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CASUISTIC PAPER

Analysis of dysarthria in a 55-year-old female patient with multiple sclerosis by means of an IT tool based on respiratory and phonatory examination – a case study

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ABSTRACT

Introduction and aim. There are no available objective tools for assessing dysarthric disorders in the course of multiple sclerosis (MS). The aim of the study is to analyse a case of mixed dysarthria in a 55-year-old female patient in the course of secondary progressive MS and to present the severity of the patient's dysarthric disorder in contrast with the control group as evaluated by means of an IT tool based on respiratory and phonatory examination.

Description of the case. A 55-year-old patient was admitted to the Clinic of Neurology with the Stroke Unit due to a worsening condition in the course of MS. She was examined with an objective tool for respiratory and phonatory disorders. Her results were, then, compared to those of 24 healthy individuals from the control group, matched in terms of sex and age. Following speech parameters were analysed: phonetics of utterances, number of produced syllables per breath during the execution of individual texts, sound quality, intonation, and the total performance time of each.

Conclusion. The analysed case indicates that the developed objective IT tool is a promising diagnostic method that can facilitate diagnosis and can be used in clinical practice.

Keywords. dysarthria, multiple sclerosis, respiratory and phonatory disorders

Introduction

Multiple sclerosis (MS) is a demyelinating, inflammatory disease of the central nervous system. It is one of the most common causes of disability in young adults.[1] In Poland, MS incidence and prevalence are higher than previously reported. In 2019 it amounted to 6.6, currently 131.2/100,000 inhabitants.[2] Globally, the disease affects a total of 2.8 million people – 35.9 per 100,000 population.[3] The most common clinical symptoms include retrobulbar optic neuritis, spastic paresis, cerebellar ataxia, sensory disturbances.[4]

In the course of MS, especially in its primary and secondary progressive forms, the most common disorder that affects the quality of verbal communication is dysarthria, which due to the nature of MS, most often occurs in a mixed form and affects up to 45% of patients.[5] At the same time, dysarthria is the least accurately described clinical symptoms in the course of

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MS.[5-7] Speech-related symptoms in the course of MS may be caused or aggravated by weakness, spasticity of the tongue muscles, jaw muscles, soft ligament, diaphragm, and vocal cords. Movement coordination disorders of the above organs may also occur.[8] Impaired communication may result from difficulties in voice control and articulation of words due to the impaired function of the muscles responsible for speech and insufficient subglottic pressure.[9]

The most frequently reported speech disorders include comprehension problems pertaining to understanding the content of the message, slowed down rate of speech, hoarseness, volume and tone control complications, disfluent speech and problems with swallowing.[9-12]

The motivation for undertaking the study was the lack of available, objective tools for the assessment of dysarthric disorders in the course of MS. So far, in Poland, dysarthric disorders have most often been assessed on the basis of patient's interview and by using scales, e.g. the Speech Pathology Specific Questionnaire for people with MS.[13] However, the subjectivity of these tools carries the risk of error, therefore we decided to create an objective tool for the assessment of dysarthric disorders in MS patients in the form of an IT tool (software with elements of machine learning) based on the examination of respiratory and phonatory disorders, which aims to diagnose and track the dynamics of dysarthric changes.

Aim

The aim of the paper is to analyse the case of mixed dysarthria in a 55-year-old female patient with a secondary progressive type of multiple sclerosis. We attempt to present the severity of the patient's dysarthric disorder in comparison with the control group of 24 healthy individuals based on the output data obtained by means of an IT device examining respiratory and phonatory disorders.

Description of the case

Presentation

A 55-year-old female patient was admitted to the Clinic of Neurology with the Stroke Unit due to a worsening condition in the course of MS (Fig. 1). She was diagnosed with relapsing remitting MS in 2015. In 2015-2020 she was treated with immunomodulation as part of drug programs (initially INFb, then from 2019 with dimethyl fumarate). In 02.2021, due to the transition of the disease to a secondary progressive form, the patient began treatment with Mitoxantrone, which was discontinued after the 4th dose in 08.2021.

