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CHARACTERISTICS OF VOICE IN STUTTERING CHILDREN

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ABSTRACT

Introduction: The purpose of this research was to establish voice acoustic characteristics in stuttering children with mild and severe stuttering and relationship between degree of stuttering and characteristics of voice in children.
Methods: Sample consisted of two subsamples of male subjects (subsample of subjects with mild stuttering and subsample of subjects with severe stuttering) aged 7 to 10,5. Control group of subjects consisted of 46 fluent speakers, matched by age and sex with experimenal group. This research was conducted in twenty primary schools in Tuzla Canton among children attending grades 1 to 4.
Results: Results of this research showed that subjects with severe stuttering had more expressed short frequency variations and variations of amplitude in the vocal tone. Factor analysis revealed four significant factors: factor of frequency variation, phonation factor, factor of aerodynamic phonation characteristics and intensity variation factor. Results of one-way factor analysis of variance between examined groups in factors of voice acoustic characteristics showed that factor 4 contributed the most to differentiation of groups. This factor was created from variables describing variation of amplitude in the vocal tone. Examination of correlation between four factors revealed statistically significant correlation between factor of frequency variation and intensity variation factor. Results of canonic analysis showed that variables of stuttering intesity correlated significantly with variable intensity variation. Results of this study also showed that acoustic analysis of voice in stuttering children might be useful for indepth analyses of stuttering manifestations.
Conclusions: Results of this study might serve as incentive for furthter studies of different aspects of acoustic and physiologic phonation characteristics in stuttering children.

Keywords: *acoustic characteristics, stuttering, children*

INTRODUCTION

Many researchers consider that data on various aspects of laryngeal function in stuttering children may enhance understanding of this speech disorder. Obvious disturbances in speech production system of stuttering individuals might be related to generalized temporal discoordination between respiration, phonation, and articulation.[1] During stuttering there is abnormal functioning of essentially the whole speech system including the larynx. Characterizing aspect of that abnormal functioning is excessive muscular tension.[2] In the past few years there has been an increasing number of scientific studies describing the laryngeal dynamics of stuttering individuals during identifiable segments of stuttering or fluent speech.[1] New studies on stuttering research deal with examination of differences in voice characteristics between the stuttering and nonstuttering individuals. These studies are induced by assumption that speech motor deficits liable for stuttering are present the whole time during speech production and will be revealed by identification of differences between acoustical recordings of stuttering subjects and normally fluent speakers.[3] Using different methodologies, several researchers have reported certain acoustical and physiological differences between perceptu-

Table 1. *Basic statistic parameters of voice acoustic variables*

Variables	Mild stuttering (N=34)		Severe stuttering (N=33)		Fluent speech (N=46)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
AGE	8.74	0.93	9.15	0.80	9.02	0.95
FR-S	5.38	1.86	6.11	2.00	6.01	2.10
FR-Z	5.85	2.04	6.75	2.36	6.42	2.41
S/Z	0.93	0.19	0.92	0.16	0.97	0.20
MFV	9.97	3.23	10.82	3.49	11.17	4.81
F0	264.13	26.86	262.97	29.26	271.08	22.46
To	3.83	0.40	3.85	0.44	3.72	0.30
Fhi	287.49	40.65	289.20	45.39	286.45	25.53
Flo	246.85	27.47	241.20	29.73	253.89	31.17
PFR	3.59	2.08	4.21	2.56	3.24	2.89
F0R	40.14	35.31	47.40	42.61	32.56	29.56
Jita	52.27	9.44	69.13	34.93	51.69	10.61
Jitt	1.37	0.22	1.81	0.94	1.40	0.31
RAP	0.82	0.14	1.09	0.58	0.83	0.19
PPQ	0.84	0.13	1.07	0.54	0.86	0.21
SPPQ	0.96	0.15	1.20	0.47	0.97	0.17
vF0	2.18	0.62	2.43	1.38	2.34	2.94
ShdB	0.01	0.2	0.07	0.12	0.02	0.06
Shim	0.10	0.17	0.66	1.24	0.24	0.65
APQ	0.11	0.30	0.50	0.92	0.17	0.42
sAPQ	0.16	0.54	0.62	1.24	0.22	0.53
vAm	0.64	1.60	1.96	4.45	0.70	1.72
DSH	0.18	0.81	2.65	6.19	0.74	3.14
NHR	0.18	0.02	0.19	0.04	0.18	0.03
STD	5.74	1.75	6.44	4.10	6.35	7.82
Tsam	1.50	0.48	1.56	0.48	1.57	0.49
SPI	3.74	1.16	4.23	2.30	3.65	1.88
DVB	0.00	0.00	0.00	0.00	0.00	0.00
DUV	0.36	2.08	0.41	1.90	0.03	0.22
PER	394.74	136.46	408.45	135.66	423.15	139.13
VTI	0.09	0.02	0.08	0.03	0.10	0.03

