

# Is the Voice of Professional Voice Users With no Vocal Cord Lesions Similar to That of Non Professional Voice Users?

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**Summary: Objective.** The objective of this study was to analyze if the voice of professional voice users (PVU) is comparable with that of a nonprofessional voice users (NPVUs), both of whom have no obvious vocal cord lesions.

**Materials and Methods.** Fifty professional and 50 NPVUs with no obvious vocal fold pathologies underwent voice analysis and videostroboscopic study, and various parameters were analyzed.

**Results.** Majority of the participants were found to be less than 40 years. Teachers formed the largest group (40%) of PVUs. PVUs had a significantly higher incidence of voice-related complaints compared with NPVUs. The former group also showed a higher deviation from the normative data. A significant influence of gender and the duration of work experience was also observed among PVUs.

**Conclusions.** The voice of an apparently normal PVU is not similar to that of an apparently normal NPVU. Female PVUs and PVUs with a longer duration of work experience show the highest deviation from normative data.

**Key Words:** Professional voice user–Fundamental frequency–Jitter–Videostroboscopy–Gender.

## INTRODUCTION

A professional voice user (PVU) is defined as an individual whose profession, either wholly or partially, depends on the use of voice.<sup>1</sup> For such an individual, the consistent quality and endurance of his or her voice is paramount. As these individuals are perpetually exposed to increased phonotrauma,<sup>2</sup> inefficient voice use, and heavy vocal loading, a higher prevalence of vocal fold lesions has been reported in PVUs than that observed in the general population.<sup>3</sup> It is an established fact that the presence of vocal fold lesions in any individual worsens the voice quality.<sup>4</sup> Therefore, PVUs with vocal fold lesions have a better voice quality after medical or surgical treatment of these lesions. However, it is currently unknown whether “normal” vocal fold in PVUs ensures having a voice quality comparable with that of the general population.

A literature review revealed that most of the studies analyzing the voice quality of PVUs have included those who showed structural changes of the vocal folds. The present study was conducted to investigate the voice quality of PVUs with normal vocal folds in comparison with the general population.

## AIM

The objective of the present study was to compare the voice of PVUs with that of nonprofessional voice users (NPVUs), both of whom have no obvious vocal fold pathology by using voice analysis (VA) and videostroboscopy (VSB).

## MATERIALS AND METHODS

This was a case control study conducted between March 2013 and March 2014. A total of 100 subjects (50 PVUs and 50 NPVUs) were selected as per selection criteria. NPVUs were considered as the control group. The inclusion of a comparison group was essential to form a normative contrast for the PVUs in the same relative geographic area. Without the control group, it was difficult to determine the significance of the results obtained in PVUs.

### Participant selection

Information brochures and posters were displayed in the Department of Otolaryngology outpatient center. Some participants (both PVUs and NPVUs) who attended the outpatient center were a part of a routine health checkup program organized by their respective employers and insurance companies. Other participants volunteered for the study while they were accompanying a patient to the hospital. Some of the participants were encouraged to take part in the study by their friends or relatives who had information regarding the study.

After procuring the institutional review board’s approval, subjects were selected. For the purpose of the present study, normal vocal folds were defined as an absence of obvious vocal fold lesions, which included any finding altering the normal appearance of the folds. These lesions mainly included polyps, nodules, scar tissue, vocal fold edema, sulcus vocalis, and acid reflux changes.

Participants less than 18 years of age were excluded from the study. In addition, conditions that precluded performing laryngoscopic examination comfortably (eg, stridor, markedly decreased mouth opening, excessive gag reflex, and temporomandibular joint abnormalities), conditions that precluded the ability to produce voice or caused changes in the voice not related to phonotrauma or heavy vocal loading (eg, smoker’s cough, presence of tracheotomy tube, nasopharyngeal or oral mass, postlaryngeal trauma, and postlaryngectomy patients), medical conditions affecting voice production or the quality of voice (eg,

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**TABLE 1.**  
**Demographic Details**

Variables	PVU, n (%)	NPVU, n (%)	P Value
Age			
Less than or equal to 40 y	41 (82.00)	37 (74.00)	0.4695
More than 40 y	09 (18.00)	13 (26.00)	
Gender			
Male	16 (32.00)	19 (38.00)	0.6753
Female	34 (68.00)	31 (62.00)	
History of smoking			
Yes	05 (10.00)	03 (06.00)	0.7150
No	45 (90.00)	47 (94.00)	
History of alcohol intake			
Yes	02 (04.00)	06 (12.00)	0.2687
No	48 (96.00)	44 (88.00)	

Levels of significance: \* $P < 0.05$  and \*\* $P < 0.001$ .

