Comparison of Supraglottic Activity and Spectral Slope Between Theater Actors and Vocally Untrained Subjects

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Summary: Purpose. The present study aimed to assess supraglottic activity in theater actors and to observe whether they present differences compared with subjects with no voice training. Acoustic and perceptual analyses were also performed.

Methods. A total of 20 participants were divided into two groups: an experimental group of trained theater actors, and a comparative group of subjects with no voice training. Absence of laryngeal pathology was confirmed by rigid videostroboscopy. Flexible laryngoscopy was performed to assess supraglottic activity during speaking phonatory tasks. Voice recording was also carried out. Four blinded judges were asked to assess laryngoscopic and perceptual variables using a visual analog scale. A comparison between groups, phonatory tasks, and loudness levels was performed.

Results. Multivariate linear regression showed that trained participants had a higher degree of both laryngeal and pharyngeal activities compared with untrained participants. Moreover, phonatory tasks at high intensity showed higher activity than those at medium and low intensities for most phonatory tasks and laryngoscopic parameters. Vocally trained participants evidenced higher values for all spectral variables compared with untrained participants.

Conclusion. Actors have a greater degree of both laryngeal and pharyngeal activities than vocally untrained subjects. Apparently, this higher activity is associated to speaking voice training and not to a hyperfunctional vocal behavior. Anterior-posterior laryngeal compression is greater than medial compression. Intensity and phonatory tasks have an effect on all laryngoscopic variables. Supraglottic activity during professional speaking voice may be not necessarily a hyperfunctional behavior, but a strategy to avoid vocal fold damage while producing the desired voice quality.

Key Words: Supraglottic activity–Laryngeal hyperfunction–Laryngoscopy–Actors–Voice training.

INTRODUCTION

Medial and anterior-posterior (A-P) laryngeal compression has commonly been described as endoscopic signs of vocal hyperfunction.[1] Previous studies, however, have shown that a perceived increase in supraglottic activity may also occur in subjects diagnosed with normal voice.[2–7] The present investigation is part of a line of research whose general purpose is to obtain more specific evidence related to laryngeal and pharyngeal activities during voice production in professional voice users. In this regard, a series of studies have been carried out in different groups of singers so far. In a work designed to evaluate the degree of supraglottic compressions in healthy opera singers of different voice classifications while singing different pitches, loudness, and phonatory tasks, Mayerhoff et al[8] demonstrated that supraglottic activity was observed in healthy singers. Specifically, medial compression was significantly greater in male subjects, tenors, during loud phonation, during high pitch, and while phonating the vowel /a/. A-P compression was also significantly greater in men, baritones, loud voice production, and with phonation of the vowel /a/. Additionally, A-P compression was more prominent than medial compression. Guzman et al[9] evaluated a group of rock singers who perform growl voice and/or reinforced falsetto in high pitches. Laryngoscopic examination evidenced that most of the participants presented a high vertical laryngeal position (VLP), pharyngeal compression, and laryngeal supraglottic compression. All of these signs are traditionally labeled as signs of hyperfunction, and they occur during both singing and speaking voice in this group. However, vocal fold indemnity was demonstrated in all participants at the time of examination. In a recent study performed with pop singers, it was found that three singing styles (pop, rock, and jazz) presented a certain degree of A-P laryngeal compression, medial compression, pharyngeal constriction, and high VLP. Rock singing showed the highest degree of both laryngeal and pharyngeal activities. All singers were found to be laryngoscopically and perceptually healthy.[10] Several other earlier works have explored laryngeal compression during singing voice production and have demonstrated similar findings.[5–7,11–14]

Some explanations have been provided to suggest why supraglottic compression may not necessarily be a hyperfunctional vocal behavior, but rather a normal and even desirable muscle activity. These modifications of the vocal tract shape may constitute an important way to modify vocal quality during singing. Sundberg[15,16] stated that the area ratio between the hypopharynx and the epilaryngeal tube may be the main explanation for the singer's formant cluster. This spectral prominence would help voice projection, especially in classical singing. Furthermore, an A-P narrowing of the epilaryngeal tube has been reported to have a positive impact for vocal fold oscillation and vocal fold adduction.[17–19] This narrowing produces a greater source-filter interaction and a higher vocal tract inertance, which have been associated with a more resonant voice quality and easy voice production.[17–19]

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Most earlier works suggesting that supraglottic and pharyngeal activities may not be vocally harmful in professional voice users have explored the singing voice. To the best of our knowledge, to date, no studies have compared laryngoscopic behavior in subjects that are trained and untrained in speaking. The purpose of the present study was to assess supraglottic activity in professional theater actors and to observe whether they present differences compared with subjects with no voice training. Acoustic and perceptual analyses were also performed. We hypothesize that supraglottic activity may not necessarily be greater in untrained participants, and it could be even more prominent in vocally trained individuals.

