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Preliminary Assessment of Voice Disorders Induced by COVID-19

Abstract: This study assessed discomfort symptoms in the vocal tract of 49 post-COVID-19 patients (41 females, 8 males; aged 19-82) referred to a speech therapy clinic for voice dysfunction. The aim was to identify dominant symptoms during vocal emission. Conducted in 2020-2021 at the Speech Therapy Clinic in Kielce, participants had no prior phoniatric issues. Vocal Tract Discomfort Scale (VTD) evaluated symptom intensity across normative to severe voice changes. COVID-19 voice disorders are transient. Common symptoms included throat/laryngeal pain, tension, dryness, irritation, and obstruction sensation. Three symptom groups emerged: rare (e.g., „lump in throat"), moderate (e.g., „tenderness"), and frequent (Group III: „dryness," „scratchy throat," „irritation"). Untreated phonatory/respiratory dysfunctions may worsen. Post-COVID residuals cause functional and paralytic voice issues (hoarseness, fatigue, dryness, voice loss, lump sensation, pain, cough). Speech therapy effectively improves phonation.

Key words: COVID-19, functional dysphonia, paralysis-related dysphonia, speech therapy

Wstępna ocena zaburzeń głosu wywołanych przez COVID-19

Streszczenie: Badanie oceniało objawy dyskomfortu w narządzie głosu u 49 pacjentów po COVID-19 (41 kobiet, 8 mężczyzn; w wieku 19-82 lat), skierowanych do poradni logopedycznej z powodu dysfunkcji głosu. Celem było zidentyfikowanie dominujących objawów podczas emisji głosu. Przeprowadzone w 2020-2021 w Poradni Logopedycznej w Kielcach, uczestnicy nie mieli wcześniej problemów foniatrycznych. Skala Vocal Tract Discomfort Scale (VTD) oceniała intensywność objawów od normatywnych do ciężkich zmian głosu. Zaburzenia głosu po COVID-19 mają charakter przejściowy. Częste objawy to ból gardła/krtani, napięcie, suchość, podrażnienie i uczucie przeszkody. Wyodrębniono trzy grupy: rzadkie (np. „guzek w gardle"), umiarkowane (np. „tkliwość") i częste (grupa III: „suchość", „drapanie w gardle", „podrażnienie"). Nieleczone dysfunkcje fonacyjne i oddechowe mogą się nasilać. Resztkowe objawy po COVID-19 powodują zaburzenia głosu funkcjonalne i paralityczne (chrypka, zmęczenie głosu, suchość, utrata głosu, uczucie guzka, ból, kaszel). Logopedia skutecznie poprawia fonację.

Słowa kluczowe: COVID-19, dysfonia czynnościowa, dysfonia porażenna, terapia logopedyczna

Additional information: The study was approved by the Research Ethics Committee of the Faculty of Humanities at the Jan Kochanowski University in Kielce (No. 2/2024).

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Introduction

COVID-19 is an infectious disease caused by the coronavirus-2 (SARS-CoV-2), capable of inducing severe acute respiratory distress syndrome, a characteristic systemic hyperinflammatory response, vascular damage, microangiopathy, angiogenesis, and extensive thrombosis. It has been identified in four stages: the first stage involves upper respiratory tract infection; the second stage presents with breathlessness and pneumonia; the third is dominated by a cytokine storm and the resulting hyperinflammatory state; the fourth stage, depending on the resolution or intensification of acute symptoms, leads to either recovery or death (Stasi, Fallani et al., 2020). The resolution of acute symptoms does not always guarantee a complete return to health. Long-term consequences of COVID-19, while not fully known, show scientific evidence of persistent impairment of lung function and physical abilities, reduced quality of life, and emotional stress (McFee, 2020). Other studies also indicate a connection between SARS-CoV-2 infection and