Abbreviations: NPVU, nonprofessional voice user; PVU, professional voice user.

neurologic diseases; endocrine diseases; psychiatric disturbances; asthma; and speech, language, and hearing problems) and infectious or allergic conditions affecting voice quality or its production (eg, infectious laryngitis, nasal allergy, sinusitis, pharyngitis, and tonsillitis) in the past 1 month were excluded. Participants (both PVUs and NPVUs) who attended the outpatient center for any voice-related complaints were also excluded because normal participants were apparently needed for the study. None of the participants had any voice-related complaints on the day of assessment.

A total of 100 participants were part of the study with 50 PVUs and 50 NPVUs each. The male-to-female ratio was 0.53:1.0. Majority of the participants were found to be less than 40 years in both PVUs and NPVUs. The minimum age in the first group was 22 years and the minimum age in the latter group was 24 years. The maximum age in PVUs group was 47 years and the maximum age in the NPVU group was 51 years. The mean age in the PVU group was  $33.3 \pm 7.882$  years and the mean age in the NPVU group was  $33.58 \pm 8.394$  years. Statistically, based on the demographic details, both groups were found to be comparable. The rest of the demographic details are tabulated in Table 1.

### Participant assessment

To maintain uniformity in the data collection, all participants were instructed to undergo assessment before reporting to their respective workplaces. The day of assessment was fixed as the day following a typical voice use day for each individual. If a participant reported disproportionately less or more voice use during the previous day, he or she was instructed to report for assessment after a gap of at least 3 days. After obtaining a written informed consent from the participant, an exhaustive history regarding the profession, formal training in usage of the singing or speaking voice, and the duration of professional experience in their respective professions (in years) were collected. History of tobacco smoking, alcohol consumption, and drug use were also collected. The participants were asked to elaborate on their voice-related complaints in the past 1 month. The four different voice complaints, namely, throat irritation, hoarseness, voice

fatigue, and pain in the throat during or after voice use, were included in the history. If participants had any of the previously mentioned complaints for most part of the day on at least 3 days a week in any of the preceding 1 month, the complaint was recorded as a positive voice history. All participants were blinded regarding the purpose of the assessment so as to avoid bias created due to exaggeration of the complaints. The participants were asked to preserve a voice use diary for 4 weeks starting from the day of assessment to record the duration of use of voice per day at their place of work. The recordings of the diary (ie, hours of voice use at the workplace each day) were collected telephonically after 4 weeks. A general physical examination including head and neck examinations was done to rule out any underlying illness, if any. An indirect mirror laryngoscopy was utilized to perform a preliminary laryngeal examination to record the absence of any obvious vocal fold pathologies. To maintain consistency and to reduce interobserver bias, only one otolaryngologist was delegated for the collection of all the relevant history and for performing physical examinations. Both tests, VA and VSB, were performed on the same day. The tests were nonrandomly orderless to avoid bias due to specific order.

### Voice analysis

VA was mainly done to assess the quality of voice of the PVUs and to compare it with that of the control group (NPVUs).

### Procedure and instrumentation

*Dr. Speech* commercial software (Tiger Electronics Inc., Seattle, WA) was utilized to assess the acoustic parameters of voice. Each participant was given detailed instructions before the start of the assessment. A sampling frequency of 44,100 Hz was selected. A sound-protected room with a noise level less than 40-dB sound pressure level was utilized for sample collection. A microphone (ECM-717 Electret Condenser Microphone; Sony Corporation, Minato, Tokyo, Japan) mounted on a stand at an angle of approximately  $45^\circ$  and at a distance of 10 cm from the mouth of the participant was placed. The participant was instructed to say a sustained vowel (/a/) for at least 10 seconds at

a comfortable pitch and in a habitual way. The new wav files recorded were stored under a 16-bit resolution. A mid-5-second segment of each sample was chosen for analysis. Three readings were obtained, and the average of these three readings was taken as the final reading. The Real Analysis program of *Dr. Speech* software was utilized for calculation. The parameters analyzed included the mean fundamental frequency ( $F_0$ ), the mean jitter percent (JP), the mean shimmer percent (SP), the mean harmonic-to-noise ratio (HNR), and the grade of breathiness.

