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Assessment of Clinical and Social Characteristics That Distinguish Presbylaryngis From Pathologic Presbyphonia in Elderly Individuals

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Supplemental content

IMPORTANCE An aging population experiences an increase in age-related problems, such as presbyphonia. The causes of pathologic presbyphonia are incompletely understood.

OBJECTIVE To determine what distinguishes pathologic presbyphonia from presbylaryngis.

DESIGN, SETTING, AND PARTICIPANTS This was a cohort study at an outpatient otolaryngology subspecialty clinic of a tertiary academic referral center. Participants were consecutive consenting adults older than 74 years without laryngeal pathologic abnormalities who visited the clinic as participants or companions. Patient questionnaires, otolaryngologic, video stroboscopic, and voice examinations were compiled. Patients were divided into groups based on whether they endorsed a voice complaint. Three blinded authors graded stroboscopic examinations for findings consistent with presbylaryngis (vocal fold bowing, vocal process prominence, glottic insufficiency).

MAIN OUTCOMES AND MEASURES Voice Handicap Index–10, Reflux Symptom Index, Cough Severity Index, Dyspnea Index, Singing Voice Handicap Index-10 , Eating Assessment Tool -10, Voice-Related Quality of Life (VRQOL), and Short-Form Health Survey; face-sheet addressing social situation, work, marital status, education, voice use, transportation; acoustic and aerodynamic measures; and a full otolaryngologic examination, including videostroboscopic imaging.

RESULTS A total of 31 participants with dysphonia (21 were female; their mean age was 83 years [range, 75-97 years]) and 26 control participants (16 were female; their mean age was 81 years [range, 75-103 years]) completed the study. Presbylaryngis was visible in 27 patients with dysphonia (87%) and 22 controls (85%). VHI-10 and VRQOL scores were worse in patients with pathologic presbyphonia (median [range] VHI-10 scores, 15 (0-40) vs 0 (0-16) and median VRQOL score, 19 [0-43] vs 10 [10-23]). All other survey results were indistinguishable, and no social differences were elucidated. Acoustic measures revealed that both groups averaged lower than normal speaking fundamental frequency (mean [SD], 150.01 [36.23] vs 150.85 [38.00]). Jitter was 3.44% (95% CI, 2.46%-4.61%) for pathologic presbyphonia and 1.74% (95% CI, 1.35%-2.14%) for controls (d = 0.75). Shimmer means (95% CI) were 7.8 2 (6.08-10.06) for the pathologic presbyphonia group and 4.84 (3.94-5.72) for controls (d = 0.69). Aerodynamic measures revealed an odds ratio of 3.03 (95% CI, 0.83-11.04) for patients with a maximum phonation time of less than 12 seconds who had complaints about dysphonia.

CONCLUSIONS AND RELEVANCE Presbylaryngis is present in most ambulatory people older than 74 years. Some will endorse pathologic presbyphonia that has a negative effect on their voice and quality of life. Pathologic presbyphonia seems to be influenced by respiratory capacity and sex. Further study is required to isolate other social, physiologic, and general health characteristics that contribute to pathologic presbyphonia.

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Dysphonia is a common complaint in elderly persons, contributing to withdrawal from social participation, depression, and decreased quality of life. It is estimated that 5% to 30%[1-4] of all those older than 65 years will endorse dysphonia, a potentially large absolute number when considering the aging American population.[5] Dysphonia has many causes, but one possible contributor common in the elderly population is that of presbylaryngis, or an aging larynx.[6] The prevalence of presbylaryngis is unknown. Although some signs of presbylaryngis are visible in most people older than 40 years, many will not acknowledge any vocal difficulties.[7] Others will present with pathologic presbyphonia, or age-related changes in the voice that cause distress, and request treatment for dysphonia. This study was initiated to investigate presbylaryngis and pathologic presbyphonia. We anticipated that presbylaryngis would not uniformly produce pathologic presbyphonia but rather that it would be present in most patients with pathologic presbyphonia. We postulated that a combination of distinct social, anatomic, and acoustic factors would combine with presbylaryngis to produce pathologic presbyphonia. To isolate these factors, we included elderly people presumed to have presbylaryngis with or without subjective dysphonia.

Key Points

Question What factors distinguish pathologic presbyphonia from presbylaryngis?

Findings In this cohort study of 57 people older than 74 years, Voice Handicap Index-10 and Voice-Related Quality of Life scores and scores for jitter and shimmer were significantly higher in those with pathologic presbyphonia. Other findings did not differ, although female sex and decreased respiratory capacity were more likely to be associated with pathologic presbyphonia.