unwanted symptoms in the oral cavity (Bardellini, Bondioni, et al. 2021). Positive patients reported changes or loss of taste, dryness in the oral cavity and ulcers, xerostomia, bone, jaw, or joint pain, halitosis (Abubakr, Salem, et al. 2021), pseudomembranous inflammation of the mouth, geographic tongue, coated tongue, and congested throat (Bardellini, Bondioni, et al. 2021), discoloration, ulcers of the oral mucosa, tongue fungus, unilateral (more often left-sided) aphthous-like changes on the hard palate, atrophic inflammation of the lips; salivary secretion disorders (Rafałowicz, Wagner et al., 202; Nijakowski, Wyzga et al., 2022). These symptoms in the oral cavity affect the functions of the orofacial, respiratory, and phonatory apparatus, requiring rehabilitative interventions, including speech therapy (Halfpenny, Stewart et al. 2021). In the perceptual assessment, a normal voice is resonant, clear, remains so even after effort, does not contain noise components, is rich in resonance, created with a soft setting, has a pitch appropriate to gender and age, has an intensity suitable for the situation, and during speech, changes in intensity and pitch occur smoothly, in accordance with the content of the speech, with proper articulation, and expressiveness. In dysphonias, adverse changes occur in the way the voice is produced and emitted, its character, average position, and range, phonation time, voice intensity, and vocal endurance (Pawłowski, 2005). A significant factor that prompts patients to visit a speech therapist is subjective feelings associated with voice disorder symptoms during emission. An instrument that can assist speech therapists in the initial assessment of a patient's voice is the Vocal Tract Discomfort Scale (VTD) (Woźnicka, Niebudek-Bogusz, Kwiecień, 2012). The aim of the research was to identify the dominant symptoms during vocal emission in individuals after recovering from Covid-19. Thus, the subject of the study involved the assessment of the frequency of discomfort symptoms in the vocal tract of 49 patients who had suffered from Covid-19 and were referred to a speech therapy clinic due to voice organ dysfunction[1]. To illustrate the condition of the vocal folds in patients exhibiting voice dis-

[1]In addition to Vocal Tract Discomfort (used in this study), perceptual (auditory) voice assessment also utilizes systematic scales commonly used by phoniatrists and speech therapists. The most frequently used scale is GRBAS. This scale describes voice disorders using five well-defined parameters: G – grade of hoarseness, R – roughness of the voice resulting from irregular vocal fold vibrations, B – breathiness – breathy voice, caused by air leakage during phonation through incompletely closed vocal folds, A – asthenic – weak voice, and S – strained – tense, hyperfunctional voice. The five-parameter GRBAS scale has four degrees of severity for each parameter: "0" – indicates a normal voice, "1" – mild intensity, "2" – moderate, "3" – severe intensity of the disorder in relation to all parameters. When determining the way the voice is produced, attention is paid not only to the tension of neck muscles and shoulder girdle but also to the dilation of veins during phonation, indicating a faulty, tense way of creating the voice. Observing chest movements during breathing, the breathing path is established: upper-chest, middle-chest-abdominal, or lower-abdominal. Then, the phonation time is measured, a significant indicator of the efficiency of the vocal organ. Its measurement involves determining the maximum phonation

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orders due to Covid-19, videostroboscopy was previously employed. This method allowed for a precise assessment of the mobility of the mentioned structure and the classification of patients for therapy.

Materials and methods

The studies were conducted in 2020– 2021 at the Speech Therapy Clinic in the "Dla Rodziny" Medical Center in Kielce. The study group consisted of patients (41 females and 8 males) aged 19 to 82 years, who did not report phoniatric problems before falling ill.

The study utilized the Vocal Tract Discomfort Scale (VTD) (Woźnicka, Niebudek-Bogusz, Kwiecień, 2012; Olszewski J., Nowosielska-Grygiel, 2017). Patients were asked to describe sensations or discomfort they experience during speaking[2]. The instruction was as follows: "Below are listed discomforts or sensations that you may observe in your throat or larynx. They may be part of the symptoms of voice problems. Please indicate the symptoms and specify their frequency by marking an X next to one response for each symptom in the appropriate column (Table 1)."