aly fluent utterances of stutterers and normally fluent speakers. Comparisons of fundamental frequency, jitter, and shimmer between the stuttering and nonstuttering children contribute to clarifying the role of phonation control in early stages of stuttering.[1]

Considering the current research trends on stuttering etiology and phenomenology, the objectives of this study were to determine acoustical characteristics of fundamental frequency in stuttering children and children without voice and speech disorders, and also to determine correlations between the stuttering severity and acoustical characteristics in stuttering children.

SUBJECTS AND METHODS

Subjects were randomly selected. Sample of experimental subjects consisted of two subsamples of stuttering male subjects aged from 7 to 10.5 years. First subsample consisted of 34 subjects, who were classified as mild stutterers according to "Stuttering Severity Instrument for Children and Adults".[4] Second subsample consisted of 33 subjects who were classified as severe stutterers according to "Stuttering Severity Instrument for Children and Adults." Control group consisted of 46 subjects of the same age and sex as subjects from experimental group. Verbal behaviour of control subjects was analyzed by the same logopedic diagnostic procedure as experimental group.

Table 2. *Characteristic roots of variables intercorrelation matrix of voice acoustic characteristics*

Variables	Communalities	Factor	Eigenvalue	%Variance explained	Cumulative %
F0	1.00000	1	3.98113	30.6	30.6
Fhi	1.00000	2	2.56642	19.7	50.4
Flo	1.00000	3	2.30715	17.7	68.1
MFV	1.00000	4	1.49585	11.5	79.6
FR-S	1.00000	5	0.82978	6.4	86.0
FR-Z	1.00000	6	0.63829	4.9	90.9
NHR	1.00000	7	0.48513	3.7	94.6
APQ	1.00000	8	0.27474	2.1	96.8
Jitt	1.00000	9	0.22201	1.7	98.5
Shim	1.00000	10	0.14831	1.1	99.6
vF0	1.00000	11	0.02886	0.2	99.8
PPQ	1.00000	12	0.01774	0.1	100.0
DSH	1.00000	13	0.00458	0.0	100.0

After determining that subject had no difficulties in speech/motoric realization symptomatic to stuttering or some other speech and language disorder, subject was included in control group. Using subjective voice assessment according to Ishiki we determined which subjects had hoarseness, pneumofonic incoordination, astenic or hyperkinetic voice. Those subjects were excluded from experimental and control group. Both groups of subjects consisted of pupils attending the first four grades of primary schools in Tuzla, Kladanj, Lukavac and Srebrenik.

