Acoustic Voice Analysis of Young Turkish Speakers

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Summary: Objective/Hypothesis. One of the objective assessments of voice is acoustic analysis, particularly, the parameters fundamental frequency (F_0), jitter, shimmer, and noise-to-harmonics ratio (NHR). Because the normative data for healthy native Turkish male and female speakers are lacking in the literature, this study aimed to obtain F_0, perturbation parameters, and NHR in three sustained vowels (/ʌ/, /i/, and /u/) among young Turkish speaking adults.
Methods. The native Turkish speakers with normal voice aged between 18 and 32 years were included in the study (44 women, 39 men). Voice samples were recorded using *Computerized Speech Lab*, and data were analyzed with the statistics software *SPSS Statistics 21.0* (IBM Corp., Armonk, NY, USA).
Results. The F_0 values of vowels /ʌ/, /i/, and /u/ were greater for women (239.78 Hz, 251.97 Hz, and 250.29 Hz, respectively) than for men (127.11 Hz, 137.23 Hz, and 134.15 Hz, respectively). All shimmer values for all vowels and jitter values for /ʌ/ and /u/ were found significantly low in men; however, no difference was found for jitter values of /i/ between genders. There is no effect of gender on NHR. Only in women, NHR of high vowels was found to be lower than that of vowel /ʌ/.
Conclusions. There is a significant difference for F_0 values between the genders as expected. Comparisons of perturbation values were significantly different for some pairs of vowels. There was no significant difference between NHR values between the genders. These findings can be compared with Turkish speakers who have different voice disorders for the further studies.
Key Words: Normal voice–Acoustic measurements–Fundamental frequency–Jitter–Shimmer–Noise-to-harmonics ratio–Turkish adults.

INTRODUCTION

In the assessment and diagnosis of voice disorders, both subjective and objective measures have been widely used by clinicians and researchers.[1] Acoustic analysis is one of the highly preferred tools for objective assessment of voice. Because it is noninvasive and easily applicable procedure that provides quantitative data on laryngeal function, computerized acoustic voice analysis gained importance in the last few decades. Fundamental frequency (F_0), jitter, shimmer, and noise-to-harmonics ratio (NHR) are the most commonly used acoustic parameters to evaluate vocal function.[2,3] These parameters are derived from the emitted acoustic signals resulting from the laryngeal function and considered to be related to the working mechanisms of the voice production. Although acoustic voice analysis is still not a part of routine examination of voice disorders, a growing number of studies emphasize the role of F_0, jitter, shimmer, and NHR as significant prognostic markers for abnormal patterns of voice function.[4–7]

F_0 is the first harmonic of the voice, that is, the number of cycles generated by vocal folds per second. It is mainly controlled by mass, elasticity, compliance, and the membranous length of vocal folds.[8]

Jitter and shimmer are the perturbation measures, which show short-term cycle-to-cycle variability in fundamental frequency and amplitude, respectively.[9] Normal voice also has some cycle-to-cycle variation in both frequency and amplitude, but excessive variation is a sign of unhealthy vocal function. Studies showed that perturbation measures are effective in discrimination between healthy and pathological voices and also discrimination of pathological voice subtypes.[10,11]

Harmonics-to-noise ratio (HNR) or NHR is a ratio of inharmonic energy in 1500–4500 Hz range to harmonic spectral energy in 70–4500 Hz range, and it is useful for quantifying the amount of noise in the signal.[12] Yumoto et al[13] and Ferrand[14] concluded that the HNR is an appropriate measure in the clinic as a quantitative index of the degree of hoarseness.

As one of the purposes of acoustic voice analysis is to discriminate the pathologic and normal voices, normalization of acoustic voice parameters for a given healthy population is an essential condition for the next step of the clinical usage. Because cultural and linguistic factors influence acoustic characteristics of voice, normative data of acoustic parameters were reported for healthy population of many ethnic groups such as African American and Caucasian standard American English speakers,[15] native Hindi Indian speakers,[15] native Mandarin Chinese speakers,[15] Malaysian Malays,[16] Malaysian Chinese,[17] and Persians.[18]

Turkish has eight vowels. The letters and corresponding sounds of Turkish vowels were summarized in Table 1.[19] There are some controversial issues for Turkish vowels. The formant frequencies of the Turkish vowels were studied, and researchers reported different formant frequencies for some vowels.[20–22] Thus, authors used different International Phonetic Alphabet (IPA) symbols for some vowels. For example, some authors transcribed /ʌ/ and /ɯ/ as /a/ and /ɨ/, respectively.[19] This controversial issue is caused by different methodology of the studies.

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TABLE 1.
Turkish Vowels

Letter	a	e	ı	i	o	ö	u	ü
IPA	ʌ	ɛ	ɯ	i	o	œ	u	y

Abbreviation: IPA, international phonetic alphabet.