The assessment of the frequency of these symptoms was conducted on a scale from 0 to 6, where 0 means never, 1-3 means sometimes, 3-5 means often, and 6 means always. In terms of intensity, 0 indicates none, 1-3 indicates mild, 3-5 indicates moderate, and 6 indicates high intensity. The total score ranges from 0 (8 questions with 0 points each) to 48 (8 questions with 6 points each).

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time for the vowel "a" during full exhalation (the result is the average of three measurements); the norm is 20 seconds. If the measurement value is < 20 seconds, it indicates a shortened phonation time and reduced vocal efficiency (por. Wysocka, 2015; Jacobson, Johnson, Grywalski, 1997; Pawłowski, 2005; Wiskirska-Woźnica, 2002). The VTD (Vocal Tract Discomfort) scale utilized in our study is useful for the initial assessment of voice disorders. It involves the patient filling out a questionnaire independently. This scale comprises 8 items related to the vocal tract (burning, tension, dryness, pain, scratching, tenderness, irritation, lump in the throat), assessed in terms of both frequency and intensity. Evaluation of each item on the scale is done on a scale from 0 to 6 points. In the frequency subscale, 0 means never, 1–3 means sometimes, 4–5 means often, and 6 means always. In the intensity subscale, 0 indicates no intensity, 1–3 indicates mild intensity, 4–5 indicates moderate intensity, and 6 indicates high intensity. The total score can range from 0 points (8 questions with answers of 0 points each) to 48 points (8 questions with answers of 6 points each) (Woźnicka, Niebudek-Bogusz, Kwiecień, 2012).

[2] The patients provided informed consent to participate in the study. It is also important to emphasize that the nature of the study was non-invasive.

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Table 1
Vocal Tract Discomfort Scale (VTD) Card [9, 10]

First and last name	Frequency			
Date of the study	0 Never	1–3 Sometimes	3–5 Often	6 Always
Burning				
Tension				
Dryness				
Pain				
Scratching				
Tenderness/Pain upon touch				
Irritation				
Lump in the throat				

Description of tools used in data processing and statistical analysis:

The data analysis was performed using the Google Colab platform (Colaboratory). For the implementation of the analysis, the Python programming language version 3.10.12 was utilized, along with the following libraries and their versions (Panda: 1.5.3, Numpy: 1.23.5, Plotly: 5.17.0, SciPy: 1.11.2, Pingouin: 0.5.3) along with all their internal dependencies.

Results

Description of the studied group:

In the conducted study, 49 respondents participated, including 41 women and 8 men. The average age of the respondents was 53.86 years with a standard deviation of 12.34.

An analysis based on gender revealed that the average age of women was 53.1 years with a standard deviation of 12.61, while for men, it was 57.75 years with a standard deviation of 10.67. The minimum age in the study for women was 19 years, which is also the lowest age value for the entire study group. In the case of men, the minimum age was 33 years. The maximum age for women was 82 years, and for men, it was 68 years. An age analysis showed a slight difference in the age of the respondents, where women were on average 4.65 years younger than men. With a similar standard deviation, this allows for treating the groups as a cohesive whole with similar diversity in terms of age. The distribution of the studied population, considering the division into age groups, is presented in Chart No. 1.

