Original article

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PERCEPTIVE VOICE ANALYSIS IN CHILDREN WITH SPECIFIC LANGUAGE DISORDERS

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Specific language disorder (SLD) is a neurodevelopmental disorder that characterizes language deficits together with the preservation of some cognitive domains. Voice evaluation in children with SLD should indicate and encourage a new perspective and provide us with a conceptual approach that has the potential to better understand the voice system of children with SLD by completing a guide to voice rehabilitation in these children.

The aim of this research was to determine the components of the voice system, voice quality, as well as potential gender differences among children with SLD. The sample included 30 children with developmental dysphasia, aged 3 to 9 years (AS = 6.40; SD = 1.714), of whom 20 were boys and 10 were girls.

The adapted Quick Screen For Voice and GRBAS scale were used to assess the voice quality.

The obtained results show that the largest number of children with SLD have adequate biological predispositions for typical voice quality. A large number of children with SLD have no change in all analyzed perceptual voice parameters. The most common perceptual changes in the voice have been mild, followed by moderate, and the least common have been pronounced changes in the voice. There have been significant differences in the degree of hoarseness and hoarseness of the voice in relation to gender, more pronounced in boys ($p < 0.05$).

Although the changes in voice quality in children with SLD have been mild, they are potentially significant for vocal pathologists, pointing to the importance of prevention, which should be implemented at an early age in order to preserve a healthy and quality voice.

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Introduction

Voice is a sound with which living beings are announced, and which is produced by special phonation organs (1). The voice is closely related to the sense of self-identity and is an indicator of health, emotions, age and gender of individuals (2). If they last longer, certain changes in the quality and duration of voice can potentially indicate the presence of a serious illness (3). Vocal cords are a source of voice that vibrates to periodically coagulate and dilute the air current (1).

Effective assessment of the voice in children requires knowledge and understanding of the anatomical and structural development of the phonation system during maturation. Scanning electron microscopy of children's larynx showed that there is a development of superficial and deep structures up to the age of 10, and a defined, layered structure of the characteristic lamina up to the age of 17 (4).

Previous research has shown that the most common voice disorders in children are dysphonia (impaired voice quality) and rhinophonia (impaired voice resonance). In most children, the voice naturally stabilizes after puberty, while in some it does not, according to some authors, as much as 15% does not show improvement in voice (5). So far, the findings so far have shown that children with dysphonia have a lower score on the scales of assessment of functionality in the social environment (6). Some authors point out that children with voice disorders respond to treatment, with voice weakness being the predominant disorder in children's voice pathology (7).

A study conducted in Brazil in which (N = 71) children aged 3 to 9 years participated showed that

most children had a slight deviation of the voice, with straining and instability when breathing as the main characteristics of the voice. Deviations of the fundamental frequency (F0) are correlated with stress and phonation. Shimmer and glottal cavities (GNE) are correlated with the general degree of voice deviation and the parameters of roughness, weakness and tension. In the mentioned research, it has been shown that the mean value (GNE) and (F0) in speech were the only measures that distinguished the voices in terms of the severity of the voice deviation. There was a connection between the perceptual and acoustic measures of children's voices. Children with a high voice had larger voice deviations (8).

Specific language disorder (SLD) is a neurodevelopmental disorder that characterizes language deficits with the preservation of some cognitive domains (9, 10). In these children, language difficulties include delayed onset and slower acquisition of lexical and grammatical forms, poorer vocabulary, and difficulties in acquiring and using flexible morphology and complex syntax. By definition, SLD is not a consequence of hearing loss, articulatory disorders, neurological diseases, or complex developmental disorders (11). Prevalence studies suggest that SLD has about 5-7% of school-age children (12). SLD thus differs from other disorders such as aphasia, intellectual disability, sensory impairment, and personality disorders (13). Children with SLD show poor oralpractical abilities, which as a result changes the nature of the vibration of the vocal folds compared to the vibration of the vocal folds in a healthy voice. Leonard (1998) points out that children with certain language deficits may misidentify certain speech elements due to their inherent "low phonetic substance", i.e. short-term low-intensity acoustics (14). Wright et al. point out that coarticulation or masking with longer, stronger vowels can contribute to poorer perception of previously produced consonant-vocal combinations (15).