Sample of variables consisted of following variables: AGE – age of subjects - expressed in years; variables of stuttering severity – which represented evaluated stuttering manifestations which met the criteria according to the test for assessment of stuttering severity - used in this study – "Stuttering Severity Instrument for Children and Adults"[4]: frequency of repetitions and prolongations of voices and syllables (stuttering frequency) in spontaneous speech and reading (UČESTR), mean duration of longest blocks (TRZR), total number of accessory features (PPUK), total result of stuttering severity (RUKUP) – formed by adding points for each of three subtests and adding results of subtests; acoustic variables: F0–average fundamental frequency; To – average pitch period; Fhi – highest fundamental frequency; Flo–lowest fundamental frequency; PFR – phonatory F0 range in semitones; Jita – absolute jitter (fundamental frequency variation – in μs); Jitt - jitter in percentage (fundamental frequency variation – in %); RAP – relative average perturbation; PPQ–pitch perturbation quotient; sPPQ–smoothed pitch perturbation quotient; vF0–fundamental frequency variation; ShdB – shimmer in decibels (variation of amplitude in the vocal tone in dB); Shim–shimmer in percentage (variation of amplitude in the vocal tone in %); APQ – amplitude perturbation quotient; sAPQ – smoothed amplitude perturbation quotient; vAm – peak-to-peak amplitude variation; DSH – degree of sub-harmonics; NHR – noise to harmonic ratio; STD – standard deviation of fundamental frequency; Tsam – lenght of analyzed signal; SPI – soft phonation index; DVB – degree of voice breaks; PER – total number detected pitch periods; VTI – voice turbulence index; aerodynamic variables: MFV - maximum phonation time; voice friction of /S/ and /Z/ (FR-S and FR-S) and /S/ and /Z/ friction ratio(S/Z).

"Stuttering Severity Instrument for Children and

Table 3. Cumulative of variables of voice acoustic characteristics

Variables	Communalities	Factor	Eigenvalue	%Variance explained	Cumulative %
F0	0.94496	1	3.98113	30.6	30.6
Fhi	0.81402	2	2.56642	19.7	50.4
Flo	0.88693	3	2.30715	17.7	68.1
MFV	0.60156	4	1.49585	11.5	79.6
FR-S	0.82868				
FR-Z	0.87960				
NHR	0.65431				
APQ	0.84447				
Jitt	0.85659				
Shim	0.89157				
vF0	0.64762				
PPQ	0.88623				
DSH	0.61400				

Table 4. *Matrix of parallel projections on obtained factors*

Variables	Factor 1	Factor 2	Factor 3	Factor 4
F0	-0.01097	0.96184	0.05034	-0.07602
Fhi	0.25701	0.86192	-0.02280	-0.07056
Flo	-0.53339	0.77883	0.05903	0.02904
MFV	-0.17561	-0.05517	0.74183	0.05406
FR-S	0.12685	0.07104	0.90664	-0.02545
FR-Z	0.08573	0.03111	0.94006	-0.02868
NHR	0.64667	-0.24703	0.09911	0.26297
APQ	0.09460	-0.00677	0.02791	0.88989
Jitt	0.72261	0.27335	-0.04835	0.35729
Shim	0.02581	0.01032	-0.00080	0.93755
vF0	0.83489	-0.06630	0.00079	-0.21381
PPQ	0.77786	0.28131	-0.04721	0.29076
DSH	-0.08691	-0.10082	0.04258	0.78457

Adults"[4] was used for assessment of stuttering severity. Assessment was performed during observation of subjects and by analysis of tape recordings, whereas intensity of exhibited symptoms was scored and points were assigned. Computer programs for voice analysis Cool Edit and MDVP (Multi Dimensional Voice Program) were used for acoustic analysis of sustained phonation of vowel /A/, and by this analysis variables for determining of voice acoustic characteristics were obtained. Variables for determining of aerodynamic phonation characteristics were obtained using aerodynamic tests. This study was conducted in twenty primary schools in Tuzla Canton area, among pupils attending the first four grades. After determining which subjects stuttered, with teacher's approval, they were placed in separate room isolated from noise. Stuttering assessment was performed for every subject by at least three examiners using "Stuttering Severity Instrument for Children and Adults." Upon determining that subject had mild or severe stuttering, an audio recording of subject's three consecutive vowel /a/ phonations was made for the purpose of phonation parameters evaluation. The microphone was placed 30 cm in front of the subject's mouth, and voices were recorded using high quality dictaphone. Data on voice parameters were obtained by software analysis. Cool Edit and MDVP (Multi Dimensional Voice Program) were used for voice analysis. In this study Cool Edit was used for preparation of voice signal for further acoustic and statistic analysis. Quantitative acoustic-statistical voice analysis of analyzed groups was performed by MDVP. Basic statistic parameters were calculated for each variables applied in this study. Factor analysis was used for obtaining of detailed insight into latent structure of manifest space. One-way factor analysis of variance was used for examination of differences: between the children with different stuttering degrees and between the stuttering children and normally fluent speakers in the whole variable space. Correlation analysis and cannonic correlation analysis were used

