original article

Acute effects of inhaling Oud incense on voice of Saudi adults

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BACKGROUND AND OBJECTIVE: Like in most of the Arab countries, incense burning, including Oud, is widely used in Saudi Arabia. The widespread effects of the Oud incense on voice have not been examined. Thus, the aim of this study was to examine the short-term effects of Oud incense on laryngeal symptoms and voice acoustics in normal Saudi adults.

DESIGN AND SETTINGS: A prospective study that has been carried out at King Abdulaziz University Hospital between July 2012 and Jan 2014.

MATERIAL AND METHODS: Study subjects were recruited on a volunteer basis. A total of 72 adults (44.4% males and 55.6 % females), were exposed to Oud incense smoke for 5 minutes while sitting 1 m away from an electrical sensor in a closed room. Symptom and acoustic voice analyses were performed pre-exposure and immediately post-exposure.

RESULTS: A total of 27.8% of the subjects reported throat and voice symptoms after 5 minutes of exposure. Some frequency-related acoustic measures increased in male and female subjects after exposure to Oud incense. However, the difference between the pre- and post-exposure measures was not statistically significant.

CONCLUSION: One third of the study subjects reported voice-related symptoms following exposure to Oud incense. Despite the absence of statistical significant difference, some frequency-based acoustic parameters increased following exposure to Oud incense smoke.

In most of the Arab countries, incense burning, including Oud, is widely used by many people. Many substances are used to produce incense including Oud, frankincense, aromatic wood, herbs, flowers, essential oils, and perfumes.[1,2] The most commonly used incense for burning in Saudi Arabia is Oud. The Oud tree is known as the Aquilaria agallocha, which has at least 15 species of Aquilaria and is also known as lignum aloe, agarwood, and eagle wood.[3] The unique aroma, which is produced as a result of fungal infection to the heartwood tree, has been used since ancient times as a source of perfumes and incense in the Middle East.[1,3,4] The perfumes of the agarwood known as Oud are common in Saudi Arabia and the United Arab Emirates. They are not only inhaled but also used in making perfumes in many other countries. Although Oud is the most popular incense burned, it is also mixed with various other natural scents.[1-3,5] All of these including the Oud are mostly burned in traditional charcoal burners.

Many pollutants could be produced in the continuous smoke of incense burning due to the slow and incomplete combustion of this substance especially under poor ventilation.[2,3,5-7] Several illnesses have been reported to be related to incense smoke exposure including respiratory symptoms, asthma, elevated cord blood immunoglobulin E levels, contact dermatitis, and cancer.[1,5,8-15] Also, significant morphological changes in rat pneumocytes have been linked to incense smoke exposure.[2,16]

The smoke of the burning incense includes a complex of mixture that contains both particulate and gas materials to which recipients can be exposed. Emitted materials include: particulate matter, carbon monoxide, oxides of nitrogen, formaldehyde, sulfur dioxide, and

other substances.[3,5,17] Arabian Oud is a natural indoor fragrance, especially in occasions like wedding parties and other ceremonies. It is also used to perfume clothing and home.[3] Because of its wide use, many individuals are exposed to its fumes throughout large parts of the day in Eastern countries and, especially in Saudi Arabia. The produced incense from burning Oud in a humid and poorly ventilated indoor environment tends to persist over long periods.

It is well known that voice production can be affected by irritation from cigarette smoke and passive cigarette smoke,[18,19] causing hoarseness and laryngeal inflammation. Previous findings of the effects of incense smoke on health, especially the respiratory system, raise the possibility of having similar harmful and irritating effects on the larynx and vocal folds. Several studies have investigated the effect of burning incense and its smoke on airway diseases including asthma and other allergic manifestations of the tracheobronchial tree.[2,5,20,21] However, to the best of our knowledge, the effects of Oud incense on voice have not been examined before. Thus, the aim of this study was to examine the short-term effects of Oud incense on laryngeal symptoms and voice acoustics in normal Saudi adults.

MATERIAL AND METHODS

This is a prospective study that has been carried out at the voice clinic, King Abdulaziz University Hospital, King Saud University. The study was approved by the Institutional Review Board of College of Medicine, King Saud University.