The definitions of the parameters are as follows<sup>5-11</sup>

- Frequency parameters:  
Fundamental frequency: the number of vibrations of the vocal folds per second (Hz)
- Frequency perturbation measures:  
JP: short-term evaluation of cycle-to-cycle variation in  $F_0$  (%)  
SP: short-term evaluation of cycle-to-cycle variation in amplitude (%)
- Noise parameters:  
HNR: ratio between the total energy of harmonics and the total energy of the noise components of a signal (dB).
- Vocal quality estimate:  
Breathiness: impression of the extent of air leakage through the glottis. The *Dr. Speech* software measures breathiness using the subject's voice sample into four different grades: 0, 1, 2, and 3.

### Videostroboscopy

VSB served a dual purpose. It was utilized to not only to analyze the videostroboscopic changes in the study participants but also to reconfirm the findings of the indirect mirror laryngoscopy, which recorded the absence of any vocal fold structural abnormalities.

### Procedure and instrumentation

ATMOS Endo Stroboscope L with Cam 21 with 70° laryngoscope (ATMOS Inc., Allen, PA) was used for videostroboscopic analysis. Before each participant underwent a videostroboscopic assessment, detailed instructions were provided regarding the procedure. A 70° rigid endoscope connected to a strobe light was inserted inside after holding the tongue in a protruded position, and images were recorded at a comfortable pitch and loudness. For participants who were overtly sensitive to the endoscopy, an anesthetizing 10% xylocaine spray was utilized before the procedure. The parameters analyzed include<sup>5,6,12-16</sup>

- Regularity (periodicity): the extent to which one phonatory cycle is similar to the next cycle in both amplitude and time; normally, the cycles are regular.
- Mucosal wave: the vertical upheaval of the cover over the body of the vocal folds; the quality of the mucosal wave measures the physiology of the layered structure of the vocal folds.
- Amplitude: the lateral excursion of the vocal folds during their displacement from the midline in oscillation, rated

during normal pitch and loudness; a typical amplitude is approximately one-third of the total width of the vocal fold.

- Symmetry: the degree to which the vocal folds provide mirror images of each other during vibration; it is rated as either symmetrical or asymmetrical.
- Vocal fold edge: the vertical free boundary of the vocal folds, which can be either smooth or rough.
- Adynamic segment: the nonvibrating area of the vocal fold (ie, segments that have a minimal lateral amplitude of excursion and over which the mucosal wave does not travel).
- Glottic closure: the extent to which the vocal folds approximate during the closed phase of vibratory cycles with normal pitch and loudness. It is either complete or incomplete. VSB analysis was performed by a set of two otolaryngologists, independently. Each otolaryngologist analyzed the recordings twice, with a gap of 4 weeks between the two readings to test for intrarater variability.

### Statistical analysis

Data were analyzed with *SPSS Statistics v.17* for windows (SPSS Inc., Chicago, IL). A two-tailed  $P$  value from the Fisher exact test was used for nominal variables, whereas unpaired  $t$  test was used for continuous variables.  $P < 0.05$  was considered statistically significant (\*) and  $P < 0.001$  was considered as highly significant (\*\*).

### Reliability

Parameters that were recorded using two observers (videostroboscopic parameters) underwent a Pearson  $r$  interrater correlation coefficient test; the score was noted to be 0.74. Intrarater reliability scores for the same parameters were found to be 0.85 and 0.88.