Table 5. *Matrix of orthogonal projections on obtained factors*

Variables	Factor 1	Factor 2	Factor 3	Factor 4
F0	-0.03112	0.96782	0.06574	-0.13704
Fhi	0.24201	0.86687	0.02387	-0.05822
Flo	-0.52604	0.77641	0.10781	-0.16166
MFV	-0.20179	-0.04299	0.75475	0.07139
FR-S	0.07040	0.09302	0.89912	0.07976
FR-Z	0.02643	0.05390	0.93365	0.07068
NHR	0.71198	-0.25964	0.08002	0.46325
APQ	0.33841	-0.06461	0.04061	0.91377
Jitt	0.82349	0.25167	-0.05236	0.53235
Shim	0.28117	-0.05024	0.07583	0.94384
vF0	0.77640	-0.04958	-0.06424	0.01787
PPQ	0.86059	0.26414	-0.05959	0.48045
DSH	0.12403	0.15093	0.11026	0.77096

Table 6. *Analysis of variance on factors in latent space between three subject groups*

Source	df	Sum of squares	Mean sum of squares	F- ratio	P value
Factor 1					
Inter-group	2	5.3011	2.6505	2.7325	0.0695
Intra-group	110	106.6989	0.9700		
Total	112	112.0000			
Factor 2					
Inter-group	2	0.4898	0.2449	0.2416	0.7858
Intra-group	110	111.5102	1.0137		
Total	112	112.0000			
Factor 3					
Inter-group	2	2.8949	1.4475	1.4593	0.2369
Intra-group	110	109.1051	0.9919		
Total	112	112.0000			
Factor 4					
Inter-group	2	11.4403	5.7202	6.2571	0.0027
Intra-group	110	100.5597	0.9142		
Total	112	112.0000			

for determining possible correlation between stuttering severity and experimental variables. SPSS for WINDOWS Release 6.0 and STATISTICA for Windows Release 4.5 were used for statistic data processing.

RESULTS

Table 1 summarizes the basic statistic parameters of acoustic voice variables. From inspection of the Table 1 it can be concluded that mean values of aerodynamic variables were similar in all three groups of subjects. Analyzing the acoustic variables it can be seen that F0 was highest in normally fluent speakers (271,08 Hz), whereas stuttering children exhibited similar values of F0 (F0 was 264,13 Hz in children with mild stuttering, and F0 was lowest in children with severe stuttering – 262,9 Hz). Variables pertaining to short variation of fundamental frequency, average absolute jitter (Jita) and jitter in % values were highest in subjects with severe stuttering. Short variation of amplitude in the vocal tone (shimmer in dB-ShdB) were highest in subjects with severe stutering (0,07 dB). Mean value of relative assessment of other harmonics toward components of fundamental frequency (DSH) in voice sample was highest in children with severe stuttering (2,65%), in normally fluent speakers it was 0,74%, and it was lowest in children with mild stutering – 0,18%.