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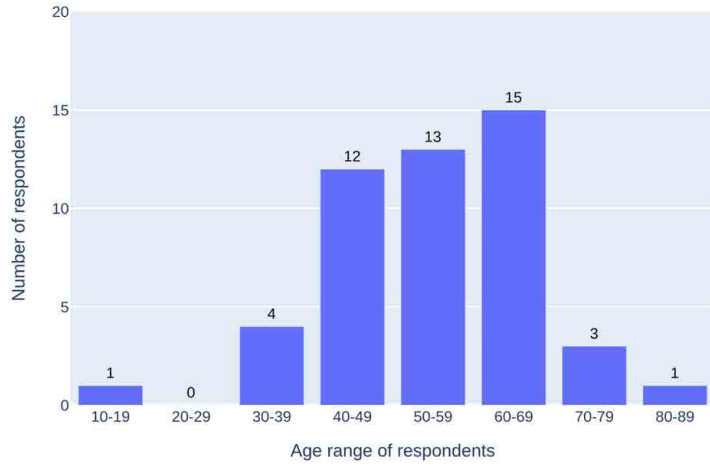
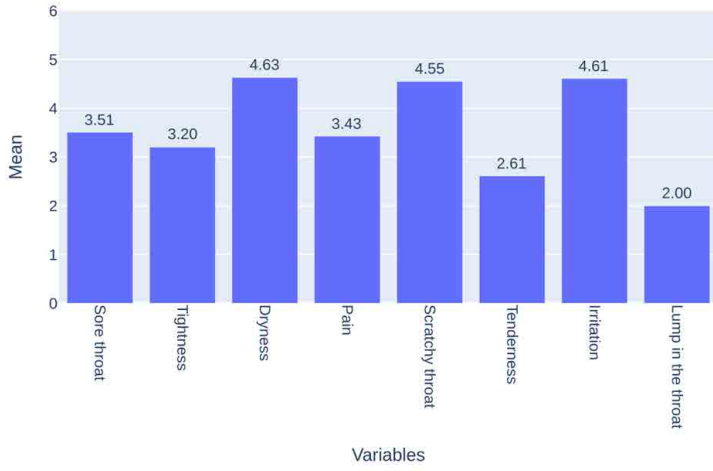
Chart 1
The distribution of the studied population, considering the division into age groups



The VTD scale was used for the study, focusing on the frequency of occurrence of each factor, expressing results on scales from 0 to 6, where 0 indicates the absence, and 6 indicates a constant presence of a particular factor. Additionally, the value 2 represents periodic occurrence, and the value 4 indicates frequent manifestation.

The average obtained results are as follows.

Chart 2
The average frequency of dysphonia symptoms by age



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Based on the conducted analysis of the average frequency of occurrence of individual symptoms, three groups can be identified.

Group I includes two symptoms: "Lump in the throat: and "Tenderness."

1. "Lump in the throat" with a mean (M) value of 2, and a median (Me) also equal to 2. The standard deviation (SD) is 1.22, and the standard error of the mean (SEM) is 0.17.
2. For "Tenderness," the mean (M) is 2.61, the median (Me) is 3, and the standard deviation (SD) is 1.47, with a standard error of the mean (SEM) equal to 0.21.

It can be concluded that this group of symptoms occurs relatively infrequently, with "Tenderness" being slightly more common, as indicated by the higher average and median values. However, the authors believe that this difference is not significant enough to warrant the separation of this symptom into a distinct group.

Group II: includes three symptoms, Sore throat, Tightness, Pain..

1. "Sore throat" with a mean (M) value of 3.51 and a median (Me) equal to 4. The standard deviation (SD) is 1.75, and the standard error of the mean (SEM) is 0.25.
2. For "Tightness," the mean (M) is 3.2, and the median (Me) is also equal to 4. The standard deviation (SD) is 1.54, and the standard error of the mean (SEM) is 0.22.
3. "Pain" has a mean (M) of 3.43, with a median (Me) equal to 4. The standard deviation (SD) is 1.67, and the standard error of the mean (SEM) is 0.19.

The occurrence of this group of symptoms was observed more frequently than in the previous group. Additionally, the median values between the symptoms were identical.

Group III: also includes three symptoms, i.e.. Dryness, Scratchy throat, and Irritation.

1. Dryness; the mean (M) is 4.63, and the median (Me) has a value of 5. The standard deviation (SD) is 1.35, and the standard error of the mean (SEM) is 0.19.
2. Scratchy throat; the mean (M) is 4.55, and the median (Me) has a value of 5. The standard deviation (SD) is 1.24, and the standard error of the mean (SEM) is 0.18.
3. Irritation; the mean (M) is 4.61, and the median (Me) has a value of 5. The standard deviation (SD) is 1.24, and the standard error of the mean (SEM) is 0.18.