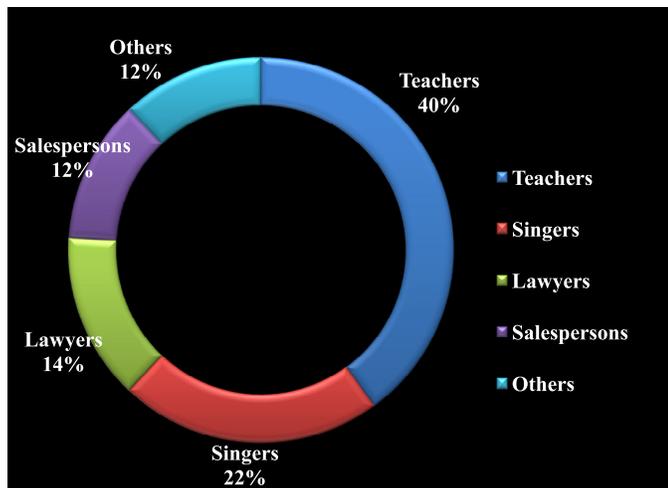
### Results

On analyzing the type of profession of the PVUs, it was found that teachers formed the largest group (40%). All these were classroom teachers working in schools or colleges. The details of the profession of the PVUs are illustrated in [Figure 1](#). Majority of the study participants had no formal training regarding the proper usage of either the speaking (100%) or the singing (91%) voice. Out of 50 PVUs, 9 singers reported undergoing formal training for the usage of the singing voice.

The exact duration each participant has spent in his or her respective professions (in years) was tabulated. This duration is illustrated in [Table 2](#). Most of the cases had a work experience of 10 years or less.

Both groups were comparable in terms of their respective work experience. Based on the formal diary that the participants maintained, it was observed that the average number of hours of voice use per day by the PVUs at their place of work was  $6.18 \pm 0.587$  (range 5.5–7.1 hours) hours in an 8-hour/day work duration, whereas in NPVUs, the average number of hours of voice use per day was  $4.01 \pm 0.338$  (range 3.8–5.4 hours).

On analyzing the voice-related history of participants, it was found that PVUs had a significantly higher incidence of voice-related complaints compared with NPVUs. Among



**FIGURE 1.** Details of the profession of the voice professionals. The different types of professions of the PVUs have been illustrated. Each type of profession has been coded with a different color (as indicated in the data label). The category “Others” includes insurance agents, priests, receptionists, telemarketers, hawkers, and telephone operators.

**TABLE 2.**  
**Details of the Duration of the Professional Career of the Participants**

Work Experience	PVU, n (%)	NPVU, n (%)
10 y and below	22 (44)	26 (52)
11–15 y	16 (32)	09 (18)
16–20 y	09 (18)	12 (24)
20 y and above	03 (06)	03 (06)

Abbreviations: NPVU, nonprofessional voice user; PVU, professional voice user.

the subjects who reported at least one voice complaint, 18% of the PVUs and 50% of NPVUs had sought medical care. The details of all the voice complaints are tabulated in [Table 3](#).

**TABLE 3.**  
**Details of Voice-related Complaints Among PVUs and NPVUs**

Voice Complaints	PVU, n (%)	NPVU, n (%)	P Value
Throat irritation during or after speaking			
Yes	19 (38.00)	07 (14.00)	0.0113*
No	31 (62.00)	43 (86.00)	
Hoarseness during or after speaking			
Yes	45 (90.00)	06 (12.00)	<0.0001**
No	05 (10.00)	44 (88.00)	
Voice fatigue during or after speaking			
Yes	30 (60.00)	02 (04.00)	<0.0001**
No	20 (40.00)	48 (98.00)	
Pain in throat during or after speaking			
Yes	12 (24.00)	01 (00.00)	0.0018*
No	38 (64.00)	49 (98.00)	

Levels of significance: \* $P < 0.05$  and \*\* $P < 0.001$ .

Abbreviations: NPVU, nonprofessional voice user; PVU, professional voice user.

On performing VA, the four different parameters— $F_0$ , JP, SP, and HNR—were compared between both groups. It was found that there was a significant difference between both groups. The details of VA between PVUs and NPVUs are tabulated in [Table 4](#). The two significant differences in VA between both groups were the mean JP and the mean HNR, both of which are illustrated further. [Figures 3 and 4](#) illustrate the difference in the mean JP and the mean HNR between PVUs and NPVUs, respectively. In both parameters, PVUs showed a higher deviation from the normative data compared with the controls.