On neurological examination the patient was conscious, in logical verbal contact, presenting dysarthric speech, dysphagia, shallow right nasolabial fold, spastic paresis of the right upper limb of medium degree, exaggerated reflexes in both upper limbs, tremor of the left upper limb, significant spastic paresis of the right lower limb, exaggerated deep reflexes in both lower limbs, bilateral Babinski sign, painful paraesthesia in the right half of the body, positive Romberg test with eyes open. She could pass several meters with bilateral support, a walker (the Expanded Disability Status Scale EDSS-6.5).

On speech examination the patient communicated verbally and performed suggested verbal tasks. Aphasia was not observed. She also denied experiencing problems of such type. The examination revealed mixed dysarthric disorders, chanted speech, slightly hoarse voice with increased muscle tension. The motility of the articulation apparatus was slightly reduced with preserved praxis of the articulation organs. Facial muscle tone was slightly reduced on the right side with the soft palate evenly toned. In terms of phonetics irregularities were observed in spontaneous speech including rare elisions of fricatives, especially the final ones, and irregular and rare substitution of fricatives with plosives.

During her stay at the hospital ward the patient was assessed with an objective tool for examining respiratory and phonatory disorders (Figure 1).

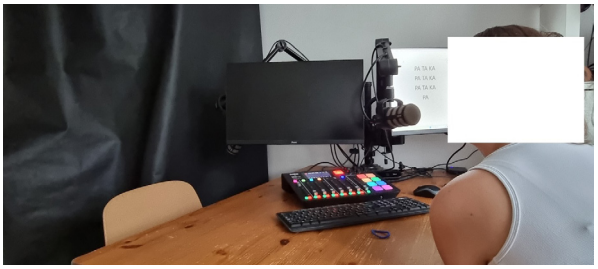

Fig. 1. Taking patient's voice sample

Methods

The results were then compared with those of 24 persons from the control group matched in terms of sex and age. The characteristics of the control group are presented in Table 1.

Table 1. Baseline characteristics of the control group

	Control group (n=24)
Age [years], mean	41.25
Sex [female/male]	12/12
Age < 40 years	12
Age > 40 years	12

The assessment involved reading 3 suggested texts in Polish:

1. A poem: 16 lines 10 syllables each – a poem in verse 2 lines each;
2. A text in prose: including simple and complex sentences; containing all sounds of the Polish language, as well as phonetic phenomena indicating potential dysarthric disorders, for instance consonantal clus-

ters provoking phonetic mistakes, 4 sentences, 3 complex and 1 simple: 1st sentence – 24 words, 2nd sentence – 4 words, 3rd sentence- 21 words, 4th sentence – 23 words;

3. The diction exercise: required accurate (without phonetic mistakes) realization of 10 syllables in the fastest possible manner).
   PA TA KA PA TA KA PA TA KA PA

Following speech parameters were subject to analysis:

- Phonetics: whether there were errors in terms of phonetic realization, elisions of fricatives and their substitution with plosives, phonetic simplifications concerning the manner and place of articulation not attributable to articulatory inaccuracy;
- Number of syllables produced per breath during the realization of each text;
- Sound quality assessment with GRBAS (0-3) scale
- G (grade of hoarseness)
- R (rough- ness)
- B (breathiness)
- A (asthenic)
- S (strained)
- Intonation – changes in relation to falling intonation (applies to affirmative sentences);
- Performance time of particular texts – in contrast with the results obtained in the control group

All speech parameters shown in the manuscript were first analyzed by a specialist, and then the results of the examination were entered into the IT tool. For the purposes of machine learning, a scale of 0-5 has been introduced, where 0 means no speech disorders and 5 extreme disorders in relation to the results of healthy people.

Results

In the control group there were no disorders connected to an improper intonation or phonetic errors due to dysarthria. In terms of voice quality according to GRBAS scale the result was 0 (G0 R0 B0 A0 S0). The average performance time was: a text in prose 46.41s , a poem – 36.21s, a diction exercise – 1.61s. The average number of breaths needed for producing individual texts was: a text in prose – 7.5 , a poem – 8.21, a diction exercise – 1. The average number of syllables produced per breath: a text in prose – 29.4, a poem – 19.5, a diction exercise – 10.

Whereas, in the analysed case of the MS patient with dysarthric disorder presenting itself with improper intonation and phonetic errors the GRBAS scale result was 6 (G1 R2 B0 A0 S3). The average performance time was: 90.57s – a text in prose, 58.93s – a poem, 2.99s – a diction exercise. The average number of breaths needed for producing individual texts was: a text in prose – 24, a poem – 16, a diction exercise – 1. The average number of syllables produced per breath: a text in prose – 9.01, a poem – 10, a diction exercise – 10. Table 2 shows the results in comparison with the control group.