For the last group of symptoms, they occur on average most frequently, and the median takes a value of 5 in each case. Moreover, highly significantly, each of the mentioned symptoms exhibits a low level of standard error of the mean, indicating a small uncertainty and relative precision in estimating the sample mean. This is related to the representativeness of the sample.

The next stage of the analysis was conducted by our team using Pearson correlation analysis (r) and 95% confidence intervals for correlations (CI95%), as well as the significance level (p) along with Bayes Factor (BF10) and test power. Correlation pairs with $p<0.050$ were considered statistically significant (Table 2).

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Table 2
Symptoms of dysphonia

X	Y	r	CI95%	P	BF10	Power
Sore throat	Tightness	0.797	[0.66 0.88]	0	1.358e+09	1
Sore throat	Dryness	0.4	[0.13 0.61]	0.004	9.072	0.825
Sore throat	Pain	0.759	[0.61 0.86]	0	4.662e+07	1
Sore throat	Scratchy throat	0.444	[0.19 0.64]	0.001	25.333	0.904
Sore throat	Tenderness	0.566	[0.34 0.73]	0	1093.697	0.992
Sore throat	Irritation	0.471	[0.22 0.66]	0.001	51.144	0.938
Sore throat	Lump in the throat	0.234	[-0.05 0.48]	0.106	0.635	0.371
Tightness	Dryness	0.508	[0.26 0.69]	0	149.525	0.969
Tightness	Pain	0.823	[0.71 0.9]	0	2.169e+10	1
Tightness	Scratchy throat	0.473	[0.22 0.67]	0.001	54.509	0.94
Tightness	Tenderness	0.625	[0.42 0.77]	0	1.254e+04	0.999
Tightness	Irritation	0.475	[0.22 0.67]	0.001	56.569	0.942
Tightness	Lump in the throat	0.199	[-0.09 0.45]	0.171	0.443	0.28
Dryness	Pain	0.413	[0.15 0.62]	0.003	12.214	0.852
Dryness	Scratchy throat	0.844	[0.74 0.91]	0	2.809e+11	1
Dryness	Tenderness	0.357	[0.08 0.58]	0.012	3.907	0.725
Dryness	Irritation	0.775	[0.63 0.87]	0	1.715e+08	1
Dryness	Lump in the throat	0.164	[-0.12 0.43]	0.26	0.329	0.204
Pain	Scratchy throat	0.456	[0.2 0.65]	0.001	34.261	0.92
Pain	Tenderness	0.748	[0.59 0.85]	0	1.921e+07	1
Pain	Irritation	0.477	[0.23 0.67]	0.001	61.308	0.945
Pain	Lump in the throat	0.183	[-0.1 0.44]	0.208	0.385	0.245
Scratchy throat	Tenderness	0.439	[0.18 0.64]	0.002	22.358	0.897
Scratchy throat	Irritation	0.859	[0.76 0.92]	0	2.461e+12	1
Scratchy throat	Lump in the throat	0.246	[-0.04 0.49]	0.088	0.733	0.406
Tenderness	Irritation	0.421	[0.16 0.63]	0.003	14.491	0.866
Tenderness	Lump in the throat	-0.023	[-0.3 0.26]	0.875	0.18	0.053
Irritation	Lump in the throat	0.242	[-0.04 0.49]	0.094	0.696	0.393

Table 2. Symptoms of dysphonia. Columns **X** and **Y** present pairs of symptoms. Column r shows the Pearson correlation level, followed by the **CI95%** column, which includes the 95% confidence interval for each correlation. Column **p** indicates the unadjusted p-value, the **BF10** column presents the Bayes Factor, and the **power** column specifies the statistical test power.

All statistically significant correlations demonstrated a positive relationship. The applied classification[3] for statistically significant correlations revealed 7 pairs with a very strong correlation, 3 pairs with a strong correlation, and 11 pairs with

[3] r > 0.7 - Very strong correlation, 0.5 <= r < 0.7 - Strong correlation, 0.3 <= r <0.5 - Moderate positive correlation, 0 <= r < 0.3 - Weak or no correlation.

