The Relationship Between the Aerodynamic Parameters of Voice and Perceptual Evaluation in the Iranian Population With or Without Voice Disorders

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Summary: Objectives. Aerodynamic evaluations can provide useful information about the interaction between the respiratory and the phonation systems. The present study was conducted to investigate the relationship of maximum phonation time (MPT), vital capacity (VC), and phonation quotient (PQ) with perceptual evaluation in different types of dysphonia. The relationship between these parameters and the type of dysphonia was also examined.

Materials and Methods. The study participants consisted of 300 individuals with different types of dysphonia (104 women and 196 men) and 100 healthy samples (63 women and 37 men). A professional speech-language pathologist conducted the perceptual evaluation based on the G (grade) component of the GRBAS scale, which stands for grade, roughness, breathiness, asthenia, and strain. VC was measured using a spirometer and MPT using a stopwatch. PQ was calculated as the ratio of VC to MPT.

Results. The difference between the mean ± standard deviation of PQ, VC, and MPT were found to be significant at all the four degrees of dysphonia severity ($P < 0.001$). There was a significant difference in mean MPT and VC between the genders ($P < 0.001$), but no significant gender differences were observed in terms of the mean PQ ($P = 0.346$). The study participants were classified into four groups, including the organic dysphonia group, neurologic dysphonia and functional dysphonia groups, and the normal group; the study variables measured were found to be significantly different between all the four groups ($P < 0.001$).

Conclusion. As MPT and PQ were correlated with the perceptual G (grade) and differentiated dysphonic from healthy individuals, clinicians are recommended to take account of them in their instrumental evaluations.

Key Words: Phonation quotient–Vital capacity–Maximum phonation time–Dysphonia–GRBAS.

INTRODUCTION

Phonation or the generation of audible sound energy is caused by muscular and aerodynamic activities that affect the vocal cords. Sufficient airflow during exhalation is a prerequisite for efficient vibration of the vocal cords while producing voice.[1] Laryngeal injuries and physiological imbalance in the subsystems responsible for voice production change aerodynamic flow and pressure.[2] Therefore, it is of special importance to evaluate the aerodynamic status in the study of physiology and pathophysiology of voice production.

Boone et al. divides dysphonia into three general categories: organic, functional, and neurologic dysphonia.[3] The severity of dysphonia is often measured by perceptual judgments and using instrumental measurements. The objective assessment of voice is still a subject of debate in daily clinical practices. The perceptual evaluation of voice is valued by physicians and researchers as a gold standard in recording the severity of voice disorders.[4] The GRBAS scale is currently being widely used in perceptual evaluations and consists of components including grade, roughness, breathiness, asthenia, and strain, which are given a score from 0 to 3 (0: normal, 1: mild hoarseness, 2: moderate hoarseness, and 3: severe hoarseness). This scale has been widely used in the literature as a valid assessment tool.[5–8] G (grade) is the most applicable of all the components of the scale, as it involves the best scoring for the overall severity of dysphonia, whereas the other components reflect only part of the overall severity. G (grade) is therefore taken as the most important index in this scale[9] and is associated with the overall quality of voice and the integration of the other components.[10]

An important aspect of assessing the vocal performance in patients with dysphonia is the manner they use respiration during phonation.[11] The voice assessment tool presented by the European Laryngological Society also incorporates aerodynamic measurements.[12] Although the aerodynamic analysis of voice provides valuable information on the interaction between the respiratory and phonatory mechanisms of the speech system, it is less commonly used in practice in clinical evaluations. Aerodynamic analyses can provide particular details about the physiological context of phonation and show the effort needed for phonation as well as the compensatory behaviors performed by patients with dysphonia.[13–15]

Common aerodynamic evaluations include measuring the lung volume, subglottal air pressure, laryngeal airflow, and laryngeal resistance,[16] as well as maximum phonation time (MPT), vital capacity (VC), and phonation quotient (PQ).[6] As the simplest aerodynamic voice parameter, MPT is expressed in seconds and includes the maximum sound prolongation of a vowel such as /a/ produced on a deep breath at a relatively comfortable pitch and loudness. MPT is a frequently used clinical tool for voice

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evaluation and is also the most common aerodynamic measure for assessing glottal sufficiency.[17] MPT has been used in different studies for voice evaluation,[6] the investigation of glottal sufficiency, differentiation between normal and dysphonic voice,[18] and examining the effects of age and gender.[19] The reliability of MPT was reported as 0.987 with five test-retests.[20] This tool was proved to be hypersensitive to the impact of learning and fatigue. The potential bias can be reduced by measuring the average phonation airflow or PQ.[21] PQ is the ratio of VC to MPT and is expressed in mL/s[22] and is used as a tool for measuring glottal sufficiency, differentiating between damaged and normal voice, and recording treatment results.[18,23,24] VC is the difference in the volume of air in the mouth between the deepest inhalation and a complete exhalation and is measured with a spirometer.[21]