Table 2. Speech parameters compared between the MS patient and the control group

Control group				MS patient
Performance time (PT)				
Performance time in seconds	mean	maximum	minimum	**PT**
PROSE	46.41	66.016	32.89	90.57
POEM	36.21	43.63	28.33	58.93
DICTION EXERCISE	1.61	2.91	1.08	2.99
Average number of breaths needed for reading the text	mean	maximum	minimum	**Average number of breaths needed for reading the text**
PROSE	7.5	12	4	24
POEM	8.21	14	6	16
DICTION EXERCISE	1	1	1	1
Average number of syllables per breath:				
PROSE	29.4	90	21	9.01
POEM	19.5	60	20	10
DICTION EXERCISE	10	10	10	10
GRBAS SCALE				
grade of hoarseness		0		1
roughness		0		2
breathiness		0		0
aesthetic		0		0
strained		0		3
Number of phonetic errors				
POEM		0		0
PROSE		0		8

In addition to a much longer performance time than the average obtained in the control group, the patient has an ascending intonation, which indicates, among others, the increased utterance effort in each presented speech sample, as shown in Figure 2. All graphs present intonation during the execution of declarative sentences.

Discussion

The fact that the subject of dysarthric disorders in MS has so far been neglected became the main motivation for the study. Another reason was the lack of available, objective tools for the assessment of dysarthric disorders in the course of MS. Therefore, an IT tool was developed. It aims to diagnose and track the dynamics of dysarthric changes in, among others, MS patients. Consequently, the purpose of the study is to analyse the case of mixed dysarthria in a 55-year-old patient in the course of MS of the secondary progressive form, to present the severity of the dysarthric disorders in contrast with the control group, which consisted of 24 healthy people, matched in terms of sex and age, using an IT tool examining of respiratory and phonatory disorders.

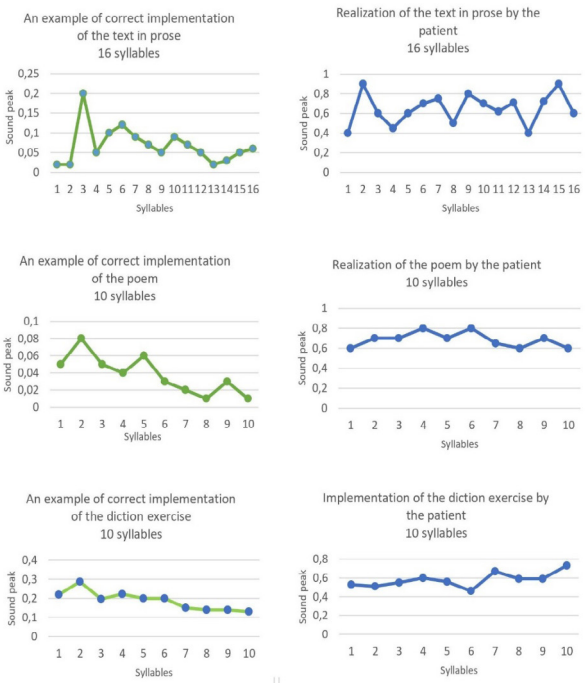

Fig. 2. Intonation graphs of texts fragments and diction exercises

On analysing individual speech parameters, it was shown that in the control group of healthy people assessed using the aforementioned IT tool, there were no disorders that could be associated with incorrect intonation and phonetic errors resulting from dysarthric disorders. Comparing these with the results of the MS patient, it was shown that not only was the performance time (reading a text in prose, a poem and the diction exercise) much longer than the average time in control group but also the average number of breaths needed to complete individual texts increased, except for diction exercise, where it was the same as in the control group (1 breath). The patient's effort and fatigue in the implementation of the above-mentioned texts was much larger. Her articulation and, above all, speech distribution abilities were definitely weaker than in the case of the control group.