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a moderate correlation. In all observed, statistically significant correlations, there was a positive relationship, suggesting a common intensification of symptoms within the presented pairs. The BF10 analysis conducted through the obtained results for this study indicates strong support for the existence of correlations for all statistically significant symptoms. The power value suggests adequate statistical power for the conducted analysis. For "Lump in the throat," none of the correlations indicate a statistically significant p-value. It can be assumed that there is a different physiological basis for the occurrence of this symptom than for the other symptoms during the course of COVID-19. Pairs of symptoms that did not show a statistically significant p-value are marked in red. Regardless of age, the nature of symptoms, and their frequency, each reported person requires speech therapy. However, it should be emphasized that these data do not constitute statistical penetration but only a research sample in which the phenomenon of voice disorders arising as a residual form of COVID-19 was signaled. The mentioned study is a contribution to further analysis. Below, the condition of the right vocal fold in a patient with paralysis dystonia due to Covid-19 is illustrated. The videostroboscopic method was used for a precise assessment of fold mobility and tension.

As a result of this dysfunction, in the case of unilateral paralysis of the vocal folds not induced by Covid-19, respiratory disorders do not always occur, although they may appear during intense physical exertion. However, the occurrence of symptoms of vocal fold paralysis in the context of coronavirus is associated with the weakening not only of the phonatory function but also of the respiratory and protective functions of the larynx (see discussion).

Discussion

The phenomenon of human voice arises through a series of reflexes, including partially conditioned reflexes. In the individual development from infancy to old age, the voice undergoes many changes dependent on both physiological and environmental processes (Maniecka-Aleksandrowicz, Szkiełkowska, 1998; Śliwińska-Kowalska, Niebudek-Bogusz, 2009). The production of voice and speech requires the collaboration of the respiratory pathways as a subglottic air reservoir generating a high-pressure airflow, the larynx containing the vibrating mechanism, i.e., the vocal folds producing the fundamental tone, and the resonant spaces giving the characteristic color to the voice and forming speech sounds. A condition for proper phonation is, alongside unchanged morphologically and functionally normal vocal folds, full mobility in the cricothyroid joints, correct and symmetrical phonatory vibrations with full phonatory efficiency of the vocal folds (complete

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closure), and a soft vocal setting (Stasi, Fallani et al., 2020; McFee, 2020; Bardellini; Bondioni 2019; Abubakr, Salem, Kamel, 2021).

Undoubtedly, COVID-19 disrupts the homeostasis of these processes, affecting the patient's body in a multi-systemic manner (influencing the circulatory and respiratory systems, altering the external environment, e.g., wearing masks, sometimes under oxygen or with an intubation tube). Dysphonia may occur in one-fourth of COVID-19 patients ranging from mild to moderate, and it should be regarded as one of the infection symptoms (Halfpenny, Stewart, Carter, 2021). Often, due to the disturbed functioning of the respiratory and circulatory systems, there is a weakening of the internal muscles of the larynx, improper tension, difficulties in breathing during speech, shortening of the inhalation and exhalation phases, abnormal function of the vocal folds, and dysfunction of muscles affecting the work of resonant cavities. During a speech therapy examination, such as articulation assessment or during speech, patients may exhibit a lack of coordination in the movements of the lips, tongue, and their simultaneous continuity due to weakened orofacial and laryngeal muscle apparatus. This results from difficult phonation and significant voice fatigue. Patients compensate for speaking-related pathology with increased respiratory effort. In many patients, a decrease in the palatopharyngeal efficiency has also been observed, leading to reduced resistance in the respiratory pathways. If this pathological process persists for a long time, it may cause structural compensations, such as weaker tongue elevation, increased resistance at the vocal fold level characterized by excessive compensatory closure of the vocal folds, or too weak vocal fold closure. These symptoms, depending on the pathomechanism of voice disorders, can take the form of functional and paralysis dysphonias.