Meaning Pathologic presbyphonia is not explained solely by the presence of presbylaryngis; factors that influence pathologic presbyphonia include respiratory capacity and sex, as well as presbylaryngis.

Methods

All English-speaking people visiting our subspecialty otolaryngology clinics (voice and swallowing, sinus and allergy, endocrine, facial plastic surgery), including patients, spouses, and companions older than 74 years, were invited to participate in this study. The Loma Linda University Health institutional review board approved this prospective study. Patients were not compensated for their participation. Those who provided written informed consent and reported a voice complaint comprised the study (pathologic presbyphonia) group, and those who did not perceive any vocal difficulties when directly asked were included as healthy controls. Participants were excluded if they had neurologic diagnoses, such as Parkinson disease and laryngeal or essential tremor, vocal fold paralysis, vocal fold lesions or sulci, a history of cancer or neck irradiation, or laryngeal procedures or surgery. Participants completed our standard intake forms (Voice Handicap Index-10 [VHI-10],[8] Reflux Symptom Index [RSI],[9] Eating Assessment Tool [EAT-10],[10] Cough Severity Index [CSI],[11] Dyspnea Index [DI],[12] Singing Voice Handicap Index-10 [SVHI-10][13]) as well as the Voice-Related Quality of Life (VRQOL),[14] Short-Form Health Survey (SF-36),[15,16] and a face sheet that recorded demographic information, including level of education, marital status, hobbies, work, transportation. All study participants then underwent videostroboscopic examinations, voice recording, and acoustic and aerodynamic testing. All videostroboscopic evaluations were performed and recorded by 2 experienced laryngologists (B.K.C. and P.K.). The Kay-Pentax 9310HD recording system, 9400 strobe, EPKi processor, and VLS-1190STK flexible laryngoscopes (Kay Pentax Medical Company) were used. These examinations included sustained phonation at a modal pitch and at a comfortable effort level, range of comfortable frequencies, phonation to complete expulsion of air, phrase repetition, and rapid alternating vocal fold movement. Other tasks determined to be appropriate were also recorded in the pathological group.

Acoustic data were collected using the Kay Pentax MDVP program (model 5105 3.3). The recording equipment consisted of a Shure PG48-QTR cardioid dynamic microphone held 6 inches directly in front of the participant's lips. A metal bar attached to the microphone ensured that distance remained constant for all recordings. All participants were seated. They were instructed to sustain the vowel /a/ at a comfortable effort level after counting from 1 to 5 in a normal voice. A 3-second sample minus the initial and final one-fourth seconds of the vowel were analyzed to obtain speaking fundamental frequency, mean jitter in percentage, mean shimmer in percentage, and noise to harmonic ratio. These measures were selected because they have been previously reported in studies of elderly patients.[17-20] Perceptual ratings were not available.

Aerodynamic data were collected with the Phonatory Aerodynamic System (PAS) (model 6600; Kay Pentax Medical Company). Participants were instructed to speak into a sealed face mask with a sensing tube inserted between the lips. Following a short period of comfortable breathing into the mask, all participants repeated "Ha, ha, ha." These sharp breath pulses were used to verify that the mask was sealed properly over the face. Participants were then instructed to repeat a series of 7 to 8 syllables ("pa") at approximately 1.5 syllables per second. All participants also produced a maximally sustained /a/ following maximum inhalation (MPT). Three trials were obtained while the participants were seated, and the longest trial was accepted for analysis. The MPT, acoustic, and aerodynamic data were entered on a spreadsheet and provided to an independent statistician for analysis.

Videostroboscopic examinations were graded by 3 independent clinicians (2 laryngologists and 1 speech pathologist [B.K.C, P.K., and T.M.]) for presence or absence of findings that included vocal fold bowing and/or flaccidity, vocal process prominence in abduction, glottic closure at initial vocal process contact (also described as spindle-shaped closure), phase symmetry, and periodicity.[21-23] The graders were blinded to patient voice complaints, and 10% of all studies (determined by random number generator) were graded twice to reveal intrarater reliability. All studies were graded during the same

session by all graders. Prior to this session, a standardized approach regarding the viewing and evaluation of studies was agreed on by all graders. Examination anchors were determined by consensus of all raters through the review of 15 unrelated studies for the presence or absence of these findings.[24] All videostroboscopic examinations were rated without audio. The presence of presbylaryngis was confirmed based on positive findings in these areas. When at least 2 of 3 graders were in agreement, that score of "present" or "absent" was accepted for each finding in each patient. All of these data were then deidentified and compiled for analysis.