For the purpose of correlation examination between the variables and to get better insight into latent space, one-way factor analysis was applied for thirteen selected variables describing following voice acoustic characteristics: fundamental frequency (F0) measurements: average F0, highest (Fhi) and lowest (Flo); short-term and long-term variation of F0: jitter in % (jitt), period perturbation quotient (PPQ) and coefficient of fundamental frequency variation (vF0); short-term variation of amplitude in the vocal tone: shimmer in % and amplitude perturbation quotient (APQ); aerodynamic phonation characteristics: maximum phonation time (MFV); voice friction of /S/ and /Z/; variable which determined harmonic to noise ratio (NHR), and variable describing subharmonic voice degree (DSH). Factorization of above mentioned variables was applied for all stuttering and normally fluent subjects (N=113).

Table 7. Matrix of correlations between factors

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1.00000			
Factor 2	0.00344	1.00000		
Factor 3	-0.05489	0.02195	1.00000	
Factor 4	0.27228	-0.06468	0.08301	1.00000

Table 8. *Correlation between stuttering variables and four factors of voice acoustic characteristics*

Variable	Factor 1	Factor 2	Factor 3	Factor 4
UČESTR	0.1981	-0.0305	-0.1649	0.2868
TRZR	0.1709	0.0235	0.1474	0.3370
PPUK	0.2207	-0.0710	0.1927	0.2878

Correlation between the variables was very specific. Analyzing the correlation coefficients between the variables it can be seen that there was intragroup correlation. In the first group there was siginificant correlation between variables related to variation of fundamental frequency. The second group comprised variables related to fundamental frequency: average, highest and lowest fundamental frequency. In the third variables group there was significant correlation between variables which determined temporal voice characteristics (phonation duration of vowel /a/ and friction of /s/ and /z/). The fourth group of variables comprised of variables related to variation of amplitude in the vocal tone also significantly intracorrelated. Based on criterion $\lambda \geq 1$, four statistically significant roots were extracted. Four oblimin factors were extracted after 15 iterations using the direct oblimin rotation. The four factor solution explained 79,6% of the total variance as can be seen in Table 2. Analysing communalities it can be concluded that comunality ranged from 0,6 to 0,95. The majority of variables had comunality above 80 as presented in Table 3.

Tables 4 and 5 show parallel and orthogonal projection on variables of voice acoustic characteristics. As can be seen from tables, specific variable groups had higher values, but on different factors. There was high positive correlation between the first factor and variables related to variation of fundamental frequency: absolute jitter – Jitt, coefficient of fundamental frequency variation (vF0), and period perturbation quotient (PPQ).

Variables related to mean F0, highest (Fhi) and lowest (Flo) had highest positive correlation with the second factor. Variables related to aerodynamic phonation characteristics: maximum phonation time (MFV) and voice friction of /S/ and /Z/ correlated significantly with the third factor, whereas the fourth factor correlated significantly with variables related to variation of amplitude in the vocal tone: shimmer (%) – Shim and amplitude perturbation quotient (APQ). Results indicate that correlation between specific factors and variables was according to variables' subspaces of voice acoustic characteristics they determine. Considering obtained projections, the first factor could be marked as frequency variation factor, the second factor can be marked as phonation factor, the third could be marked as factor of aerodynamic voice characteristics, and the fourth one as intensity variation factor.

One-way factor analysis of variance was used to examine differences between the subjects with mild stuttering, severe stuttering and normally fluent speakers in factors of voice acoustic characteristics. Results show that the fourth factor contributed the most to differentiation of examined groups. Factor 4 was obtained by variables factorization of voice acoustic characteristics, and variables related to variation of amplitude in the vocal tone correlated statistically significant with this factor. One-way factor variance analysis revealed no statistically significant differences between three groups of subjects and factor 2. In the factorization process there was positive correlation between factor 2 and variables related to fundamental frequency measurements, and also between factor 3 and aerodynamic phonation characteristics. Differences between three group of subjects in factor 1 approached statistical significance ($p<0,0695$) (Table 6.). Based on obtained results it can be concluded that subjects with different stuttering degree and different degree of exhibited stuttering manifestation had different regulation abilities of variation of amplitude in the vocal tone. Those differences are mostly present in subject's inability to regulate variation of vocal folds amplitude. This fact probably contributed that only factor 4 of voice acoustic characteristics (variables describing variation of amplitude in the vocal tone – shimmer and amplitude perturbation quotient) differentiated group of subjects with mild stuttering, severe stuttering and normally fluent speakers.