Paralytic dysphonia after recovering from Covid-19

The diagnosis of paralytic dysphonia in patients after recovering from Covid-19 requires further interdisciplinary discussion and expanded research involving phoniatrists, speech therapists, and pulmonologists. The etiology of laryngeal neurogenic damage is most commonly caused by peripheral damage to the vagus nerves or their branches: the superior laryngeal nerve or the recurrent laryngeal nerve. Only a small percentage may have a central origin. Peripheral paresis, much more common, is typically induced by damage to the vagus nerve, superior or recurrent laryngeal nerve, through trauma mechanisms (neck or chest injuries, surgical procedures, skull base fractures), neoplastic processes (tumors of the esophagus, trachea, bronchi, nasopharynx, larynx, thyroid), inflammatory diseases, intoxication with toxic substances (alcohol, carbon monoxide, heavy metals), metabolic disorders (diabetes), and blood

disorders (Marszałek, Żebryk-Stopa, Wojnowski, 2011; Walencik-Topiłko, 2022). The most frequent cause of peripheral vocal fold paralysis is surgical treatment of thyroid diseases (Chrut, 2020). However, in the case of Covid-19, it is caused by inflammatory factors. Among the symptoms of vocal fold paralysis, we can distinguish respiratory and phonatory dysfunctions, disturbances in defensive reflexes, and swallowing disorders. Changes in the patient's voice involve qualities such as dullness, breathiness, softness, voicelessness, or hoarseness. The pitch and color of the voice are also modified, leading to hoarseness and temporary voicelessness (Walencik-Topiłko, 2022). Typically, in the case of unilateral vocal fold paralysis, patients may not experience respiratory difficulties at all, or these difficulties may only manifest during physical exertion. However, in the case of paralytic dysphonia due to Covid-19, it is different. Regardless of the extent of paralysis, patients complain of a feeling of breathlessness and an inability to breathe freely. From the authors' experience, the need for air intake can lead to hyperventilation. Therefore, it is essential, during the rehabilitation of voice disorders caused by paralytic dysphonia after Covid-19, to improve breathing while maintaining adequate air passage through the vocal folds. Walencik-Topiłko (2022) indicates that the quality of phonation depends on the position of the vocal fold. If the fold is in the midline position, voice changes will be minimal, while in the intermediate position, the voice will be breathy and dull. In bilateral paralysis, which occurs less frequently than unilateral, the most dangerous situation is laryngeal stridor, i.e., laryngeal breathlessness with clear difficulty in taking in air, especially during inhalation. The most commonly reported symptoms by patients in such cases are choking, regurgitation of food into the nose, and hoarseness. Two types of such paralysis are distinguished: tense and flaccid. In tense paralysis, inspiratory breathlessness often occurs, even at rest. In flaccid paralysis, effort-related breathlessness develops. Tense paralysis can transform into flaccid and vice versa. An important fact is that Covid-19 can cause both resting and effort-related breathlessness.

Functional dysphonia after recovering from Covid-19

A quite noticeable transient symptom of COVID-19 can be the so-called "covid hoarseness." Halfpenny et al.(2021) indicate that out of 160 individuals affected by COVID, 70 suffered from multi-faceted voice disorders. In 33 participants of the study, covid hoarseness persisted for more than 2 weeks, and in 11 cases, it lasted for over a month. Our observations, however, suggest a three-month period of hoarseness occurrence. Hoarseness (Latin: *dysphonia, raucitas*) in a narrower sense results in a disturbance of the vibrations of the vocal folds in the larynx, causing turbulent airflow within the glottis, manifested by a rough, dull voice. Due to intense infection