Statistical analysis was performed to elucidate which factors contributed to pathologic presbyphonia in the setting of presbylaryngis. Descriptive statistics are given as mean (SD) or median [range] for quantitative variables, and number (percentage) for qualitative variables.

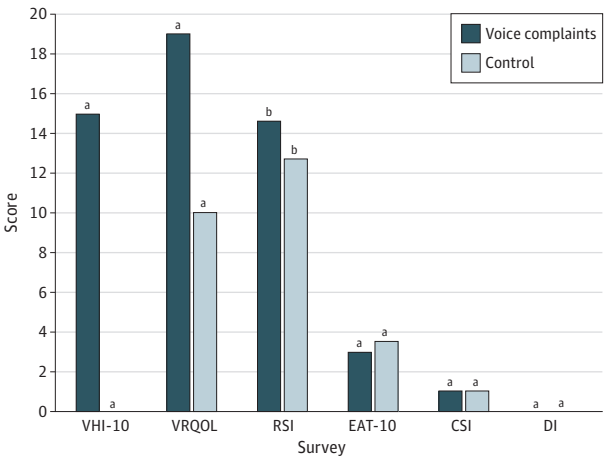
Independent Samples *t* test was performed to test for differences in quantitative variables between the pathologic presbyphonia and the control groups. For the independent samples *t* test, effect size (Cohen *d*) was estimated by calculating the mean difference between the 2 groups, and then dividing the result by the pooled standard deviation. Independent Samples Mann-Whitney U test was used when the assumptions of Independent Samples *t* tests were not met. For the Mann-Whitney test, effect size (*r*) was computed by dividing the *Z* value by the total number of observations, and then converting the result into Cohen *d* value using

$$=\frac{2r}{\sqrt{1+r^2}}$$

Fleiss κ procedure to assess the rater reliability.

Univariate logistic regression analysis was used in the analysis to assess the effect of sex and clinical factors on voice complaints. Multiple logistic regression analysis was performed in the analysis to test the effect of atrophy on pathologic presbyphonia after adjusting for other variables. Statistical analyses were performed using IBM SPSS Statistics (version 24). Alpha was set at a 0.05 significance level.

Figure 1. Average Survey Scores of Pathologic Presbyphonia (Voice Complaints) and Control Groups

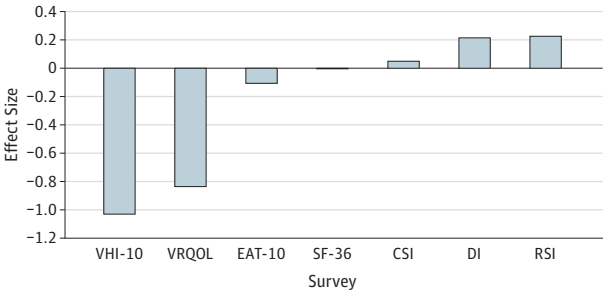


Scores for the Short-Form Health Survey (SF-36) were the same for both groups: 102. CSI indicates Cough Severity Index[11]; DI, Dyspnea Index[12]; EAT-10, Eating Assessment Tool[10]; RSI, Reflux Symptom Index[9]; VHI-10, Voice Handicap Index-10[8]; VRQOL, Voice-Related Quality of Life.[14]

[a] Median (range).

[b] Mean (SD).

Figure 2. Effect Sizes of Average Survey Scores



CSI indicates Cough Severity Index[11]; DI, Dyspnea Index[12]; EAT-10, Eating Assessment Tool[10]; RSI, Reflux Symptom Index[9]; SF-36, Short-Form Health Survey; VHI-10, Voice Handicap Index-10[8]; VRQOL, Voice-Related Quality of Life.[14]

Results

A total of 57 participants met inclusion and exclusion criteria and completed this study. Thirty-one presented with voice complaints (pathologic presbyphonia), and 26 were people who did not consider themselves to have any vocal difficulties (healthy controls). The average age of our group was 81 years (group with voice complaint, median age, 81 years; control group, median age, 80 years), although the participants ranged in age from 75 to 103 years (75 to 103 in the health control group, 75-97 years in the pathologic presbyphonia group). Women comprised 68% of the pathologic presbyphonia group (21) and 62% of the control group (16). Women account for 61% of the US population older than 74 years.[25] Fifty-two percent of the pathologic presbyphonia group (16) and 60% of the control group (15) were married. All lived at home, with the exception of 1 patient per group who lived in a care facility. Three patients in each group had a caregiver other than a spouse. In the pathologic presbyphonia group, 6 patients were still working part-time and in the control group, 2 participants were working part-time. One per group worked full-time. The average years of education after kindergarten were 14.5 years in each group; 73% of pathologic presbyphonia group (22) had at least some college education as did 68% of the control group (17). Thirty-seven percent of the pathologic presbyphonia group (11) acknowledged a recent hospitalization as did 40% of the control group (10).