Studies that have used auditory repetition and chronological judgment tasks show that children with SLD discriminate poorly or draw sequential conclusions about nonverbal stimuli, vowels, or consonants when stimuli are produced at a rapid pace or when they are short-term (16-18). In these studies, auditory repetition distinguished children with typical language abilities from children with SLD. During auditory repetition of stimuli, children with SLD exhibited abilities that were not directly related to verbal but to nonverbal abilities (19). Vowels caused the highest threshold of discrimination compared to other voice groups. Younger children (aged 3 to 5) with SLD showed elevated discrimination thresholds for vowels and complex tones compared to peers with typical language skills. Based on these results, the authors concluded that the spectral complexity rather than the phonemic nature of the stimulus affects auditory processing in children with SLD (20).

Analyzing the quality of voice in narrative speech, it has been noticed that in children with SLD there are pauses in narrative speech at the moment of difficulties in forming concepts, activating syntactic frameworks or processing syntactic and semantic information of lexical units (21, 22). Younger age groups of children with SLD show a tendency to produce speech pauses that differ in the number of vocal hesitations and in duration (measured by syllable) from the older age group (23).

Research comparing the quality of voice between the sexes in children with SLD shows that the difference between boys and girls in voice quality is significant. Girls have better results in prosody, which can be associated with better oralpractical abilities, while the boy's voice according to the authors sounds insufficiently mature for the age due to the lack of contrast of the tonal accent of the word (24). The results indicate that in most of these children, voice disorders do not disappear spontaneously with maturation (25).

Dobres et al. described the pathology of the larynx and its distribution in relation to age, sex and race in children. Data were collected based on the voice analysis of a large number of patients (N = 731) who reported to the children's hospital. It has been noticed that the most common pathologies of the larynx that affect the quality of the voice in children are subglottic stenosis, vocal nodules, laryngomalacia, functional dysphonia and vocal cord paralysis. In the overall sample, these pathologies were much more common in boys than in girls (26).

Checking the average adequate (expected) pitch, the authors found that most children with SLD have a changed pitch tone with voice interruptions in ascending/descending pitch, which can be explained by compensation for the ability to express appropriate melodic changes. along the sentence and inability to process intonation. To compensate for this deficiency, children increase the intensity of their voice in order to cause changes in the intonation of the sentence. Children with SLD tend not to use a pattern of declining intonation in their statements. Instead, they extend the final syllable to indicate the end of syntactic units. The appearance of reduced tilt in the voice in these children can be explained by the presence of motor impairment, since there is growing evidence that motor impairment is a common comorbidity in these children (27).

When assessing a child's voice, the importance of perceptual assessment of the voice is emphasized. Perceptual assessment is the most commonly used tool in the diagnosis and evaluation of the effectiveness of vocal treatment in everyday clinical environment, even in centers that have a rich selection of objective and subjective methods that can be used for the same purpose (5).

Although the principles of the therapy are largely similar to those distributed in adults, the strategy for voice rehabilitation in children should be different (28). The results of the research conducted by the Association of Vocal Pathologists in America indicate a significant connection between voice and psychosocial development of children, emphasizing the importance of voice testing at an early age in children of typical development and in children with speech and language disorders (29).

A large number of papers dealt with determining the language structure in children with SLD. The area of voice and voice disorders has been insufficiently studied in this population. Some authors have dealt with determining the acoustic characteristics of the voice and understanding prosody in children with SLD (16-24). Given the importance of perceptual assessment of voice, as pointed out by many authors in this field, this paper aims to determine the components of the voice system (respiration, phonation, resonance and range of voice) and voice quality in children with SLD. Also, the goal is to determine whether there are gender differences in the quality of voice in these children.

Method

Sample

The study included 30 children with SLD, aged 3 to 9 years (AS = 6.40; SD = 1.714). The sample consisted of 20 boys (66.7%) and 10 girls (33.3%). Respondents were uniform according to place of residence (city/village).