Subjects

Study subjects were recruited on a volunteer basis from the otolaryngology clinic attendants and medical students at College of Medicine, King Saud University. All subjects included in the study have signed a consent form explaining the nature of the study and the procedures they will be involved in. Inclusion criteria were male and female Saudi subjects in the age range between 18 and 60 years. Exclusion criteria were any history of voice disorders, asthma, laryngopharyngeal reflux, and cigarette smoking. All subjects in the study completed the reflux symptom index (RSI) before conducting the study, and subjects with RSI scores of more than 13 were excluded.

Oud incense exposure technique

Subjects were exposed to Oud incense smoke, approximately 1 g of average market quality, for 5 minutes while sitting 1 m away from an electrical sensor in a closed room with an approximate surface area of 12 m^2. The same room was used for all participants. All participants were instructed to breathe normally through their nose without phonation. Each subject was exposed to Oud incense individually. The exposure room was kept open for 10 minutes after each subject to ensure evacuation of Oud incense smoke to guard against the accumulation effect of incense in the room. Symptom analysis and acoustic voice analysis were performed pre-exposure and immediately post-exposure.

Voice assessment was done using the Multidimensional Voice Program (MDVP Model 4305, Kay Elemetrics Corp., Lincoln Park, New Jersey) software installed to the Computerized Speech Lab. (CSL, model 4300, Kay Elemetrics Corp.). Symptom analysis after exposure was obtained through direct interview with the participants right after the acoustic assessment.

Statistical analysis

Qualitative variables were presented as frequency and percentage while quantitative variables were expressed as mean and standard deviation. Nonparametric statistics were used to compare the pre-post changes in the mean values. The Wilcoxon test was used to compare between the pre- and post-exposure acoustic variables in the study groups. The SPSS, version 16.0 (SPSS Inc. Chicago, IL USA), was used for all statistical analyses. The level of significance was set at $P \leq .05$.

RESULTS

Demographic data

A total of 72 Saudi subjects (32 males [44.4%] and 40 females [55.6%]) were enrolled in our study. All met the inclusion criteria mentioned earlier. The mean age of the study group was 27.6 years (9.4 SD). **Table 1** shows the demographic data of the study subjects.

Post-exposure symptoms

The majority of subjects (72.2 %) had no after-exposure symptoms (**Table 2**). However, 27.8% of the subjects reported symptoms after 5 minutes of exposure. Nine subjects (22.5%) experienced throat-burning sensation after Oud exposure (all were females). Also, 7 subjects (20%) had throat dryness (4 males and 3 females). Moreover, 3 subjects (7.5%) had both throat dryness and burning sensation (3 females). Only 1 subject (3.1%) complained of throat burning sensation in addition to the shortness of breath (1 male). No other allergic manifestations were reported among the study subjects following exposure to Oud incense.

Table 1. Demographic data of the study group.

Subjects	Number	Mean age (y)	SD (y)	Minimum age (y)	Maximum age (y)
Male	32	27.59	9.22	18.00	54.00
Female	40	27.65	9.67	18.00	58.00
Total	**72**	**27.62**	**9.41**	**18.00**	**58.00**

Table 2. Post-Oud exposure symptom distribution among the study group.

Symptoms	Gender			
	Males		Females	
	Frequency	%	Frequency	%
No symptoms	27	84.4	25	62.5
Throat-burning sensation	–	–	9	22.5
Throat dryness	4	12.5	3	7.5
Throat-burning sensation and dryness	–	–	3	7.5
Throat-burning sensation and shortness of breath	1	3.1	–	–
Total	**32**	**100.0**	**40**	**100.0**

Acoustic analysis

Participants were divided into 2 groups (males and females) to avoid gender-related effects on acoustic analysis. MDVP parameters of the subjects' pre- and post-Oud exposure are presented in **Appendix A**. Measures of frequency variations, including jitter, shimmer, and noise-to-harmonic ratio all increased in both males and females following exposure to Oud incense smoke (**Figures 1 and 2**). In comparing pre-exposure and post-exposure readings of males and females groups, the acoustic analysis did not reveal statistical significant changes of the assessed MDVP variables (*P* values for all the parameters were >.05).

DISCUSSION

This study provides new information regarding potential health risks to the voice from Oud incense commonly found in indoor environments in many Arab countries especially Saudi Arabia. The majority of previous research on the use of inhaled foreign substances deals with medications such as corticosteroids, with cigarette smoke, or with uncontrolled substances such as cannabis. Other research studies have investigated the effect of incense, especially the Arabian incense (Bakhour), on airway and asthma symptoms and showed that Arabian incense is considered a participating factor in asthma symptoms and airway dysfunction.[1,2,8,9] However, they could not propose a specific mechanism by which incense can provoke theses respiratory symptoms.