All participants completed subjective questionnaires, and these are compared in **Figure 1** and **Figure 2** (also see eFigures 1 and 2 in the Supplement). Only the VHI-10 and VRQOL scores were found to differ between groups, with worse scores in the group with pathologic presbyphonia. This was indicated by the

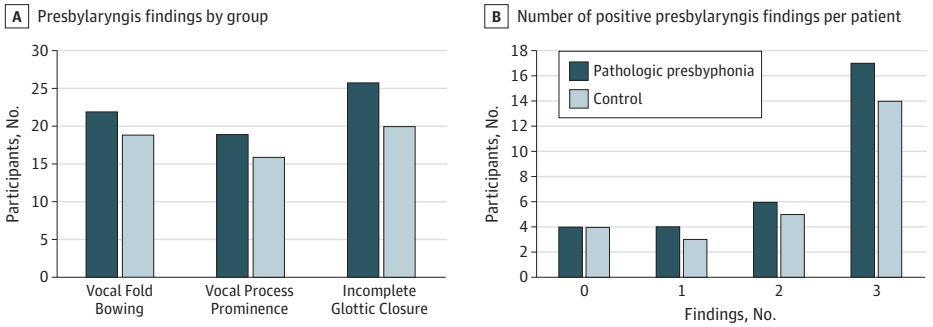
Table 1. Acoustic and Aerodynamic Results for Study and Control Groups

Acoustic and Aerodynamic Measures	Mean (95% CI)		Effect Size (95% CI)
	Pathologic Presbyphonia	Control	
Fundamental frequency[a]	150.01 (136.49 to 163.54)	150.85 (135.50 to 166.20)	−0.02 (−0.55 to 0.50)
Jitter[a]	3.44 (2.46 to 4.61)	1.74 (1.35 to 2.14)	0.75 (0.21 to 1.29)
Maximum phonation time, s[a]	16.34 (12.97 to 18.95)	17.38 (15.07 to 19.70)	−0.14 (−0.67 to 0.38)
Subglottic pressure[a]	5.76 (4.86 to 6.51)	6.48 (5.66 to 7.31)	− 0.33 (−0.86 to 0.19)
Shimmer[a]	7.82 (6.08 to 10.06)	4.84 (3.94 to 5.72)	0.69 (0.15 to 1.23)
Air flow rate, median (95% CI)[b]	120.00 (90.00 to 150.00)	125.00 (90.00 to 160.00)	0.00 (−0.51 to 0.51)
Resistance, median (95% CI)[b]	50.00 (33.00 to 69.00)	52.00 (40.00 to 92.70)	−0.20 (−0.68 to 0.32)
Efficiency, median (95% CI)[b]	19.70 (11.00 to 35.00)	26.06 (12.00 to 51.20)	−0.23 (−0.29 to 0.71)

[a] The independent *t* test.

[b] Mann-Whitney U test.

Figure 3. Presbylaryngis Findings on Videostroboscopic Examination for Each Patient in Both Groups



A, This panel demonstrates how many participants were found to have each of the 3 presbylaryngis findings and B, This panel demonstrates how many participants in each group had 0, 1, 2, or all 3 of the findings consistent with presbylaryngis.

large effect size. The RSI, EAT-10, CI, DI, and SF-36 composite scores were largely indistinguishable between healthy controls and group with pathologic presbyphonia, demonstrated by small or trivial effect sizes.

Acoustic and aerodynamic measures are presented in **Table 1**. Jitter and shimmer were significantly different when results of the 2 groups were compared. The mean jitter was 3.44% in the pathologic group and 1.74% in the control group, yielding a mean difference of 1.70% (95% CI, 0.58%-2.82%) with a *d* value of 0.75 signifying a medium to large effect size. The mean values for shimmer in the pathologic and study groups, respectively, were 7.82% and 4.84%, respectively. The mean difference was 2.98% (95% CI, 0.83%-5.13%) with a *d* value of 0.69 signifying a medium effect size. All other measures did not differ significantly between groups, although the trivial effects seen with differences in fundamental frequency and MPT could represent clinically significant trends.