Procedure

The research was conducted at the Institute for Psychophysiological Disorders and Speech Pathology "Prof. Dr. Cvetko Brajović" in Belgrade. Before the beginning of the research, the approval of the Ethics Committee of the Institute for Psychophysiological Disorders and Speech Pathology "Prof. Dr. Cvetko Brajović" was obtained. After that, the parents of the children with SLD signed an informed consent for the respondents, and then the children themselves gave their consent. Only those children for whom the consent was obtained have been included. It has been explained to the children that they could give up the research at any time during its implementation. The examination was performed individually, in a quiet room intended for the work of a speech therapist in that institution. First, the children were given clear, concise and step-by-step instructions regarding the research procedure. All the children had the task to speak calmly, in a sitting position, spontaneously, recite a song, count. The period of conducting the research was from December 2018 to March 2019.

Tools

The adapted Voice Assessment Test (30) and the GRBAS Scale (31) were used in the study. At the very beginning of the Rapid Screening Test for Voice Assessment, there are general, socio-demographic data. A rapid screening test is used for subjective assessment of voice. The interrogation is conducted in an environment where there is silence. Respondents are asked to perform some of the verbal activities such as spontaneous conversation, imitation, verse recitation, counting. As a part of the screening test, the following four categories are assessed: respiration, phonation, resonance, and voice range. The GRBAS scale for subjective voice analysis assesses the voice of the examinees by three speech therapists who independently perform voice assessment. It is a standardized scale for subjective assessment of voice and the most common method of voice scaling that enables comparison and monitoring of voice. This scale contains five qualitative parameters of voice (G - overall impression of hoarseness, R - roughness in the voice, B - presence of breathiness in the voice, A - weakness in the voice, S - tension in the voice). Parameters were assessed on a four-point scale with a score of 0-3 (0 - normal voice, 1 - slight deviation, slight changes in voice, 2 - moderate deviation, moderately altered voice, and 3 - marked deviation, pronounced voice changes), while reciting a poem or reading a standard text.

Statistical data analysis

Descriptive and analytical statistics measures were used in statistical data processing. Frequency (number) and percentage (%) were used to assess the parameters related to the components of the voice system and voice quality, and the χ^2 test was used to examine the differences in voice quality in relation to gender. The results are shown in a table.

Statistical data processing was performed using the statistical processing package in the social sciences SPSS (SPSS, version 21.0).

Results

Respiration, phonation, resonance and voice range in children with SLD

The distribution of children with SLD according to the parameters of respiration, phonation and resonance are shown in Table 1.

The results show that 27 (90%) children with SLD had normal breathing necessary for speech, while in 3 (10%) children some difficulty in breathing were registered. These difficulties were wheezing when inhaling or exhaling (3.3%) and decreased volume or voice weakness (6.7%).

When it comes to the characteristics of phonation and the frequency of changes in vocal quality, the results of descriptive statistics show that four (13.3%) children with SLD had some difficulty in phonation, while 26 (86.7%) had normal speech. Difficulties were shown in the parameters of rough and tense phonation or hoarse voice (6.7%), vocal strain or effort (3.3%) and aphonia (3.3%).

From the aspect of resonance, 27 (90%) subjects had normal resonance, while 3 (10%) subjects had some deviation in resonance. These deviations were decreased nasality (3.3%) and increased nasality (6.7%).

The distribution of children with SLD according to the parameters related to the range of voice is shown in Table 2.

Table 1. Respiration, phonation and resonance parameters

	Respiration					**Phonation**									**Resonance**					
	Wheezing	Uneven breathings	Normal breathing	Limited breathing support	Decreased volume	Hoarse voice	Straining	Persistent lar.tones	Breathing quality	Aphonia	Coarse pharyngeal pressures	The highest point	Conversational voice	Too loud or soft	Normal quality	Decreased nasality	Mouth breathing	Increased nasality	Normal resonance	Nasal turbulence	Resonant characteristic
Number	1	0	27	0	2	2	1	0	0	1	0	0	0	0	26	1	0	2	27	0	0
%	3.3	0	90	0	6.7	6.7	3.3	0	0	3.3	0	0	0	0	86.7	3.3	0	6.7	90	0	0

Table 2. Parameters tone pitch, phonation period and high tone variation

	Tone pitch		**Maximum phonation time**			**Variation of high tone**		
	Normal	Modified	With in normal values	Below normal	Above normal	Small variations tone pitch	Voice interruption	Acceptable range
Number	29	1	19	11	0	0	1	29
%	96.7	3.3	63.3	36.7	0	0	3.3	96.7