To study the effect of gender on VA, PVUs were divided into men and women and the results were compared. The results are tabulated in [Table 5](#).

The PVUs were further divided into different groups based on the duration of their professional career. Although the parameters showed higher values for the group with a professional career of more than 10 years, the results were not significant. The results are tabulated in [Table 6](#).

Using the VA software, the grade of breathiness was determined for each subject. It was noted that there were significantly more cases with grade 2 and 3 among PVUs than among NPVUs ( $P = 0.0001$ ). The results are illustrated in [Figure 4](#).

On performing VSB, it was found that PVUs were not significantly different from NPVUs. Most participants in both groups showed normative data for various parameters of VSB. The details of the comparison are shown in [Table 7](#).

## DISCUSSION

This is one of the fewer studies done to evaluate and compare the voice of PVUs with that of NPVUs, both of whom had no obvious vocal fold lesions.

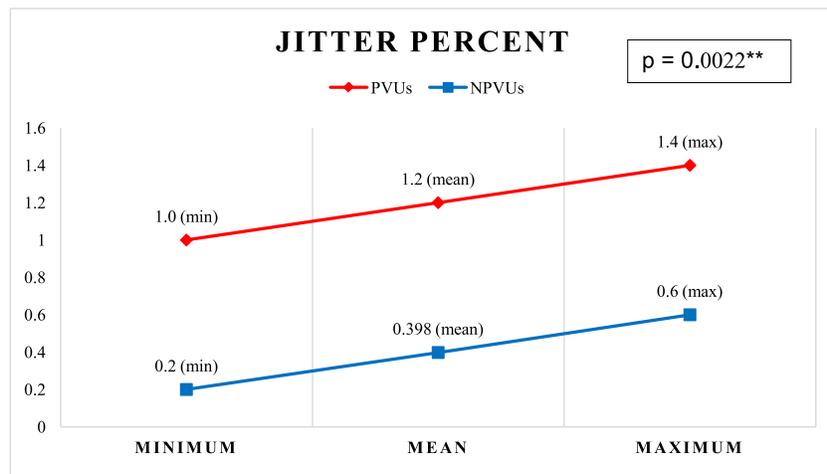
Acoustic analysis of voice revealed significantly different findings between PVUs and NPVUs. This subgroup of PVUs with no obvious vocal fold pathology may show subtle changes in voice, and it is currently unknown whether these are the individuals who eventually develop vocal fold pathologies. However, to identify this subgroup early, a baseline VA is advisable before a PVU joins the workforce and all further annual VAs can be

**TABLE 4.**  
**Details of Voice Analysis Between PVUs and NPVUs**

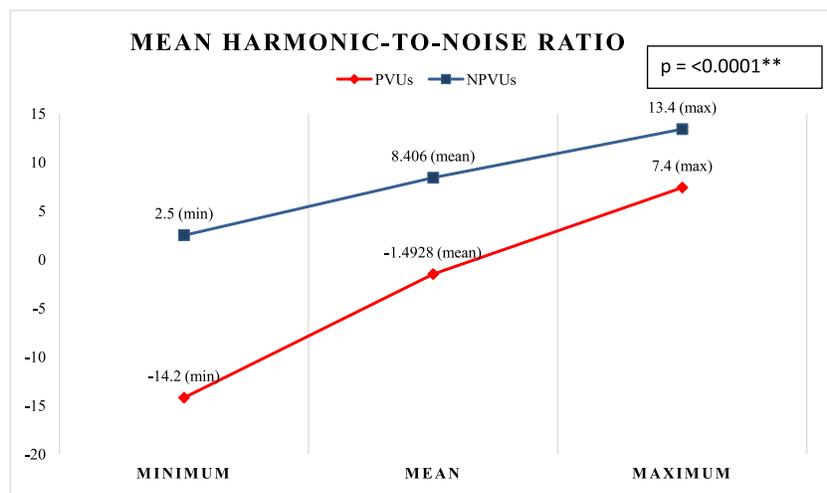
Parameters	Normative Data (Upper limit) <sup>7,8,11</sup>	PVU	NPVU	P Value
Mean $F_0$ (Hz)	180 (men)	194.2	172.74	0.0272*
Mean $F_0$ (Hz)	250 (women)	265.9	220.6	<0.0001**
Mean JP (%)	1.04	1.2	0.398	0.0022**
Mean SP (%)	3.81	5.01	2.8	0.0001**
Mean HNR(dB)	>7	-1.498	8.406	<0.0001**

Levels of significance: \* $P < 0.05$  and \*\* $P < 0.001$ .