Findings from physical examinations were analyzed to determine the presence of presbylaryngis. Vocal fold bowing and/or flaccidity, vocal process prominence in abduction (VPP), and glottic closure at initial vocal process contact were counted each as individual indicators of the presence of presbylaryngis or vocal fold atrophy. Phase symmetry and periodicity were also graded (**Figure 3**). Of the pathologic presbyphonia group, 27 (87%) had at least 1 of these indicators. This was true of 22 (85%) of the control group. Seventy-four percent of the pathologic presbyphonia group (23) had 2 of these findings and 73% of the control group (19) also had 2 of the findings. All 3 were present in 55% of the study group (17) and 54% of the control group (14). Four patients in each group were found to have none of these findings. Ten patients in each group were found to have phase asymmetry for at least 50% of the study. There were no studies in either group that were irregular to the extent that the irregularity prevented stroboscopic interpretation. Interrater reliability was determined to be moderate for all 3 graders for all findings except VPP, for which correlation was fair (vocal fold bowing $\kappa = 0.52$, VPP $\kappa = 0.34$, glottic closure $\kappa = 0.54$, phase symmetry $\kappa = 0.47$). When the presence of 2 of 3 presbylaryngis findings was considered, interrater reliability was also moderate ($\kappa = 0.49$). For the pathologic group, vocal fold bowing and glottic closure at the moment of vocal process contact were almost always for 3 of the 3 raters (25 [3 of 3 raters] – 6 [2 of 3 raters] bowing; 26 [3 of 3 rates] – 5 [2 of 3 raters] contact), but vocal process prominence was split, 16 (3 of 3 raters) vs 15 (2 of 3 raters). In the control group, these numbers were split more evenly (14 [3 of 3 raters]) – 12 [2 of 3 raters] bowing; 13-13 VPP; 17-9 contact). Intrarater reliability was good or very good for each grader considering each of the 3 presbylaryngis findings.

Univariate and multivariate analysis results are shown in **Table 2**. Although there were no significant sex differences between groups, univariate analysis revealed that women were 1.31 times more likely to present with pathologic presbyphonia. Patients with an MPT of less than 12 seconds were 3 times more likely to present with pathologic presbyphonia. Patients who had either no findings or 1 finding consistent with

presbylaryngis were 86% less likely to present with voice complaints compared with patients who had 2 or more findings after adjusting for sex and hospitalization status.

Discussion

This study explored differences in elderly people with and without voice complaints. We sought to isolate the patients with pathologic presbyphonia to determine the factors that distinguish this state from presbylaryngis. We included a group of patients and other healthy individuals older than 74 years representing a cross-section of people who visited our office. We limited our study to these "oldest old" ambulatory members of our community to capture a group that would largely exhibit signs of presbylaryngis, although not all would endorse problems with their voices. Videostroboscopic examination findings, such as vocal fold atrophy and glottic insufficiency, are well established in making the diagnosis of presbylaryngis, and our examinations confirmed that most people in both groups did possess signs consistent with presbylaryngis and that their presence was insufficient to explain pathologic presbyphonia.[22,26,27]

Previous studies have reported the overall prevalence of presbylaryngis as being fairly low.[26,28,29] These estimates were based on populations extracted from large general health databases or from within specific nursing care facilities. The current study differs in that the study population is older than other populations (most studies include participants as young as 65 years or even 55 years),[26,30] and they represent a unique and varied group of ambulatory elderly persons. The prevalence of presbylaryngis in this relatively healthy, independently living "oldest-old" group was 85% in participants without voice complaints, indicating that presbylaryngis may be more pervasive than previously thought.

We expected to discover some combination of social, health, and anatomic factors coalescing to produce pathologic presbyphonia, providing greater understanding of this disorder and potential therapeutic targets. However, we were unable to isolate any such combination of factors in this group. In our cohorts, physical examination findings; aerodynamic features; marital, social, and living status; education level; and work involvement did not seem to play distinguishing roles in the presence of pathologic presbyphonia in patients older than 74 years. In those who subjectively reported voice complaints, there was internal consistency reflected in their significantly elevated VHI-10 and VRQOL scores. This supports our confidence in the diagnosis of pathologic presbyphonia. However, the only objective findings that were different in this group were the acoustic findings, jitter and shimmer, indicative of vocal instability. These findings were consistent with those of another study[31] and are not considered to be the sole contributors to pathologic presbyphonia owing to the relative clinical insignificance of the differences. The low overall fundamental frequency of the entire group may be related to the average age of participants because normative data for this population are limited.