The results show that tone pitch in 29 (96.7%) children was within normal values, while 1 (3.3%) respondent had a voice of altered pitch. When it comes to the maximum phonation time, in 19 subjects (63.3%) it was within normal values and in 11 subjects (36.7%) below normal values. When it comes to variations of high tones, there were almost none of them among children with SLD. The majority of the respondents 29 (96.7%) had an acceptable range of the highest tones and elasticity, while 1 (3.3%) respondent had a voice interruption at the ascending/descending pitch.

Perceptual characteristics of voice in children with SLD

The distribution of children with SLD according to the perceptual parameters of the GRBAS scale is shown in Table 3.

In relation to the level of hoarseness, 19 respondents (63.3%) had no change, while changes were registered in 11 (36.7%) children with SLD. Mild changes were the most common (20.0%), followed by moderate changes (10.3%), while pronounced changes in the voice were the least common (6.7%).

Voice roughness, as one of the perceptual parameters, was not registered in the voice of 21 (70%) children with SLD, while in 8 (30%) children it was. Mild changes were the most common (23.3%), while moderate and pronounced changes were significantly less common (3.3% each).

When it comes to breathiness in the voice, 19 (63.3%) children had no changes, while 11 (36.7%) had them. Mild changes were the most common (20.0%), followed by moderate changes (10.3%), while pronounced changes were the least common (6.7%).

The results of voice weakness examination showed that 14 (46.7%) children had no changes in voice weakness, while 16 (53.3%) children had them. Mild changes were the most common (30.0%), followed by moderate changes (16.7%), while pronounced changes were the least common (6.7%).

When it comes to voice tension, 16 (53.3%) children had no changes in voice tension, while 14 (46.7%) children had. Most often, these were mild changes (33.3%), followed by moderate and pronounced changes that were equally represented (6.7%).

Table 3. Perceptual parameters of the GRBAS scale

	Hoarseness				**Roughness**				**Breathiness**				**Weakness**				**Voice tension**			
	No change	Mild changes	Moderate	Expressed	No change	Mild changes	Moderate	Expressed	No change	Mild changes	Moderate	Expressed	No change	Mild changes	Moderate	Expressed	No change	Mild changes	Moderate	Expressed
Number	19	6	3	2	21	7	1	1	19	7	3	1	14	9	5	2	16	10	2	2
%	63.3	20	10	6.7	70	23.3	3.3	3.3	63.3	23.3	10.3	3.3	46.7	30	16.7	6.7	53.3	33.3	6.7	6.7

Perceptual characteristics of voice in relation to gender in children with SLD

Statistically significant differences in the perceptual characteristics of voice in children with SLD in relation to gender have been examined by the χ^2 test and are presented in Table 4.

Using the χ^2 test, statistically significant differences ($p < 0.05$) were obtained in two of the five examined perceptual characteristics of voice and sex: degree of hoarseness ($\chi^2 = 4.669$; df = 3; p = 0.039) and voice roughness ($\chi^2 = 4.571$; df = 3; p = 0.041). Mild changes in the degree of hoarseness of the voice were more frequent in boys (65%) than in girls (35%). Mild changes in voice roughness were more common in boys (70%) than in girls (30%). No statistically significant differences were found in breathiness of the voice and in sex ($\chi^2 = 2.729$; df = 3; p = 0.435); in weakness of the voice and in sex ($\chi^2 = 1.905$; df = 3; p = 0.206) and in tension of the voice and in sex ($\chi^2 = 2.831$; df = 3; p = 0.418). Changes in breathiness of the voice, voice weakness and voice tension were equally prevalent in boys and girls with SLD.

Table 4. Gender differences in perceptual characteristics of voice in children with SLD

Perceptual parameters	χ^2	**df**	**p**
Hoarseness	4.689	3	0.039*
Roughness	4.571	3	0.041*
Breathiness	2.729	3	0.435
Weakness	1.905	3	0.206
Voice tension	2.831	3	0.418

* significance at the level of $p < 0.05$

Discussion

The paper examines the quality of voice in children with SLD and potential gender differences between them.