The most recently accepted IPA symbols for Turkish vowels were given in Table 1.

There are a few research studies on the acoustic voice analysis of Turkish speakers. Oguz et al[23] compared the acoustic analysis results obtained by two computer programs, *Praat* (Boersma and Weenink, University of Amsterdam, The Netherlands) and *Multi-Dimensional Voice Program* (*MDVP*, KayPENTAX, Lincoln Park, NJ, USA). They used both healthy and pathologic voice samples and analyzed them together. They did not aim to report normalized data. The other study is the research of Kiliç et al[24] trying to find the effects of different sustained vowel contexts on the perturbation parameters in native Turkish speakers. They made the analyses on men and without an aim to form any norm values. For a healthy decision making process in the course of diagnosis and follow-up of voice disorders, normative data are important. While evaluating a speaker's voice, comparisons should be made according to the speaker's age, gender, and culture.[1] Because the normative data for healthy native Turkish male and female speakers are lacking in the literature, this study is the first attempt to obtain F_0, perturbation parameters, and NHR in three sustained vowels among young Turkish speaking adults.

MATERIALS AND METHODS

This research was approved by the Ethics Committee of Anadolu University. The study was explained to all participants, and signed informed consent was obtained from all of them.

Participants

The native Turkish speakers with normal voice aged between 18 and 32 years (mean age, 20 years) were included in the study (44 women, 39 men). All participants were speaking modern standard Turkish language based on Istanbul dialect. The exclusion criteria consisted of the following: (1) smoking; (2) having ear pathology or hearing loss; (3) having upper respiratory tract infection in last 3 weeks; (4) having professional voice training; (5) history of surgery in head and neck region; (6) having neurologic or respiratory disease; (7) having structural pathology of oral cavity, pharynx, or larynx; and (8) having puberphonia or juvenile voice. All subjects having symptom or history of any pathology were examined by otolaryngologist for structural pathology of oral cavity, pharynx, and larynx. Stroboscopic examination was also performed for all these subjects to rule out any organic pathology of the vocal folds. The participants having symptoms of cold, allergy, and reflux at the time of acoustic voice analysis were also excluded. All participants were perceptually assessed with GRBAS scale that consists of 5 parameters: G, overall grade of hoarseness; R, roughness; B, breathiness; A, asthenia; S, strain. Each parameter was rated with a grading scale ranging from 0 to 3 corresponding to a healthy voice and severe deviation, respectively. The participants having any parameter higher than "0" were also excluded from the study.

Procedure and analysis

Voice samples were recorded in the Anadolu University, Department of Speech and Language Therapy, Phoniatry Unit, in a quiet room with a high-quality microphone (Shure SM48; Shure Inc., Niles, IL, USA). The microphone was placed at a 45° angle and 10 cm away from the speaker's mouth. All recordings were sampled at 44.10 kHz sampling rate with 16-bit resolution on *Computerized Speech Lab* model 4500 (KayPENTAX, Lincoln Park, NJ) analysis system and *MDVP* software model 5105, Version 3.1.7. To reduce the computer case noise, case was placed 180° opposite to microphone.

The task was explained and demonstrated to the participants before the recording. Participants were instructed to produce a sustained phonation of the vowels /Λ/, /i/, and /u/ three consecutive times at a comfortable pitch and loudness level each time for a duration of 5 seconds. The voice samples were analyzed with *MDVP*. A mid-3-second segment of each sample was analyzed. The parameters of fundamental frequency, F_0 (Hz), jitter (%), shimmer (%), and NHR (dB) were calculated for each vowel, and the values of three recordings were averaged. Sound pressure levels (SPLs) for each voice sample were also calculated. Minimum, maximum, and mean SPL values for each vowel were calculated.

Statistics

Data were analyzed with the statistics software *SPSS Statistics 21.0* for Windows. Group mean differences between male and female speakers were calculated with independent sample *t* test. Paired sample *t* test was used to compare *F*0, jitter, shimmer, and NHR parameters between the vowels for each gender. The significance level is set at $P < 0.05$ for all statistical analyses.

RESULTS

The mean value of F_0 in men for vowels /Λ/, /i/, and /u/ were 127.11 Hz, 137.23 Hz, and 134.15 Hz, respectively. The

TABLE 2.
Comparison of Acoustic Analysis Data of Vowel /ʌ/ Between Turkish Men and Women

Group	F_0 (Hz)	Jitter (%)	Shimmer (%)	NHR (dB)
Men (n = 39)				
Mean	127.11	0.51	2.56	0.13
SD	16.77	0.20	0.60	0.01
Women (n = 44)				
Mean	239.78	0.90	3.10	0.13
SD	19.11	0.44	1.04	0.02
P value	0.000*	0.000*	0.005*	0.280

*$P < 0.05$ indicated significant difference.
Abbreviation: SD, standard deviation.

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