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.³,¹,⁴ 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. 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. 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, 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. 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 m². 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 \( P \leq 0.05 \).

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.
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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                                         | Males | | % | | Females | | % |
|--------------------------------------------------|-------|---|---|---|---------|---|---|
| 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. However, they could not propose a specific mechanism by which incense can provoke these 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, and...
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 | Mean | Standard deviation | Minimum | Maximum | P value |
|----------------|------|--------------------|---------|---------|---------|
| Fc_pre         | 128.001 | 20.001              | 103.406 | 181.563 | .911    |
| Fc_post        | 127.513 | 20.355              | 102.917 | 183.920 | .537    |
| Mfo_pre        | 127.994 | 19.987              | 103.327 | 181.516 | .601    |
| Mfo_post       | 124.936 | 22.452              | 76.753  | 183.901 | .751    |
| To_pre         | 7.986   | 1.137               | 5.514   | 9.678   | .837    |
| To_post        | 8.024   | 1.168               | 5.438   | 9.720   | .781    |
| Fhi_pre        | 132.403 | 23.915              | 75.487  | 193.915 | .708    |
| Fhi_post       | 132.446 | 21.286              | 105.467 | 191.139 | .638    |
| Flo_pre        | 121.702 | 20.646              | 70.805  | 169.551 |        |
| Flo_post       | 121.236 | 21.334              | 74.812  | 177.045 | .224    |
| STD_pre        | 1.348   | 0.541               | 0.513   | 2.920   |         |
| STD_post       | 1.389   | 0.437               | 0.614   | 2.380   |         |
| PFR_pre        | 2.521   | 1.256               | 1.333   | 7.000   |         |
| PFR_post       | 2.396   | 0.740               | 1.000   | 4.333   |         |
| Ffr_pre        | 4.153   | 1.281               | 2.107   | 7.283   |         |
| Ffr_post       | 4.319   | 1.489               | 2.328   | 7.058   |         |
| Fatr_pre       | 3.300   | 1.604               | 0.000   | 6.631   |         |
| Fatr_post      | 3.641   | 1.685               | 0.000   | 6.478   |         |
| Tsam_pre       | 2.936   | 0.452               | 1.645   | 3.750   |         |
| 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   | .955    |
| sPPQ_pre       | 0.672   | 0.256               | 0.322   | 1.538   | .667    |
| sPPQ_post      | 0.672   | 0.222               | 0.350   | 1.196   |         |
| vFo_pre        | 1.058   | 0.404               | 0.451   | 2.689   | .150    |
| vFo_post       | 1.092   | 0.359               | 0.515   | 2.000   |         |
| ShdB_pre       | 0.293   | 0.103               | 0.148   | 0.616   |         |
| ShdB_post      | 0.312   | 0.125               | 0.117   | 0.631   |         |
| Measure   | Shim_pre | Shim_post | APQ_pre | APQ_post | sAPQ_pre | sAPQ_post | vAm_pre | vAm_post | NHR_pre | NHR_post | VTI_pre | VTI_post | SPI_pre | SPI_post | FTRI_pre | FTRI_post | ATRI_pre | ATRI_post | DVB_pre | DVB_post | DSH_pre | DSH_post | DUV_pre | DUV_post | NVB_pre | NVB_post | NSH_pre | NSH_post | NUV_pre | NUV_post | SEG_pre | SEG_post | PER_pre | PER_post |
|-----------|----------|-----------|---------|----------|----------|-----------|--------|---------|--------|---------|--------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Pre       | 3.347    | 3.540     | 2.541   | 2.594    | 4.340    | 4.179     | 10.090 | 9.688   | 0.134  | 0.138   | 0.045  | 0.043   | 15.348 | 14.786  | 0.311   | 0.330   | 3.411   | 3.317   | 0.000  | 0.000   | 0.010  | 0.088   | 0.649   | 0.779   | 0.000  | 0.000   | 0.021  | 0.094   | 0.594   | 0.698   | 97.229 | 95.552  | 370.854 | 364.771 |