By analyzing the obtained data in the field of respiration, we see that the largest number of children have normal breathing, while only a small percentage shows some difficulties, such as wheezing and weakness of the voice. The obtained results are in accordance with the results of some authors (8) who talk about difficulties in respiration in children of typical development, emphasizing that stress and instability during breathing are registered in most children.

The obtained results show that a small percentage of children with SLD have some difficulty in phonation, which manifests itself in the form of rough and tense phonation, vocal strain or aphonia, while most of the examined children have an adequate phonation, which is a prerequisite for normal speech. When it comes to the impact of resonance on voice quality in children with SLD, the research has shown that most children have normal resonance while a small percentage show a deviation in the form of decreased nasality or increased nasality. These findings are consistent with the previous research that points out that the most common voice disorders in children of typical development are dysphonia (impaired voice quality) and

rhinophonia (impaired voice resonance), indicating a correlation of fundamental frequency deviation (F0) with phonation and vocal straining (5, 8).

Analysis of the average, expected pitch with minimal variations in the range of voice, showed that most children with SLD had a normal pitch and acceptable range of highest tones and elasticity, while a small percentage of children had a pitch that was altered with voice interruptions at ascending/ descending pitch. The maximum phonation time in most children with SLD was within normal values. This result confirms the findings of the previous research which points out that most children with SLD have a tone of altered pitch with interruptions of voice at ascending/descending pitch which correlates with compensating for the ability to express appropriate melodic changes along a sentence and inability to process intonation. To compensate for this deficiency, children with SLD increase the intensity of the voice in order to cause changes in sentence intonation (27).

The obtained results show that there are no statistically significant differences in respiration, phonation, resonance and voice range in children with SLD in relation to gender. All examined parameters are equally represented in both sexes in children with SLD. The results of the previous research suggest that all pathologies of the larynx in children that affect voice quality (subglottic stenosis, vocal nodules, laryngomalacia, functional dysphonia and vocal cord paralysis) are much more common in boys than in girls (26).

By analyzing the obtained data, we have found that in children with SLD there are mild and moderate changes in voice quality (degree of hoarseness; hoarseness of voice; noise in the voice; weakness in the voice; tension in the voice). Mild changes are the most common, followed by moderate changes, while pronounced changes in the voice are the least common. The obtained results are in line with the previous research on voice quality, which confirms that most children have a slight deviation of the voice and that there are more frequent deviations in the voice in children with a high voice (8), and that voice weakness is the predominant disorder in pathology of the child's voice (7).

Analyzing the perceptual characteristics of the voice (degree of hoarseness; roughness of the voice; breathiness in the voice; weakness in the voice; tension in the voice) in relation to gender, statistically significant differences have been obtained for the two perceptual parameters. Mild changes in hoarseness and roughness of the voice are more frequent in boys, while changes in breathiness in the voice, weakness in the voice and tension in the voice are equally present in boys and girls with SLD. These results confirm previous research that points out that boys voices do not sound mature enough for the age, which is associated with a lack of contrast in the tonal accent of words, while girls have better results in prosody because they have better oral-practical abilities (24).

Restrictions

One of the limitations of this paper relates to the small sample. There is also a gender inequality of the sample, due to the generally higher tendency of boys in the population of children with SLD. The significance of the obtained results should further learn the results of future studies so that they can be generalized. Therefore, it is recommended that future research be directed towards larger samples, homogeneous in terms of gender and age. As we had even stronger strength, it would be good to compare children with SLD with children with other speech-language and voice disorders. Also, it would be desirable to explore additional instruments to process the voice system and voice quality.

Implications

Given the challenge that this research brings to speech therapy science and practice, the task for future research is to pay more attention to the quality of voice in the child population with speech and language disorders. Although difficulties have been reported in a small number of children, they have significant scientific and practical implications. They point to the importance of perceptual assessment of the voice performed by a vocal pathologist who has a trained sensibility for professional recognition of possible voice disorders. At the same time, they focus on the importance of preventive work with children with SLD and on vocal treatment, which is often neglected in the speech therapy practice with these children, yet it would be desirable to start with at an early stage in order to preserve a healthy and quality voice.