Examination of correlation between four obtained factors revealed low positive statistically significant correlation between factor 1 and factor 4. Both factors pertain to variations of fundamental frequency, whereas factor 1 was related to frequency variations, and factor 4 was related to variation of amplitude in the vocal tone. Correlation coefficient between above mentioned factors was 0,27228 and it was statistically significant indicating relationship between those two factors which was expected considering subspaces of voice acoustic characteristics they describe. Based on factor analysis results and determined correlation between obtained factors it can be concluded that acoustic analyses of sustained vowel phonation in stuttering children could be used for more precise analyses of specific stuttering manifestations.

Cannonic correlation analysis was used to examine possible correlation between variables of stuttering severity and four factors of voice acoustic characteristics in latent space of stuttering children (subjects wild mild and severe stuttering). Crosscorrelation coefficients between variables of stuttering severity and factors of voice acoustic characteristics are displayed in Table 8. From inspection of the table it appears that variables of stuttering severity i.e. frequency of stuttering, duration of blocks and total number of accessory features reached statistical significance only with factor 4 (intensity variation factor). Correlation coefficients ranged from 0,2868 (p<0,019 for variable frequency of stuttering) to 0,3370 (p<0,005 for variable duration of blocks).

DISCUSSION

Measurement of friction /z/ duration represent expiratory control measurement, whereas friction of /s/ represent addition to laryngeal assignment component. Researchers suggest these instruments should be used for examination of laryngeal and expiratory contribution to phonation problem, and they also reported similar friction duration of /s/ and /z/ in normally fluent speakers.[5] Subjects with mild stutering achieved slightly longer duration of /z/ friction. Other studies reported s/z friction of 1, with slightly longer duration of /z/ friction, which concur with data in this study.[6] Normally fluent speakers had longest maximum phonation time, and S/Z ratio in these subject approached to ideal value of 1. Values for maximum phonation time increases with age. In relation to sex these differences appear in favor of males only at age of nine years.[5] Bolfan-Stošić 1998 determined in normally fluent school children maximum phonation time of 12,07 seconds, duration of /s/ friction which yielded 8,23 seconds, and /z/ friction of 11,02 seconds.[7] Using acoustic analyses of temporal parameters in stuttering and normally fluent children (mean age was 9,7 years) Healey and Adams 1981 found no statistically significant differences between stuttering and normally fluent speakers in any variable.[8] Aerodynamic examination of phonation characteristics could serve as supplement to examination of phonation acoustics,[9] because those examinations most clearly display interaction between laryngeal and respiratory function.[5,10] Hirano suggested that main purpose of laryngeal dynamics measurement should be differentiation between respiratory and laryngeal problems.[9]

Results of the study showed slightly lower fundamental frequency in stuttering children. Average fundamental frequency, standard deviation and phonatory range in Hz and semitones on dysfluent and perceptually fluent speech segments were examined in 5 preschool stuttering children and 5 normally fluent children of the same age. Acoustic analysis of perceptually fluent speech samples revealed slightly lower mean of F0 (314 Hz) in stuttering children than in normally fluent children (F0=358 Hz) during part-word repetitions, but these differences were not statistically significant. Similar results were obtained for phrase repetitions, but no statistically significant differences were found either.[11] In fluent speech samples of preschool stuttering children F0 was 283 Hz, and in normally fluent children F0 was 310 Hz. According to these results it can be concluded that "stuttering children tended to exhibit slightly lower fundamental frequency than normally fluent children did",[1] as shown in our study. Obtained results concur with results obtained by Sorenson in 1989.[12] Author conducted a study on 30 normally fluent children, aged between 6 and 10, and determined mean F0 of 262 Hz in boys and mean F0 of 281 Hz in girls, and found no statistically significant differences between boys and girls in fundamental frequency.