The present study used incense from Oud, which is the most common incense burned in many Arab countries. The findings of throat burning, throat dryness,

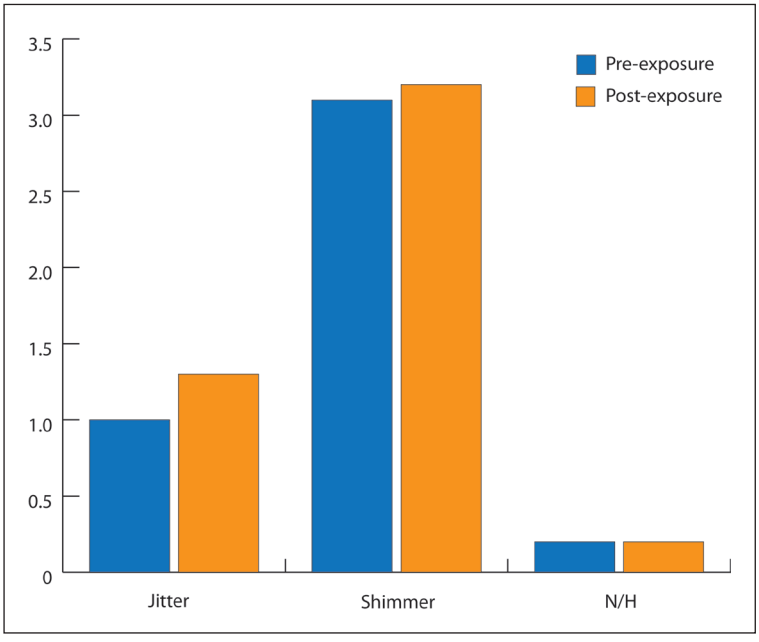

Figure 1. Pre- and post-Oud exposure results of the frequency-related acoustic measures in the female group.

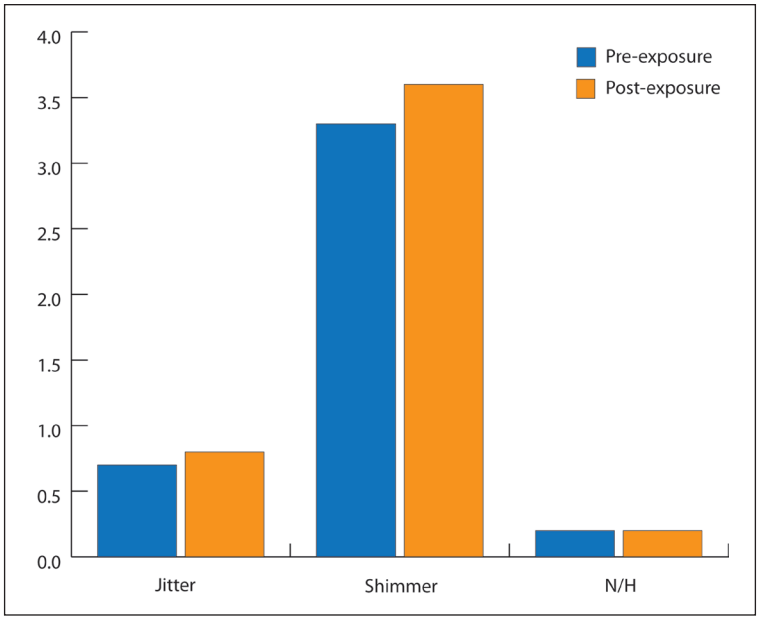

Figure 2. Pre- and post-Oud exposure results of the frequency-related acoustic measures in the male group.

and shortness of breath in 20 out of the 72 subjects (almost one third of the study subjects, 27.8%), suggests that even short-term exposure may have an effect on the voice and airway. These symptoms were directly precipitated by Oud incense smoke because we used electric sensor to avoid any additional effects that can result from charcoal burning. Despite having such symptoms following exposure to Oud incense smoke, it is difficult to propose a mechanism that explains the occurrence of these symptoms because of the different emitted materials in the smoke of the burned Oud incense. It should be kept in mind that the current subjects were subjected to the smoke in a normal-size room for only 5 minutes, and the majority of the subjects were young with a mean age of 27.6 years. Thus, with a longer exposure time and a wider range of age group, a greater effect can be expected.