| Post      | 1.167    | 1.437     | 0.828   | 0.971    | 1.570    | 1.152     | 2.592  | 2.478   | 0.019  | 0.022   | 0.013  | 0.012   | 6.612  | 6.124   | 0.150   | 0.137   | 2.126   | 1.789   | 0.000  | 0.000   | 0.055  | 0.346   | 2.386   | 1.990   | 0.000  | 0.000   | 0.082  | 0.371   | 2.047   | 1.578   | 15.076 | 15.374  | 93.964  | 96.732  |
|           |          |           |         |          |          |           |        |         |        |         |        |         |        |        |        |        |        |        |        |        |         |        |        |         |         |        |        |        |         |        |        |        |        |        |        |        |
|           | 1.704    | 1.343     | 1.257   | 0.999    | 2.040    | 1.689     | 6.767  | 5.429   | 0.114  | 0.089   | 0.022  | 0.023   | 3.435  | 3.841   | 0.100   | 0.112   | 0.000   | 0.000   | 0.000  | 0.000   | 0.309  | 1.499   | 10.463  | 10.070  | 0.000  | 0.000   | 0.333  | 1.667   | 8.667   | 7.000   | 54.333 | 66.333  | 221.333 | 205.000 | 657.333 | 646.000 |
|           | 7.025    | 7.002     | 5.158   | 4.988    | 9.667    | 6.977     | 17.582 | 13.937  | 0.219  | 0.173   | 0.071  | 0.068   | 30.897 | 28.549  | 0.920   | 0.759   | 9.364   | 7.237   | 0.000  | 0.000   | 0.180  | 0.543   | 0.681   | 0.139   | 0.000  | 1.000   | 0.285  | 0.324   | 0.364   | 0.394   |        |        |        |        |        |
|           | .270     | .822      | .513    | .501     | .390     | .355      |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
|           |          |           |         |          |          |           |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |

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); Ffr, Fo-tremor frequency (Hz); Fi, highest fundamental frequency (Hz); Flf, lowest fundamental frequency (Hz); Fe, 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 (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); Ts, 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.
Pre- and post-Oud exposure MDVP variables of female subjects.

| MDVP variables | Mean | Standard deviation | Females | Minimum | Maximum | P value |
|----------------|------|--------------------|---------|---------|---------|---------|
| FD_pre         | 221.806 | 31.544            | 144.862 | 288.773 | .610    |
| FD_post        | 222.571 | 30.758            | 149.523 | 277.723 | .968    |
| MFD_pre        | 221.573 | 31.555            | 144.827 | 288.732 | .968    |
| MFD_post       | 218.818 | 34.839            | 138.579 | 277.673 | .968    |
| T0_pre         | 4.619   | 0.759             | 3.465   | 6.905   | .502    |
| T0_post        | 4.598   | 0.707             | 3.602   | 6.690   | .502    |
| Fhi_pre        | 227.895 | 31.508            | 155.015 | 289.043 | .600    |
| Fhi_post       | 227.142 | 37.186            | 113.635 | 292.024 | .600    |
| Fio_pre        | 209.259 | 33.974            | 136.606 | 280.067 | .600    |
| Fio_post       | 213.569 | 31.879            | 136.855 | 267.455 | .600    |
| STD_pre        | 2.480   | 0.771             | 1.071   | 4.461   | .904    |
| STD_post       | 2.513   | 0.922             | 1.185   | 5.406   | .836    |
| PFR_pre        | 2.492   | 1.027             | 1.000   | 6.667   | .836    |
| PFR_post       | 2.500   | 0.981             | 1.000   | 6.667   | .836    |
| Ftr_pre        | 3.729   | 1.568             | 0.000   | 7.143   | .806    |
| Ftr_post       | 515.769 | 3236.515          | 0.000   | 20473.546 | .600    |
| Fatr_pre       | 2.581   | 1.990             | 0.000   | 6.136   | .883    |
| Fatr_post      | 2.484   | 1.688             | 0.000   | 5.082   | .883    |
| Tsam_pre       | 3.106   | 0.247             | 2.341   | 3.741   | .558    |
| Tsam_post      | 3.106   | 0.247             | 2.341   | 3.741   | .558    |
| Jita_pre       | 48.233  | 31.714            | 11.218  | 134.530 | .798    |
| Jita_post      | 47.249  | 31.940            | 13.313  | 152.118 | .798    |
| Jitt_pre       | 0.996   | 0.546             | 0.309   | 2.536   | .224    |
| Jitt_post      | 1.342   | 1.494             | 0.332   | 8.692   | .224    |