In clinical practices and research, aerodynamic measurement is often taken to refer to MPT,[20,25] PQ,[25,26] the mean flow rate, and the subglottal pressure.[27,28] The selection of aerodynamic parameters is therefore useful for differentiating normal from dysphonic voices. The airflow rate can be measured to help monitor the effects of the treatments when glottal performance is compared before and after surgical interventions or before and after the use of voice therapy techniques.[29] For instance, to compare the effectiveness of a treatment intervention, the average phonation airflow is recommended to be measured before and after the intervention using a single method.[26] MPT is used for externalizing the degree of dysphonia and for determining the effects of voice therapy.[30] To date, many studies have been conducted on aerodynamic parameters; however, the majority of them have examined only certain disorders or limited populations.

In one study, Cantarella et al used logistic regression analysis to show that only 3 of the 12 variables examined are competent for discriminating dysphonic from normal samples. MPT was one of the three confirmed variables. In the mentioned study MPT was found to be a sensitive indicator of dysphonia that can differentiate between pathologic and normal voices.[14] Yu et al conducted a study to determine the clinical value of the multiparametric objective voice evaluation protocol and compared aerodynamic and acoustic parameters through the perceptual analysis of continuous speech. The results showed that a nonlinear combination of six parameters matched the evaluators' perceptual classification by 86% and a high correlation was thus obtained between MPT and perceptual-auditory judgments.[8]

Piccirillo et al used multivariate logistic regression to determine the objective voice parameters used for describing the severity of dysphonia and found that 4 of the 14 study indices can discriminate between normal and dysphonic voice, and MPT was one of the confirmed indices.[31] Wuyts et al conducted a study that led to the development of the dysphonia severity index and found that MPT is an effective parameter for predicting the perceptual severity of dysphonia. They also found in their study that VC and PQ were significantly correlated with the perceptual G (grade); however, MPT was the only parameter that was approved for the final model.[6] MPT is therefore a phonation control marker. MPT, VC, and average phonation airflow are among the aerodynamic parameters of voice assessment that are most convenient in terms of time requirements and cost-effectiveness.

Unfortunately, there are few data demonstrating the aerodynamic results of a wide range of voice disorders in Asian people. Given the ethnic differences, and consequently anatomic and physiological differences between Asian and European or American people, the present study was conducted to explore the relationship of MPT, VC, and PQ with the G (grade) parameter of perceptual GRBAS scale in the Iranian population with or without voice disorders.

MATERIALS AND METHODS

The ethical principles of the Declaration of Helsinki were followed throughout the study. Moreover, the ethics committee of Social Welfare and Rehabilitation Sciences University approved the study protocol. Subjects were completely aware of the study's content and provided consent before participating.

Study participants

The study participants consisted of 300 willing patients with different types of dysphonia (104 women and 196 men) presenting to the Ear, Nose and Throat Clinic of Amiralam Hospital in Tehran, Iran, between November 2014 and June 2015, and a total of 100 healthy samples without dysphonia (63 women and 37 men). The samples without dysphonia had no history of laryngeal injuries or use of larynx damaging substances and did not have a cold or allergies at the time of sampling. None of the subjects had a history of lung disease, and they all gave their full consent for participation in this analytical cross-sectional study and spoke Persian. The subjects were at an age range of 18–65 with a mean ± standard deviation (M ± SD) of 45.3 ± 12.9 in the dysphonic and 40.3 ± 14.1 in the healthy group.

Perceptual voice evaluation

A digital voice recorder, SONY ICD-UX530, was used to record each subject's voice sample through an interview discussing their voice condition. The recorded voice was then presented to a professional speech-language pathologist with more than 15 years of experience in the evaluation and treatment of voice disorders. The G (grade) parameter of the GRBAS scale was scored for each participant based on the total hoarseness in his speech sample. The participants were divided into four groups, including the normal, mild dysphonia, moderate dysphonia, and severe dysphonia groups, based on the perceptual judgments and their G (grade) on the GRBAS scale.

Aerodynamic measures

VC was recorded for each participant using the Fukuda Sangyo St-250 spiroanalyzer. The participants were asked to inhale deeply and then blow into the spirometer as lengthily and strongly as possible. This experiment was repeated three times and the maximum VC was recorded for each participant. To measure the MPT, the participants were asked to pronounce the vowel /a/ and prolong it as long as possible and to repeat this task three times, and the longest MPT was used for analyses. The MPT was then recorded for each participant. The PQ was calculated by dividing the maximum VC by the MPT.