Results of our study suggest statistically significant differences between subjects with mild and severe stuttering, and normally fluent speakers in all exhibited variables. Stuttering subjects exhibited substantially significant intragroup differences in variables describing frequency, frequency variation and variation of amplitude in the vocal tone than other two groups of subjects. Normative threshold for absolute jitter (jita) was 83,2 µs, and for jitter it was 1%.[13] Variation in frequency of normal voice (jitter %) is usually lower than 0,7% of average fundamental frequency produced in the whole speech sample.[14] In stuttering children mean value of jitter was 0,05 msec, and shimmer was 6,15%. During normal phonation, variation of average amplitude in the vocal tone is usually not higher than 0,5 dB or 5% of voice signal.[14] In subjects with normal voice and speech who were tested as control group the jitter value was 1,86%, and shimmer in decibels was 0,29 dB.[15] Bamberg et al. 19901 have also determined that shimmer values were significantly higher in stuttering individuals than in normally fluent speakers.[16] Statistically significant difference was determined between preschool stuttering children and control group for shimmer values.[1] Results obtained in this and other studies regarding differences between stuttering subjects and control group in variables describing variation of amplitude in the vocal tone might be explained with the fact that pitch intensity depends on interaction between subglotal pressure and aerodynamics at vocal folds level.[17] It was determined that stuttering individuals have variable, sometimes even chaotic subglotal pressure.[18] It is thought that this is caused by muscle incoordination of respiratory tract.[19] Baer[1] considers that stuttering children have weaker laryngeal neuromuscular control and greater disturbances in integrating respiratory and laryngeal control which justifies measurements of voice distrubances. Short

- term indicators of phonation system instability (jitter and shimmer) might be associated with weak laryngeal neuromuscular control. Differences between stuttering and normally fluent speakers in phonation parameters are more pronounced in stuttering adults than in stuttering children and those differences occur as reflection of usual compensatory behaviour in reaction to dysfluencies and can not be considered as etiologic stuttering factor. Therefore, it is neccessary to conduct researches in order to determine correlation between stuttering severity and voice acoustic characteristics, and experimental subjects proposed for this type of research should be adults with severe stuttering.[6]

Resuts of factor analysis demonstrated a statistically significant difference between factor 1 and variables determining variation in fundamental frequency. Highest projections with factor 2 had variables pertaining to fundamental frequency and F0 range. Factor 3 correlated statistically significant with variables describing aerodynamic phonation characteristics. Statistically significant difference was also determined between factor 4 and variables describing variation of amplitude in the vocal tone. Analysis of correlation coefficients obtained between variables of stuttering severity i.e.: frequency of stuttering in spontaneous speech and reading, duration of blocks, total number of accessory features and four factors of voice acoustic characteristics in stuttering children: factor 1 (frequency variation factor), factor 2 (phonation factor), factor 3 (factor of aerodynamic phonation characteristics) and factor 4 (intensity variation factor) revealed that all variables of stuttering severity correlated statistically significant only with factor 4. In preschool stuttering children whose stuttering was rated from mild to severe, correlation between stuttering severity and four acoustic variables (F0, F0 range, jitter and shimmer) was examined. Low positive correlation between severity of stuttering and fundamental frequency was determined, however low negative correlation between stuttering severity and shimmer was determined. No statistically significant correlation was determined between stuttering severity and voice jitter.[1] Differences between used methodologies limit study comparisons. However, it is interesting to point out similarities which exist between present results and results for acoustic variables for older children and stuttering adults.

CONCLUSIONS

Results of this study might serve as incentive for furthter studies of different aspects of acoustic and physiologic phonation characteristics in stuttering children. Acoustic-statistic analyses of phonation parameters in stuttering children could be used for indepth analyses of stuttering manifestations. Measurements of phonation parameters, especially variables describing amplitude perturbation of voice might be valuable addition to diagnostic set for assessment of stutering severity in children, or for differentiation between stuttering children and normally fluent speakers.

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