| RAP_pre        | 0.606   | 0.337             | 0.189   | 1.591   | .737    |
| RAP_post       | 0.607   | 0.303             | 0.195   | 1.434   | .737    |
| PPQ_pre        | 0.571   | 0.310             | 0.173   | 1.348   | .155    |
| PPQ_post       | 4.031   | 21.700            | 0.190   | 137.830 | .155    |
| sPPQ_pre       | 0.688   | 0.325             | 0.272   | 1.539   | .667    |
| sPPQ_post      | 0.696   | 0.305             | 0.294   | 1.693   | .667    |
| vFo_pre        | 1.159   | 0.474             | 0.550   | 2.795   | .687    |
| vFo_post       | 6.570   | 34.145            | 0.556   | 217.102 | .687    |
| ShdB_pre       | 0.287   | 0.138             | 0.130   | 0.838   | .920    |
| ShdB_post      | 0.281   | 0.108             | 0.113   | 0.750   | .920    |
| Shim_pre       | 3.153   | 1.593             | 1.480   | 9.686   | .610    |
| Shim_post      | 3.239   | 1.274             | 1.303   | 8.686   | .610    |
|        | APQ_pre | APQ_post | sAPQ_pre | sAPQ_post | vAm_pre | vAm_post | NHR_pre | NHR_post | VTI_pre | VTI_post | SPI_pre | SPI_post | FTRI_pre | FTRI_post | ATRI_pre | ATRI_post | DVB_pre | DVB_post | DSH_pre | DSH_post | DUV_pre | DUV_post | NVB_pre | NVB_post | NSH_pre | NSH_post | NUV_pre | NUV_post | SEG_pre | SEG_post | PER_pre | PER_post |
|--------|---------|----------|----------|-----------|----------|----------|---------|----------|---------|----------|--------|----------|---------|-----------|---------|-----------|---------|----------|--------|----------|---------|----------|---------|----------|---------|----------|---------|----------|---------|----------|---------|----------|---------|----------|
|       | 2.261   | 2.225    | 3.669    | 3.486     | 12.165   | 11.985   | 0.118   | 0.119    | 0.049   | 0.047    | 10.297 | 10.086   | 0.268   | 0.259     | 3.131   | 2.867     | 0.000   | 0.000    | 0.846   | 0.855     | 0.101   | 0.018    | 0.000   | 0.000    | 0.775   | 0.775    | 0.250   | 0.025    | 101.442 | 103.000   | 679.250 | 867.967   | 103.495 | 643.333   | 462.333 | 890.667   |
|        | 1.036   | 0.835    | 1.280    | 1.118     | 4.074    | 3.990    | 0.015   | 0.012    | 0.016   | 0.012    | 6.182  | 5.853    | 0.183   | 0.146     | 2.927   | 2.603     | 0.000   | 0.000    | 2.281   | 2.231     | 0.315   | 0.079    | 0.000   | 0.000    | 2.190   | 1.809    | 0.989   | 0.089    | 9.148   | 8.041     | 98.843  | 92.966    | 475.333 | 881.667   | 462.333 | 890.667   |
|        | 1.008   | 0.946    | 1.481    | 1.750     | 5.865    | 5.272    | 0.078   | 0.094    | 0.025   | 0.024    | 2.748  | 3.062    | 0.040   | 0.032     | 0.000   | 0.000     | 0.000   | 0.000    | 0.000   | 0.000     | 0.000   | 0.000    | 0.000   | 0.000    | 0.000   | 0.000    | 0.000   | 0.000    | 0.000   | 0.000    | 0.000   | 0.000    | 0.000   | 0.000    | 0.000   | 0.000    |
|        | 6.501   | 5.781    | 7.331    | 6.926     | 24.631   | 20.126   | 0.154   | 0.151    | 0.115   | 0.079    | 29.969 | 27.801   | 1.045   | 0.795     | 10.768  | 10.955    | 10.000  | 12.072    | 12.656  | 1.229     | 1.397   | 0.972     | 6.000   | 0.333    | 119.000 | 119.000   | 861.667 | 861.667   | 462.333 | 890.667   | 462.333 | 890.667   |
|        | .882    | .216     | .216     | .645      | .757     | .615     | .519    | .615     | .528    | .806     | .519   | .519     | .528    | .806      | .806    | .806      | 1.000   | .820      | .820    | .138      | .972    | .972      | .972    | .972      | .972    | .972      | .972    | .972      |

APQ, Amplitude perturbation quotient (%); ATRI, amplitude tremor intensity index (%); DSH, degree of sub-harmonic components (%); DVB, degree of voice breaks (%); Aft, amplitude tremor frequency (Hz); Ftfr, Fo-tremor frequency (Hz); Fh, highest fundamental frequency (Hz); Fh, lowest fundamental frequency (Hz); Fa, 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, 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, Shin, 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); Tsa, length of analyzed voice data sample (sec); vAm, coefficient of amplitude variation (%); vFo, coefficient of fundamental frequency variation (%); VTI, voice turbulence index.