The average number of syllables per breath proved to be significantly reduced, except for the diction exercise, where, as in the case of the average number of breaths, it was the same as in the control group, i.e. 10 syllables. This may be caused, among other things, by the lack of adequate amount of air necessary for speaking, increased effort, lack of proper respiratory and phonatory coordination and changes in muscle tension. In addition, the patient presented rising intonation, indicating, among others, the increased utterance effort in each presented speech sample. It is assumed that this is the result of excessive muscle tone during speech production.

It was not possible to find published sources that would allow a direct discussion between the results of this work. The studies by Rusz et al. and Rodgers et al. are an examination of speech rate and articulation rate. However, the measurement method differs due to a different unit of measurement (expressions/min, syllables/sec) as well as phonetic differences of the analysed languages.[14,15] Rodgers et al. studied the impact of cognitive functions and their relationship with speech and articulation rate in MS, which was also beyond our interest. Nevertheless, participants in those studies uttered syllables identical or similar to our diction exercise (/pa ta ka/ Rusz; /puh puh kuh/ Rodgers).[15] Moreover, in the work of Rusz et al. the longest realization of the /a/ sound per breath and reading an 80-word text were taken into account and analysed acoustically. The results of the study are consistent with ours, as the differences between the control group and MS patients are clearly visible. We share the conclusion regarding the encouragement of clinicians to pay special attention during therapy to coordination, including respiratory and phonatory coordination and its improvement, and not to increase muscle strength if the goal of therapy is to improve vocal/speech efficiency.[14]

In the work of Hartelius et.al. recordings of Australian and Swedish speakers were analysed. The subjects read the texts in their respective languages which were then subjectively cross-analysed by speech therapists from both countries. The study noted difficulties with unequivocal assessment of the depth of dysarthric disorders by listening to recordings by specialists – there was a lack of consistency in the assessment in many parameters.[16] Therefore, we believe that the assessment of dysarthria should primarily consider the objective features of speech. Hartelius et al. note the need for further interlinguistic work on the analysis of dysarthric disorders, which in our opinion is also interesting and important as it introduces a better understanding of such symptoms in the course of various neurological diseases.[16]

Though the results cannot be directly compared, the conclusions drawn from the cited works are consistent with our results. Sechidis et al. conducted an objective assessment of speech using machine learning modelling in patients with Parkinson's disease. The aim of their work was to find a correlation between speech and emotion. The researchers used the Mixture-of-Experts architecture for speech.[17] Primarily our studies differ in terms of the disease in question. We also do not study speech changes under the influence of emotions. In our work, we are looking for the most objective features of speech that will allow us to accurately determine the level of dysarthria and track the dynamics of changes to aid therapeutic process. For us, the acoustic parameters are an addition to the full picture of the disorder, while the main parameters are the performance time, the number of breaths needed to complete the text/phrase and the number of syllables spoken per breath. For the study,

we also used longer texts, which in our opinion increases the objectivity of the assessment. None of the cited works analysed the realization of a text in verse form.

Summing up the above considerations, it can be concluded that based on the analysed case the IT device is a promising tool for the diagnosis of dysarthric disorders, and the method of examination on which it is based is an innovative approach to the analysis of dysarthric speech disorders and can be the basis for a very thorough study of their changes also in the course of other neurological diseases.

Conclusion

The presented case involved speech disorders of the type of ataxic dysarthria in comparison to the control group of healthy people. The analysed case indicates that the developed objective IT tool, which aims to diagnose and track the dynamics of dysarthric changes in patients with MS, is a promising diagnostic method that can facilitate diagnosis and can be used in clinical practice. However, further studies on a larger group of MS patients are needed to draw far-reaching conclusions.

Declarations

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Author contributions

Conceptualization, W.A.W. and M.P.; Methodology, W.A.W.; Software, W.A.W. and M.P.; Validation, W.A.W. and M.P.; Formal Analysis, W.A.W., M.P. and A.G.; Investigation, W.A.W, M.P. and M.D.; Resources, W.A.W., M.P. and H.B.P.; Data Curation, W.A.W., H.B.P. and A.G.; Writing – Original Draft Preparation, W.A.W., M.P., M.D. and A.G ; Writing – Review & Editing, W.A.W., H.B.P. and A.G; Visualization, W.A.W; Supervision, W.A.W. and H.B.P.; Project Administration, W.A.W., M.P. and H.B.P.

Conflicts of interest

The authors declare no competing interests.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Bioethical Committee at the University of Rzeszów (approval no. 3/01/2020).

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