Decreased respiratory capacity has been advanced as a significant contributor to presbyphonia.[26,31] Although mean airflow rate has been shown to increase with age and signs of presbylaryngis,[26] no difference in the pathologic presbyphonia and control groups in our study was revealed in this or in any other aerodynamic measure. This is consistent with the uniform prevalence of presbylaryngis findings between groups. We did find a trend toward dysphonia complaints in patients with lower MPTs that could prove to be significant in a larger study population but probably does not entirely explain pathologic presbyphonia, although it is one factor that is conducive to therapeutic intervention. Interestingly, there was no difference in DI scores, suggesting that patients do not perceive shortness of breath as a particular contributor to their dysphonia. Alternatively, these measures may fail to illustrate deterioration in neuromuscular control with aging that results in discoordination of respiration and phonation, contributing to presbyphonia. These factors may help explain how patients can develop pathologic presbyphonia without presbylaryngis.

It is unknown how much general health influences the perception of dysphonia. This study and preceding work have found that overall health does not seem to influence dysphonia.[2] However, other studies[1,3] have found associations between specific disease states that become more prevalent with age, and the development of dysphonia. The difference in these studies and ours is that ours eliminated all vocal pathologic abnormalities other than what could be attributed to presbylaryngis, whereas other studies did not eliminate sources of vocal pathologic abnormalities besides presbylaryngis (eg, neurologic, neoplastic). Although it stands to reason that overall health and certain specific disease states not limited to the larynx may contribute to the perception of dysphonia, we were unable to demonstrate this.

Aging in men and women is different, although those differences may be less pronounced in advanced age. Our study did not delve deeply into the sex differences that might contribute to pathologic presbyphonia, but future study of this question may prove important because acoustic parameters did differ between the 2 groups. In addition, our study demonstrated that a woman older than 74 years is 30% more likely than a man to present with dysphonia.

Table 2. Results of Univariate and Multivariate Logistic Regression Analyses

Characteristic	Odds Ratio (95% CI)
Sex (female vs male)	
Unadjusted model	1.31 (0.44-3.91)
Adjusted for presbylaryngis findings and hospitalization	1.35 (0.40-4.54)
Maximum phonation time (<12 s vs ≥12 s)	
Unadjusted model	3.03 (0.83-11.04)
Adjusted for presbylaryngis findings and sex	2.96 (0.78-11.20)
Presbylaryngis findings (<2 vs ≥2)	
Unadjusted model	0.94 (0.29-3.08)
Adjusted for sex	0.83 (0.23-2.95)
Adjusted for sex and hospitalization	0.86 (0.23-3.16)
Hospitalization (yes vs no)	
Unadjusted model	0.92 (0.31-2.75)
Adjusted for sex	0.90 (0.30-2.72)

Limitations

The limitations of this work include the population pool from which participants were recruited. To isolate and scrutinize presbylaryngis and pathologic presbyphonia, it was thought necessary to recruit fairly healthy participants. But this group is not representative of all people older than 74 years, and therefore findings are not generalizable. There is also a potentially significant response bias because those people who did not consent to participate were neither counted nor interviewed as to why they did not wish to participate.

Based on the results of this work, our future studies will use more closely defined categories of health, more specific assessment of vocal needs, use, perception, and voice use history, and more extensive objective assessments, especially of respiratory capacity. We may also compare these findings in groups of people across different decades, across sexes, and possibly across different cultural backgrounds.

Conclusions

Signs consistent with presbylaryngis are present in most ambulatory people older than 74 years, but these are insufficient to produce pathologic presbyphonia. Pathologic presbyphonia is probably influenced by respiratory capacity and sex. Respiratory capacity may be an important therapeutic target in presbyphonia. Additional investigation may further the understanding of pathologic presbyphonia and its social, physiologic, and general health contributors.

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Study concept and design: Crawley, Krishna.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: Crawley, Mousselli.
Critical revision of the manuscript for important intellectual content: Crawley, Dehom, Thiel, Yang, Cragoe, Krishna, Murry.
Statistical analysis: Crawley, Dehom, Yang, Cragoe.
Administrative, technical, or material support: Crawley, Mousselli, Murry.
Study supervision: Crawley, Krishna.

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