthria. Thus, it was determined that there is a significant correlation between the positions of F2 of two vowels and intelligibility of sentences in individuals with dysarthria caused by amyotrophic lateral sclerosis and Parkinson's disease (12) as well as the correlation between the second formant and speech intelligibility in individuals with dysarthria caused by Parkinson's disease and stroke (18).

Today, more attention is directed towards what impact has dysarthria on individuals, their feelings related to problems during the conversation and their interaction with other people and the quality of their communication. The most important goal of communication, i.e. socialisation and transmission of information, is achieved though intrapersonal and interpersonal communication (19). A modern individual is believed to spend about 70% of the time in communication, out of which 50% is communicated by voice and speech which enable the realization of language as a symbolic system (20). In latest studies (3, 21) it is pointed out that in addition to impairing the speech intelligibility and successfulness of communication, acquired dysarthria also affects the psychosocial functioning of an individual. It is even pointed out that depression, anxiety, social exclusion and changes in the estimation and experience of oneself can occur as consequences of dysarthria (21). It has been determined that in patients tested after they experienced stroke, dysarthria has a significantly stronger impact than other diseases on social participation of an individual and their perception of their own identity (22). Other individuals with dysarthria of different etiology confirmed that due to speech problems they had come across barriers in communications because of attitudes of the environment (4).

In this research, the assessment of subjective experience of individuals with hypokinetic dysarthria of the effects of voice disorder was performed by the VHI instrument (8). The respondents expressed their opinions about the impact of the characteristics of their voice and speech on physical, emotional and functional condition, and consequently on the quality of everyday communication, whereby the information on the degree of speech handicap experienced by some individuals with hypokinetic dysarthria was also received. Unlike the previously stated studies, and given the impaired intelligibility of respondents' speech, the results of this research showed low scores on the overall VHI instrument. That indicates the presence of minimum difficulties in all aspects of functioning that are assessed by the scale, which indicates good psychosocial functioning and quality communication achieved by individuals from the sample despite the presence of speech pathology.

More precisely, the values achieved on the VHI scale can be divided into three categories: mild, moderate and severe disorder in psychosocial functioning, and received results showed that on the overall scale of psychosocial functioning, a mild disorder was identified in 73.3% of respondents, moderate in 6.7% and severe in 20% of respondents. However, there is research in which individuals with Parkinson's disease have low scores on the VHI instrument, which indicate nonexistence of communication difficulties or mild difficulties experienced by a respondent (23). Nonetheless, it is important to point out that the authors of the stated research see the lack of awareness of a speech disorder in patients with Parkinson's disease, which is an important aspect of communication deficit in these individuals, as the main reason for such score on the Voice Handicap Index.

A smaller number of studies dealt with establishing a correlation between objective data obtained by multidimensional assessment of voice and subjective assessment conducted by the VHI instrument. The researchers mainly studied the relation between acoustic parameters of voice, without special reference to the values received by spectral analysis, and the results received on subscales and total score on the VHI scale. In addition, the sample of those studies was not made of individuals with dysarthria but of individuals with different types of dysphonia (24-26). In this study, we wanted to determine whether the values of formants of vowels obtained by spectral analysis of the voice of individuals with hypokinetic dysarthria have changed compared to those of typical speakers, as well as whether the obtained values of formants as characteristics of an individual's voice and speech represent the predictors of the quality of communication in individuals with this type of speech disorder. The only statistically significant correlation was achieved between the formant F1 of the vowel /A/ and functional and emotional subscale. It was determined that the lower the values of formant F1, the higher the scores on the functional and emotional subscales. Even though only the first and the second formant of the vowel /A/ do not significantly deviate from the position of formants of the same vowel in typical speakers, the results show that the lower the values of the first formant, the higher the scores, or more precisely worse results on the above stated subscales. Thus, the first formant of the vowel /A/ has a statistically significant contribution to the explanation of the score obtained on the functional subscale, by explaining 15% of the functional subscale and the same formant explains 10% of the emotional subscale. These results

indicate that in this research only the position of the first formant of vowel /A/ in the sample of respondents with hypokinetic dysarthria can be a predictor of the quality of communication.

CONCLUSIONS

The obtained results showed, as expected, the changes in articulation and intelligibility of vowels in respondents with hypokinetic dysarthria. Speech disorder present in these individuals includes disorders in pronunciations of a large number of speech sounds, and changes occurring during the pronunciation of vowels have been presented through changed positions of the first and the second formants, and were received by a spectral analysis. However, regardless of the statistically significant difference between normal values of vowels and values of formants of vowels of the respondents from the sample, the individuals with Parkinson's disease and hypokinetic dysarthria believe that they do not have great problems in communication and that handicap caused by voice and speech disorder is not significant for them and does not largely affect their daily communication. However, this research needs to be conducted in respondents with other types of dysarthria and to determine whether there is a difference in the subjective experience of communication difficulties resulting from the voice and speech disorder of different etiology.

The research also showed that acoustic characteristics of speech and voice in adults with hypokinetic dysarthria can be predictors of the quality of communication. Thus, in this research, the position of the first formants of the vowel /A/ was the predictor which explains scores on the emotional and functional subscales of the VHI instrument. Since there is not much research examining the relation between the results obtained by a spectral analysis and scores achieved on scales, which enable self-assessment of one's own handicap, the future research should be focused on this problem and conducted on a larger sample in order to obtain more reliable results. Also, as already stated, such research should be also conducted in individuals with other types of dysarthria, in order to establish the predictors of the quality of communication for each type individually and to compare the obtained results with each other.

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