Although the data obtained from the acoustic analysis did not show significant differences between pre- and post-recordings, several specific measures may be of interest. Measures of frequency variation, jitter, shimmer, and noise-to-harmonic ratio all increased in males and females following exposure to Oud. The data suggests that an increased level of irregularity existed in the voices of subjects participated in this study even after 5 minutes of exposure. Others have shown that increased levels of brain activity are also related to exposure to incense. Iijima et al,[22] found an increased brain activity during exposure to incense. These results suggest that the odor of incense may enhance cortical activities and the function of inhibitory processing of motor response, i.e., increase in loudness or greater variability in voice production.

Although our study may be limited in certain areas such as the small sample size and the absence of a control group, the preliminary results of this study give a potential interest in studying the long-term effects of inhaling Oud incense on voice characteristics. This could have a special consideration in countries where Oud incense inhalation is considered one of the most common traditional behaviors that is practiced almost on a daily basis. The effect of Oud incense smoke on human voice and the mechanism behind it need to be further studied. Controlled studies with more documentation of long-term exposure to Oud incense may be required.

In conclusion, one third of the study subjects reported voice-related symptoms following exposure to Oud incense. There appears a potential effect of Oud incense on some acoustic derivative of voice, especially the frequency-based parameters. However, the difference between the pre- and post-exposure results did not reach a statistical significant level. The data obtained from this study provide a basis for further research in studying the effect of Oud incense exposure on voice characteristics.

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Appendix A. Acoustic analysis pre- and post-Oud exposure in male and female subjects. Pre- and post-Oud exposure MDVP variables of male subjects.

MDVP variables	Males				
	Mean	Standard deviation	Minimum	Maximum	*P* value
Fo_pre	128.001	20.001	103.406	181.563	.911
Fo_post	127.513	20.355	102.917	183.920	
Mfo_pre	127.994	19.987	103.327	181.516	.537
Mfo_post	124.936	22.452	76.753	183.901	
To__pre	7.986	1.137	5.514	9.678	.601
To_post	8.024	1.168	5.438	9.720	
Fhi_pre	132.403	23.915	75.487	193.915	.751
Fhi_post	132.446	21.286	105.467	191.139	
Flo_pre	121.702	20.064	70.905	169.551	.513
Flo_post	121.236	21.334	74.812	177.045	
STD_pre	1.348	0.541	0.513	2.920	.837
STD_post	1.369	0.437	0.614	2.380	
PFR_pre	2.521	1.256	1.333	7.000	.781
PFR_post	2.396	0.740	1.000	4.333	
Fftr_pre	4.153	1.281	2.107	7.283	.708
Fftr_post	4.319	1.489	2.328	7.058	
Fatr_pre	3.300	1.604	0.000	6.631	.638
Fatr_post	3.641	1.685	0.000	6.878	
Tsam_pre	2.936	0.452	1.645	3.750	.224
Tsam_post	2.874	0.462	2.013	3.626	
Jita_pre	59.478	36.560	16.578	207.434	.477
Jita_post	63.794	37.297	21.164	166.565	
Jitt_pre	0.742	0.432	0.222	2.143	.304
Jitt_post	0.795	0.411	0.287	1.756	
RAP_pre	0.448	0.275	0.124	1.292	.513
RAP_post	0.469	0.249	0.167	1.043	
PPQ_pre	0.440	0.263	0.129	1.280	.304
PPQ_post	0.482	0.250	0.165	1.074	
sPPQ_pre	0.672	0.256	0.322	1.538	.955
sPPQ_post	0.672	0.222	0.350	1.196	
vFo_pre	1.058	0.404	0.451	2.689	.667
vFo_post	1.092	0.359	0.515	2.000	
ShdB_pre	0.293	0.103	0.148	0.616	.150
ShdB_post	0.312	0.125	0.117	0.631	