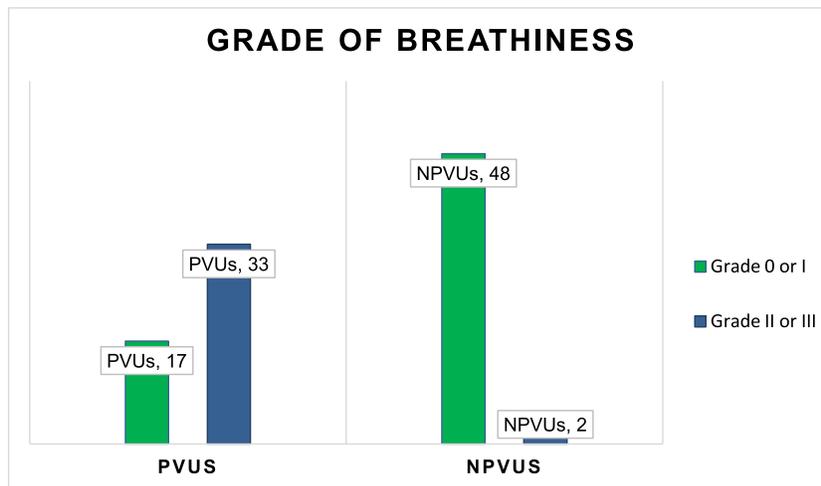
Abbreviations: HNR, harmonic-to-noise ratio; JP, jitter percent; NPVU, nonprofessional voice user; PVU, professional voice user; SP, shimmer percent.



**FIGURE 2.** Comparison of the mean jitter percent between PVUs and NPVUs. Level of significance: \* $P < 0.05$  and \*\* $P < 0.001$ . The cases are illustrated with a red line and the controls are illustrated with a blue line. The minimum (*extreme left*), mean (*center*), and maximum values (*extreme right*) of the jitter percent for both groups are depicted. The X-axis shows the jitter percent measured in percent. NPVU, nonprofessional voice user; PVU, professional voice user. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)



**FIGURE 3.** Comparison of mean HNR between PVUs and NPVUs. Level of significance: \* $P < 0.05$  and \*\* $P < 0.001$ . The PVUs are illustrated with a red line and the NPVUs are illustrated with a blue line. The minimum (*extreme left*), mean (*center*), and maximum values (*extreme right*) of the mean harmonic-to-noise ratio for both groups are depicted. The X-axis shows the mean harmonic-to-noise ratio measured in decibel. NPVU, nonprofessional voice user; PVU, professional voice user. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)



**FIGURE 4.** Details of the voice analysis regarding the grade of breathiness between PVUs and NPVUs. Level of significance: \* $P < 0.05$  and \*\* $P < 0.001$ . A comparison of the results of voice analysis regarding the grade of breathiness between PVUs and NPVUs is shown. PVUs are shown on the *left side* and NPVUs on the *right side*. The *green column* indicates grade 0 or 1 and the *blue column* indicates grade 2 or 3. NPVU, nonprofessional voice user; PVU, professional voice user. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

compared with this baseline. Additionally, the effect of excessive phonotrauma on PVUs based on their gender was analyzed, and it was found that female PVUs fared worse compared with their male counterparts. One of the reasons for this could be the higher baseline fundamental frequency in women. It has been observed that on comparing a male PVU with a  $F_0$  of 120 Hz

and a female PVU with a  $F_0$  of 220 Hz, the female PVU has 40% more vocal fold collisions per second than her male counterpart. Therefore, if a female PVU spends even as less as 17% of her workday voicing (in a 6-hour working shift), she would experience approximately 750,000 collisions per day.<sup>17</sup> This means that vocal folds in a female are at a significantly higher degree