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in the nasal and pharyngeal areas, secretions appear in the sinuses, flowing down to the throat, leading to the development of hoarseness. It is essential to emphasize that hoarseness is indeed one of the noticeable voice disorders in the context of COVID-19, but it may not be the first one. If fibrovideostroboscopic examination does not reveal changes in the vocal folds but there is a qualitative change in the voice, functional dysphonia is diagnosed (Walencik-Topiłko, 2022). Functional dysphonias are most commonly caused by abnormalities in the neuro-muscular mechanisms of the larynx. They result from disturbances in the functioning of external and internal laryngeal muscles, their tension, and mutual coordination. A characteristic feature of functional voice disorders is the absence of primary organic changes in the vocal folds. Functional dysphonias are usually caused by constitutional abnormalities of the vocal organ, incorrect voice creation technique, vocal organ overload, especially in poor hygienic conditions, lack of auditory control, and certain general health conditions (poisoning, poor nutrition, debilitating diseases) (Walencik-Topiłko, 2022). Functional dysphonia in the context of COVID-19 is a response to the inflammatory process in the upper and/or lower respiratory tract.

In summary, dysphonia in individuals with COVID has a different nature. It may result from inflammation of the vocal cords and mucous membrane swelling, including those covering the vocal folds. It may also be caused by paralysis of the recurrent nerve with a medial or intermediate position (resulting in minor voice disorders), or by flaccid paralysis with a lateral vocal fold position and weak tension, leading to significant voice disorders requiring intensive rehabilitation. A somewhat dangerous symptom of COVID-19 is the narrowing of the airways due to inflammation of the lower respiratory tract (bronchi, lungs), causing a reduction in airflow. If this flow is reduced, in addition to severe coughing, patients may experience not only hoarseness but also thick secretion flowing down the back of the throat, resulting in a feeling of a sore throat, forced dry cough, and a sense of dryness in the oral and throat cavities.

From source reports (Wang, Chau, Lui at al., 2020), symptoms such as throat and laryngeal inflammation, nasal obstruction, or nasal discharge, despite negatively affecting phonation, could be treated at home with comprehensive speech therapy. On the other hand, studies by Miles, McRae, Clunie, Gillivan-Murphy, Inamoto, Kalf, Pillay, Pownall, Ratcliffe (2022), Richard, Lechien, Saussez, Vaira, and Hans (2021) indicate that several patients, due to a severe course of COVID-19, experienced otolaryngological complications in the form of prolonged voice disorders and required hospitalization. Asiaee, Vahedian-azimi, Atashi, Keramatfar, Nourbakhsh (2020) observed changes in acoustic voice parameters in 64 hospitalized patients with COVID-19 and identified increased irregularity and aperiodicity in vocal fold vibrations.

Therefore, post-recovery from coronavirus disease may manifest as persistent, severe functional or paralytic dysphonia, leading even to voice loss, as con-

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sequences of prolonged inflammatory states (Elibol, 2021; Mohd, Ahmad at al., 2021; Jeleniewska , Niebudek-Bogusz at all., 2022).

Conclusion

Transient forms of coronavirus disease can result in functional or paralytic voice disorders. Individuals after recovering from Covid-19 report symptoms affecting the voice, both acute and chronic in nature.

Associated symptoms are commonly described as hoarseness, vocal fatigue, sensations of dryness in the throat and larynx, periodic voice loss and breaking, a lump in the throat sensation, throat pain with a feeling of obstruction during swallowing, a scratching sensation in the throat, chronic dry cough or bouts of coughing, and throat clearing. An analysis of the average frequency of symptom occurrence was conducted, and the results were categorized into three groups. In the first group, the occurrence of "Lump in the throat" was rare, with slightly more frequent instances of "Tenderness," as indicated by median values.

Symptoms belonging to the second group, such as "Sore throat," "Tightness," and "Pain," occurred more frequently than in the first group. Symptoms from the third group, including "Dryness," "Scratchy throat," and "Irritation," occurred on average most frequently. Rehabilitative speech therapy exercises are an effective means of improving phonatory and respiratory efficiency. Therapeutic interventions are based on the rehabilitation of various areas related to voice production: myofunctional, respiratory, articulatory-phonatory, as well as psychological.

Conflicts of interest

The authors of the paper declare that they have no conflicts of interest.

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