Shim_pre	3.347	1.167	1.704	7.025	.270
Shim_post	3.540	1.437	1.343	7.002	
APQ_pre	2.541	0.828	1.257	5.158	.822
APQ_post	2.594	0.971	0.999	4.988	
sAPQ_pre	4.340	1.570	2.040	9.667	.513
sAPQ_post	4.179	1.152	1.689	6.977	
vAm_pre	10.090	2.592	6.767	17.582	.501
vAm_post	9.688	2.478	5.429	13.937	
NHR_pre	0.134	0.019	0.114	0.219	.390
NHR_post	0.138	0.022	0.089	0.173	
VTI_pre	0.045	0.013	0.022	0.071	.355
VTI_post	0.043	0.012	0.023	0.068	
SPI_pre	15.348	6.612	3.435	30.897	.751
SPI_post	14.786	6.124	3.841	28.549	
FTRI_pre	0.311	0.150	0.100	0.920	.543
FTRI_post	0.330	0.137	0.112	0.759	
ATRI_pre	3.411	2.126	0.000	9.364	.681
ATRI_post	3.317	1.789	0.000	7.237	
DVB_pre	0.000	0.000	0.000	0.000	1.000
DVB_post	0.000	0.000	0.000	0.000	
DSH_pre	0.010	0.055	0.000	0.309	.180
DSH_post	0.088	0.346	0.000	1.499	
DUV_pre	0.649	2.386	0.000	10.463	.139
DUV_post	0.779	1.990	0.000	10.070	
NVB_pre	0.000	0.000	0.000	0.000	1.000
NVB_post	0.000	0.000	0.000	0.000	
NSH_pre	0.021	0.082	0.000	0.333	.285
NSH_post	0.094	0.371	0.000	1.667	
NUV_pre	0.594	2.047	0.000	8.667	.324
NUV_post	0.698	1.578	0.000	7.000	
SEG_pre	97.229	15.076	54.333	124.000	.364
SEG_post	95.552	15.374	66.333	120.333	
PER_pre	370.854	93.964	221.333	657.333	.394
PER_post	364.771	96.732	205.000	646.000	

APQ, Amplitude perturbation quotient (%); ATRI, amplitude tremor intensity index (%); DSH, degree of sub-harmonic components (%); DUV, degree of voiceless (%); DVB, degree of voice breaks (%); Aftr, amplitude-tremor Frequency (Hz); Fftr, Fo-tremor frequency (Hz); Fhi, highest fundamental frequency (Hz); Flo, lowest fundamental frequency (Hz); Fo, average fundamental frequency (Hz); FTRI, frequency tremor intensity index (%); Jita, absolute jitter (μsec); Jitt, jitter percent (%); NHR, noise-to-harmonic ratio; NSH, number of sub-harmonic segments; NUV, number of unvoiced segments; NVB, number of voice breaks; PER, number of pitch periods; PFR, phonatory fundamental frequency range (semi-tones); PPQ, pitch period perturbation quotient (%); RAP, relative average perturbation (%); sAPQ, smoothed amplitude perturbation quotient (%); SEG, total number of segments; ShdB, shimmer in dB (dB); Shim, shimmer percent (%); SPI, soft phonation index; sPQ, smoothed pitch period perturbation quotient (%); STD, standard deviation of the fundamental frequency (Hz); To, average pitch period (msec); Tsam, length of analyzed voice data sample (sec); vAm, coefficient of amplitude variation (%); vFo, coefficient of fundamental frequency variation (%); VTI, voice turbulence index.

Appendix A (cont). Pre- and post-Oud exposure MDVP variables of female subjects.

MDVP variables	Females				
	Mean	Standard deviation	Minimum	Maximum	*P* value
F0_pre	221.606	31.544	144.862	288.773	.610
Fo_post	222.571	30.758	149.523	277.723	
Mfo_pre	221.573	31.555	144.827	288.732	.968
Mfo_post	218.818	34.839	138.579	277.673	
To__pre	4.619	0.759	3.465	6.905	.502
To_post	4.588	0.707	3.602	6.690	
Fhi_pre	227.895	31.508	155.015	299.043	.600
Fhi_post	227.142	37.186	113.635	292.024	
Flo_pre	209.259	33.974	136.606	280.067	.510
Flo_post	213.569	31.879	136.865	267.455	
STD_pre	2.480	0.771	1.071	4.461	.904
STD_post	2.513	0.922	1.185	5.406	
PFR_pre	2.492	1.027	1.000	6.667	.836
PFR_post	2.500	0.981	1.000	6.667	
Fftr_pre	3.729	1.568	0.000	7.143	.606
Fftr_post	515.769	3236.515	0.000	20473.546	
Fatr_pre	2.581	1.990	0.000	6.136	.883
Fatr_post	2.464	1.688	0.000	5.082	
Tsam_pre	3.101	0.247	2.225	3.816	.558
Tsam_post	3.106	0.242	2.341	3.741	
Jita_pre	48.233	31.714	11.218	134.530	.798
Jita_post	47.249	31.940	13.313	152.118	
Jitt_pre	0.996	0.546	0.309	2.536	.224
Jitt_post	1.342	1.494	0.332	8.692	
RAP_pre	0.606	0.337	0.189	1.591	.737
RAP_post	0.607	0.303	0.195	1.434	
PPQ_pre	0.571	0.310	0.173	1.348	.155
PPQ_post	4.031	21.700	0.190	137.830	
sPPQ_pre	0.688	0.325	0.272	1.539	.667
sPPQ_post	0.696	0.305	0.294	1.693	
vFo_pre	1.159	0.474	0.550	2.795	.687
vFo_post	6.570	34.145	0.556	217.102	
ShdB_pre	0.287	0.138	0.130	0.838	.920
ShdB_post	0.281	0.108	0.113	0.750	
Shim_pre	3.153	1.593	1.480	9.686	.610
Shim_post	3.239	1.274	1.303	8.686	