**TABLE 5.**  
**Details of Voice Analysis in Voice Professionals Between Men and Women**

Parameters	Men	Women	<i>P</i> Value
Mean $F_0$ (Hz)	184.1	234.4	0.0035*
Mean JP (%)	1.10	1.46	0.3137
Mean SP (%)	4.9	5.3	0.0012**
Mean HNR (dB)	-1.235	-1.66	0.8854

Levels of significance: \* $P < 0.05$  and \*\* $P < 0.001$ .  
Abbreviations: HNR, harmonic-to-noise ratio; JP, jitter percent; SP, shimmer percent.

**TABLE 6.**  
**Details of Voice Analysis in Voice Professionals by Duration of Professional Career**

Parameters	≤10 y	>10 y	<i>P</i> Value
Mean $F_0$ (Hz)	172.6	216.2	0.0076*
Mean JP (%)	1.16	1.29	0.8037
Mean SP (%)	4.9	5.2	0.0671
Mean HNR (dB)	-1.42	-1.56	0.9587

Levels of significance: \* $P < 0.05$  and \*\* $P < 0.001$ .  
Abbreviations: HNR, harmonic-to-noise ratio; JP, jitter percent; SP, shimmer percent.

**TABLE 7.**  
**Comparison of Videostroboscopic Parameters Between Both PVUs and NPVUs**

Variables	PVU, n (%)	NPVU, n (%)	<i>P</i> Value
Periodicity			
Present	50 (100.00)	50 (100.00)	1.0000
Absent	00 (00.00)	00 (00.00)	
Amplitude			
Normal	45 (90.00)	47 (94.00)	0.7150
Reduced	05 (10.00)	03 (06.00)	
Mucosal wave			
Normal	44 (88.00)	48 (96.00)	0.2687
Reduced	06 (12.00)	02 (04.00)	
Symmetry			
Present	50 (100.00)	50 (100.00)	1.0000
Absent	00 (00.00)	00 (00.00)	
Vocal fold edge			
Smooth	50 (100.00)	50 (100.00)	1.0000
Rough	00 (00.00)	00 (00.00)	
Adynamic segments			
None	50 (100.00)	50 (100.00)	1.0000
Present	00 (00.00)	00 (00.00)	
Glottic closure			
Complete	42 (84.00)	48 (96.00)	0.0916
Incomplete	08 (16.00)	02 (04.00)	

Abbreviations: NPVU, nonprofessional voice user; PVU, professional voice user.

of vulnerability that that in a male. Therefore, a higher deviation from normative values was noticed in female PVUs. Similarly, PVUs who have spent a considerable duration in their respective profession show a cumulative effect due to the underlying vocal stress and have a poorer voice compared with those who have recently joined the workforce.

The second test performed was VSB, which is considered a gold standard to detect the structural defects in the vocal folds. However, as the study excluded all individuals with an obvious vocal fold pathology, majority of our participants had normative data for the various videostroboscopic parameters studied and showed normal vocal folds on VSB.

In our study, most (78%) of the PVUs were predominantly speaking PVUs. However, none of the PVUs were formally trained in the usage of speaking voice. Lack of knowledge regarding the effects of heavy vocal loading and unhealthy vocal habits accentuates the effects of everyday phonotrauma in these speaking PVUs<sup>18</sup>; NPVs, on the other hand; do not undergo sustained phonotraumatic behaviors. Therefore, formal training in both speaking and singing voices needs to be made mandatory for all PVUs before they enter the workforce. Attention to proper voice usage and healthy vocal habits in PVUs cannot be over emphasized.

## CONCLUSIONS

- The voice of an apparently normal PVU differs significantly from that of a normal NPVU.
- The voice of a PVU is not independent of gender. Female PVUs are more vulnerable than male PVUs to develop a poorer voice.
- The effects of phonotraumatic behaviors usually seen in PVUs have a cumulative effect and increase with an increase in the time spent in one's profession.

Being the first study of its kind to analyze the voice of PVUs without any obvious vocal fold pathology in comparison with NPVUs, we hope the data obtained will serve as a basis for

formulating guidelines regarding the prevention of voice abuse in voice professionals.

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