

## STRESZCZENIE W JĘZYKU ANGIELSKIM

**INTRODUCTION:** Speech represents the fundamental medium of human thoughts expression. An increasing number of scientific research analyzing the influence of the endocrine system on voice formation have been published over the last years. Several investigations proved the occurrence of receptors for androgens, estrogens, progesterone, as well as free thyroid hormones in vocal folds. The most common endocrine disorders causing alterations in the concentrations of the aforementioned hormones include polycystic ovary syndrome (PCOS) and chronic lymphocytic thyroiditis, also known as Hashimoto disease (HD), respectively.

PCOS is the most common hormonal disorder in women in reproductive age. The diagnostic criteria for this endocrinopathy include ovulation dysregulation in a shape of oligo/amenorrhoea, clinical or laboratory hyperandrogenism, as well as polycystic ovary morphology on ultrasonography. Several scientific reports indicate possible voice changes, especially deepening of its timbre, which can accompany women with PCOS. The potential mechanism of reported vocal changes is considered as a laryngeal muscles hypertrophy stemming from the increased androgens concentrations.

HD is defined as the continuous autoinflammatory state of the thyroid gland, coexisting with the damage of the thyroid follicles. Diagnostic criteria for HD include an increased titer of anti-thyroid peroxidase (anti-TPO) and/or anti-thyroglobulin (anti-TG) antibodies, concomitant with thyroid hypoechogenicity on ultrasonography. The most common manifestations of overt hypothyroidism include chronic fatigue, cold intolerance and weight gain. Other symptoms are vocal changes, often recognizable as hoarseness. This change in voice can stem from the mucopolysacharydes accumulation in focal folds lamina propria resulting in their oedema, laryngeal muscles oedema and weakness, as well as direct pressure on the larynx by the goiter.

Over the last few years, the vocal changes accompanying many other disorders have become the field of interest for many scientists working with machine learning (ML). ML is an algorithm-centered branch of artificial intelligence. Performing multiple analyses, the algorithms automatically and gradually self-increase their accuracy in predicting data.

**AIM:** The aim of this work was voice analysis in patients with PCOS and HD, as well as their subgroups - PCOS with laboratory hyperandrogenism (PCOS-HA) and HD with overt

hypothyroidism. The analysis of voice samples comprised of evaluating chosen acoustic features in terms of their ability to predict selected endocrinopathies, as well as training four classifiers evaluating the probability of given voice sample's owner belonging to PCOS, PCOS-HA, HD or HD with overt hypothyroidism patient group.

**MATERIALS AND METHODS:** In the part of voice analysis in PCOS, the study group comprised 39 patients with PCOS diagnosed with the Rotterdam criteria. The control group consisted of 56 healthy women. The PCOS-HA subgroup, which was separated from the PCOS group, comprised 17 patients and 49 healthy women as a control group. In the part of voice analysis in HD, the study group comprised 106 patients with HD. 14 of them fulfilled the criteria for overt hypothyroidism. In the control group, identical both for patient groups with HD and HD with overt hypothyroidism, 186 healthy women were included. All participants underwent anthropometric measurements, the oral glucose tolerance test, as well as lipids concentrations and hormonal assessment.

For women with PCOS and PCOS-HA, as well as for those in matched control groups, the hormonal measurements involved the assessment of the sex hormones. For women with HD, HD with overt hypothyroidism and those in matched control groups, the levels of TSH, fT3, fT4, as well as the titer of the antithyroid antibodies were measured. Moreover, the patients belonging to the PCOS and PCOS-HA groups underwent transvaginal ovarian ultrasonography, while women with HD and HD with overt hypothyroidism underwent thyroid gland ultrasonography. All participants provided voice recordings, which included the reading of the standardized text, a short talk with the interviewer and a speech about a discretionary topic. Afterwards, the recording was submitted for analysis by ML.

**RESULTS:** The acoustic analysis revealed the differences between all study groups and their healthy counterparts in terms of several dozen of acoustic features. In PCOS group, the acoustic features *pcm\_fftMag\_mfcc\_sd[16]* and *pcm\_fftMag\_spectralCentroid\_sdd* were associated with the diagnosis of PCOS independently of age, FAI and fasting glucose concentration. The classifier evaluating the probability that the voice analysis of the recorded woman indicates her belongingness to the group of PCOS was distinguished by the balanced accuracy equal to 74.4%, the sensitivity of 57.1% and the specificity of 91.7%. In PCOS-HA subgroup, the acoustic features *pcm\_fftMag\_mfcc\_sd[16]*, *mfcc\_sdd[3]*, *pcm\_fftMag\_spectralRollOff25\_sdd*, *pcm\_fftMag\_spectralRollOff50\_sdd* and *pcm\_fft*

*Mag\_spectralCentroid\_sdd* were associated with the diagnosis of PCOS-HA independently of age, BMI and fasting glucose concentration. The classifier evaluating the probability that the recorded woman belongs to the PCOS-HA group was distinguished by the balanced accuracy equal to 85%, the sensitivity of 100% and the specificity of 70%. In HD group, the acoustic features *pcm\_fftMag\_spectralFlatness\_sd*, *pcm\_fftMag\_melspec\_s[20]*, *pcm\_fftMag\_melspec\_sd [20]* and *pcm\_fftMag\_melspec\_sd [21]* were associated with the diagnosis of HD independently of age, BMI and TSH concentration. The classifier evaluating the probability that the recorded woman belongs to the HD group was distinguished by the balanced accuracy equal to 58.9%, the sensitivity of 42.9% and the specificity of 75%. In the subgroup of HD with overt hypothyroidism, the acoustic features *voiceProb\_s*, *F0\_s*, *pcm\_fftMag\_spectralRoll Off90\_s* and *pcm\_fftMag\_melspec\_sdd [16]* were associated with the diagnosis of HD with hypothyroidism, independently of age, BMI and total cholesterol concentration. The classifier evaluating the probability that the recorded woman belongs to the HD with over hypothyroidism group was distinguished by the balanced accuracy equal to 66.7%, the sensitivity of 66.7% and the specificity of 66.7%.

**CONCLUSIONS:** PCOS and PCOS-HA have an influence on vocal changes, while HD with overt hypothyroidism has a possible influence on the patient's voice. The classifier predicting the probability of the diagnosis of PCOS-HA, basing on the voice analysis, fulfils the criteria of the useful screening test. The classifiers predicting the probability of the diagnosis of PCOS, HD, as well as HD with overt hypothyroidism, basing on the voice analysis, don't fulfil the criteria of the useful screening test in case of the lack of additional information about the recorded patient.