METHODS

Participants

Informed consent was obtained from 20 participants (11 women and 9 men). The average age of this subject set was 31 years, with a range of 25–45 years old. They were divided into two groups: a study group of theater actors (n = 10) and a control group of subjects with no voice training (n = 10). Inclusion criteria for study group included: (1) no history of voice problems in the past year, (2) no vocal fold pathology at the time of examination, (3) perceptually normal voice, and (4) at least 5 years of formal speaking voice training. Inclusion criteria for control group included: (1) no history of voice problems in the past year, (2) no vocal fold pathology at the time of examination, (3) perceptually normal voice, and (4) no voice training. None of the participants reported a hearing impairment. Smoking habit was not considered in the present study as exclusion criterion. Participants from experimental group were recruited from various schools of theater and theater companies. All were asked to undergo rigid videostroboscopy (Digital videostroboscopy system RLS 9100-B; KayPENTAX, Lincoln Park, NJ, USA) to confirm the absence of laryngeal pathology. Flexible laryngoscopy (KAYPENTAX RLS 9100-B; KayPENTAX) with specific speaking tasks (see below) was also performed to assess supraglottic activity. Endoscopic laryngeal examinations were performed by three experienced laryngologists who are coauthors of the present study (A.O., C.O., P.C.). No topical anesthesia was used during trans-nasal endoscopy. This study was reviewed and approved by the University of Chile, Faculty of Medicine Review Board.

Speaking phonatory tasks

During the trans-nasal endoscopic examination, each participant was instructed to produce two different phonatory tasks: (1) to read a phonetically balanced text at three loudness levels (medium, high, and low) and (2) to produce sustained vowels [a:], [i:], and [u:] during 5 seconds at comfortable pitch and at three loudness levels (medium, high, and low) each production. Loudness was subjectively controlled by the subjects and experimenters. Participants were required to keep the same pitch during vowel productions. This was also perceptually controlled by experimenters. All subjects were also strongly instructed to make clear vocal differences between loudness levels. Three repetitions were performed for each phonatory task. The flexible endoscope was placed near the tip of the uvula during singing. This position allowed a full view of the pharynx and larynx. The placement was set by securing the fiberscope against the alar cartilage of the nose with the laryngologist's finger. A steady placement of the fiberscope is crucial because observation of laryngeal height adjustments and other laryngeal configurations can be affected by the movement of the endoscope.

Visual evaluation of laryngoscopic samples

Three blinded judges (speech-language pathology graduate students with training in speaking voice and laryngeal endoscopic assessment) were asked to review the laryngoscopic examinations and rate the degree of A-P laryngeal compression, medial laryngeal compression, pharyngeal compression, and VLP on a 100-mm visual analog scale (VAS). To standardize the rating parameters and rating scales, the three judges participated in a 3-hour training session in videolaryngoscopy examinations. For VLP 1 = very low, 100 = very high; for pharyngeal compression 1 = very wide, 100 = very narrow; for medial laryngeal compression 1 = very open, 100 = very narrow; and for A-P laryngeal compression 1 = very open, 100 = very narrow. All sounds were removed from video recordings (including all phonatory tasks). Each laryngoscopic examination could be reviewed as many times as desired. A total of 360 video samples (20 subjects × 2 phonatory tasks × 3 loudness levels × 3 repetitions) were obtained. Additionally, 20% of samples were randomly repeated to determine whether the judges were consistent in their perceptions (intra-rater reliability analysis).

Audio recordings

All participants were recorded when performing the same speaking phonatory tasks as during laryngoscopy (to read a text at three different loudness levels and to sustain vowels at three different loudness levels). The duration of each recording session was approximately 20 minutes. A Focusrite Scarlett 8i6 USB audio interface (Focusrite Audio Engineering, High Wycombe, UK) and a Rode condenser omnidirectional microphone, model NT2-A (Rode, Long Beach, CA, USA) were used to capture the voice samples. This microphone was selected because the manufacturer's specifications include a flat frequency response from 20 to 20,000 Hz. The microphone was positioned 30 cm from the mouth of the participants, who remained standing. The recording took place in an acoustically treated room (background noise = 30 dBZ), and samples were recorded digitally at a sampling rate of 44 kHz and 16 bit. The capture and recording of voice signals were carried out using the software *Pro Tools 9.0* (Avid Corporation, Burbank, CA, USA).

Acoustical analysis

Acoustical analysis with long-term average spectrum (LTAS) was performed. The acoustical variables in this study were (1) the energy level difference between the F1 and F0 regions (L1–L0), that is, the energy level difference between 300–800 Hz and 50–300 Hz, which provides information on the mode of phonation; (2) the alpha ratio, which is the energy level difference between 50–1000 Hz and 1000–5000 Hz, which provides information on the spectral slope declination. The LTAS spectra for each subject were obtained by *Praat* software, version 5.3.60