APQ_pre	2.261	1.036	1.008	6.501	.882
APQ_post	2.225	0.835	0.946	5.781	
sAPQ_pre	3.669	1.280	1.481	7.331	.216
sAPQ_post	3.486	1.118	1.750	6.926	
vAm_pre	12.165	4.074	5.865	24.631	.757
vAm_post	11.985	3.990	5.272	20.126	
NHR_pre	0.118	0.015	0.078	0.154	.645
NHR_post	0.119	0.012	0.094	0.151	
VTI_pre	0.049	0.016	0.025	0.115	.615
VTI_post	0.047	0.012	0.024	0.079	
SPI_pre	10.297	6.182	2.748	29.969	.519
SPI_post	10.086	5.853	3.062	27.801	
FTRI_pre	0.268	0.183	0.040	1.045	.528
FTRI_post	0.259	0.146	0.032	0.795	
ATRI_pre	3.131	2.927	0.000	10.768	.806
ATRI_post	2.867	2.603	0.000	10.955	
DVB_pre	0.000	0.000	0.000	0.000	1.000
DVB_post	0.000	0.000	0.000	0.000	
DSH_pre	0.846	2.281	0.000	12.656	.820
DSH_post	0.855	2.231	0.000	12.072	
DUV_pre	0.101	0.315	0.000	1.229	.138
DUV_post	0.018	0.079	0.000	0.397	
NVB_pre	0.000	0.000	0.000	0.000	1.000
NVB_post	0.000	0.000	0.000	0.000	
NSH_pre	0.775	2.190	0.000	13.000	.972
NSH_post	0.775	1.809	0.000	8.000	
NUV_pre	0.250	0.989	0.000	6.000	.088
NUV_post	0.025	0.089	0.000	0.333	
SEG_pre	101.442	9.148	67.000	119.000	.338
SEG_post	103.000	8.041	77.667	124.000	
PER_pre	679.250	98.843	475.333	861.667	.265
PER_post	687.967	103.495	462.333	890.667	

APQ, Amplitude perturbation quotient (%); ATRI, amplitude tremor intensity index (%); DSH, degree of sub-harmonic components (%); DUV, degree of voiceless (%); DVB, degree of voice breaks (%); Aftr, amplitude-tremor frequency (Hz); Fftr, Fo-tremor frequency (Hz); Fhi, highest fundamental frequency (Hz); Flo, lowest fundamental frequency (Hz); Fo, average fundamental frequency (Hz); FTRI, frequency tremor intensity index (%); Jita, absolute jitter (usec); Jitt, jitter percent (%); NHR, noise-to-harmonic ratio, NSH, number of sub-harmonic segments, NUV, number of unvoiced segments, NVB, number of voice breaks, PER, number of pitch periods, PFR, phonatory fundamental frequency range (semitones); PPQ, pitch period perturbation quotient (%); RAP, relative average perturbation (%); sAPQ, smoothed amplitude perturbation quotient (%); SEG, total number of segments, ShdB, shimmer in dB (dB); Shim, shimmer percent (%); SPI, soft phonation index, sPQ, Smoothed pitch period perturbation quotient (%); STD, standard deviation of the fundamental frequency (Hz); To, average pitch period (msec); Tsam, length of analyzed voice data sample (sec); vAm, coefficient of amplitude variation (%); vFo, coefficient of fundamental frequency variation (%); VTI, voice turbulence index.