Conclusion

The research has been conducted with the aim of determining the components of the voice system, voice quality as well as potential gender differences among children with SLD.

Most children with SLD have adequate respiration and normal resonance, which are necessary for voice and speech. Most children have an acceptable range of the highest tones and elasticity, normal pitch tones and maximum phonation time within normal values. Difficulties in phonation, such as hoarse voice, vocal strain and aphonia, have been reported in a small number of children. All examined voice parameters (respiration, phonation, resonance and range of voice quality) have been equally represented in the examined boys and girls with SLD. Although in a smaller number, it has been noticed that in children with SLD there were mild and moderate changes in voice quality (degree of hoarseness; roughness of the voice; breathiness in the voice; weakness in the voice; tension in the voice). Changes in breathiness, voice weakness and voice tension were equally prevalent in boys and girls with SLD. Mild changes in the degree of hoarseness and roughness of the voice were more frequent in boys than in girls.

Voice evaluation in children with SLD should indicate and encourage a new perspective and to provide us with a conceptual approach that has the potential to better understand the voice system of children with SLD by completing a guide to voice rehabilitation in these children. Considering the importance of voice and speech for social development, the research findings imply the need for early treatment and support in order to preserve a healthy and quality voice in children with SLD.

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PERCEPTIVNA ANALIZA GLASA KOD DECE SA SPECIFIČNIM JEZIČKIM POREMEĆAJEM

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Specifični jezički poremećaj (SJP) je neurorazvojni poremećaj, koji karakteriše jezičke deficite uz očuvanost nekih kognitivnih domena. Evaluacija glasa kod dece sa SJP treba da ukaže na novu perspektivu i podstakne put ka njoj, da nam pruži konceptualni pristup, koji ima potencijal za bolje razumevanje glasovnog sistema dece sa SJP, upotpunjujući vodič za rehabilitaciju glasa kod ove dece.

Cilj ovog istraživanja je da se utvrde komponente glasovnog sistema, kvalitet glasa, kao i potencijalne polne razlike među decom sa SJP. Uzorkom je obuhvaćeno 30 dece sa razvojnom disfazijom, uzrasta od 3 godine do 9 godina (AS = 6,40; SD = 1,714), od kojih 20 dečaka i 10 devojčica. Za procenu kvaliteta glasa korišćeni su adaptirani Brzi skrining test za procenu glasa (Quick Screen For Voice, Lee, Stemple & Galze, 2003) i GRBAS skala (Isshiki, Okamura, Tanabe & Morimoto, 1969). Dobijeni rezultati pokazuju da najveći broj dece sa SJP ima adekvatne biološke predispozicije za tipičan kvalitet glasa. Veliki broj dece sa SJP nema promene na svim analiziranim perceptivnim parametrima glasa. Najčešće perceptivne promene glasa su blage, potom slede umerene, a najmanje su zastupljene izražene promene glasa. Postoje značajne razlike u stepenu promuklosti i hrapavosti glasa u odnosu na pol; promuklost i hrapavost glasa izraženiji su kod dečaka ($p < 0,05$). Iako su promene u kvalitetu glasa kod dece sa SJP bile blage, one su potencijalno značajne za vokalne patologe, ukazujući na značaj prevencije, koju bi trebalo sprovoditi na što ranijem uzrastu, sa ciljem da se očuva zdrav i kvalitatan glas. Rad je nastao kao rezultat istraživanja u okviru projekta „Evaluacija tretmana stečenih poremećaja govora i jezika" (ON 179068) i „Socijalna participacija osoba sa intelektualnom ometenošću" (ON 179017), koji finansira Ministarstvo prosvete, nauke i tehnološkog razvoja Republike Srbije.

Rezultati našeg istraživanja pokazuju da najveći broj dece sa razvojnom disfazijom ima adekvatne biološke predispozicije za normalan govor podjednako zastupljene u oba pola. Najčešće perceptivne promene glasa su blage, potom slede umerene, a najmanje su zastupljene izražene promene glasa. Postoje značajne razlike u stepnu promuklosti i hrapavosti glasa u odnosu na pol, u korist dečaka.

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Ključne reči: *kvalitet glasa, specifični jezički poremećaj, peceptivne karakteristike*