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Effects of Vocal Training on Students' Voices in a Professional Drama School

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Abstract

Objective. The purpose of this study was to investigate the effect of vocal training on acoustic and aerodynamic characteristics of student actors' voices.

Study Design. Prospective cohort study.

Setting. Tertiary medical facility speech and swallow center.

Subjects and Methods. Acoustic, aerodynamic, and Voice Handicap Index–10 measures were collected from 14 first-year graduate-level drama students before and after a standard vocal training program and analyzed for changes over time.

Results. Among the aerodynamic measures that were collected, mean expiratory airflow was significantly reduced after vocal training. Among the acoustic measures that were collected, mean fundamental frequency was significantly increased after vocal training. On average, Voice Handicap Index–10 scores were unchanged after vocal training.

Conclusion. The cohort of drama students undergoing vocal training demonstrated improvements in voice aerodynamics, which indicate enhanced glottal efficiency after training. The present study also found an increased average fundamental frequency among the actors during sustained voicing and no changes in jitter and shimmer despite frequent performance.

Keywords

voice, speech acoustics, drama, speech-language pathology, laryngology, voice training, vocal cords

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Actors and other professional voice users must rely on consistent vocal capabilities to deliver good performances. Due to the unique demands placed on the voice during repeated performances, including harsh vocal behaviors (screaming, shouting, crying, etc), actors are at high risk for vocal pathology.[1] They also must often modulate their volume and pitch beyond the boundaries of typical conversation to portray characters on the stage. Vocal training programs are utilized in many acting schools and among professional voice users, with the intent of improving vocal capabilities to meet these demands and to limit potential damage to the voice.[2] Although there is anecdotal support that such vocal training is useful to voice professionals, it remains unclear what impact vocal training has on acoustic and aerodynamic measures of the voice.

Vocal training programs, such as those employed in drama schools, are varied but typically focus on breath control as one of the central aspects of training.[2,3] The Alexander technique, for example, is one such commonly used training method that teaches release of muscle tension associated with performance fatigue and is thought to enhance respiratory muscle function.[4] The Alexander technique is a method of self-care that targets improvement in posture, respiratory function, and vocal quality. Practitioners view it as a way to alleviate the pain and stress caused by everyday misuse of the body. F. M. Alexander was an actor who solved his vocal difficulties by identifying the faulty habits that interfered with his ability to function optimally. Today, students of this technique, including actors, aim to rid themselves of tension.

To differing degrees, various vocal training techniques also teach vocal hygiene and control over posture to optimize efficient use of the voice. There is evidence that vocal training may even lead to changes in voice projection, resonance, and laryngeal and pharyngeal activities visible on laryngoscopy, such as increased anterior-to-posterior

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squeeze and medial laryngeal compression, when compared with untrained individuals.[5-7]

The aim of this study is to measure the effect of vocal training on acoustic and aerodynamic characteristics of student actors' voices during their first year of drama school. This was accomplished by collecting acoustic and aerodynamic data and Voice Handicap Index–10 (VHI-10) scores before and after 8 months of training among 14 first-year students at the Yale School of Drama. These actors have a vocal training curriculum that includes traditional methods such as the Alexander technique. We hypothesized that by participating in a curriculum that employs common vocal training techniques, there would be an impact on the acoustic and aerodynamic qualities of subjects' voices.

Methods

This study was approved by the Yale University Human Investigation Committee. Informed consent was obtained from all subjects prior to their participation.

Subjects

All actively enrolled first-year students at the Yale School of Drama were invited to participate in this study, and 14 elected to do so. These students participated in voice and speech training classes as part of the standard drama curriculum. Each subject was evaluated before and after vocal training for aerodynamic, acoustic, and VHI-10 measures. For all subjects, stroboscopy was performed at each visit to screen for vocal abnormalities. There were no exclusionary criteria.

Vocal Training

All subjects in this study were enrolled in a vocal training program that included separate curricula for voice, speech and dialects, singing, and the Alexander technique. The program totaled 27 weeks, with 2.75 hours per week devoted to voice training, 2.75 hours devoted to speech and dialects, 1.5 hours devoted to singing, and 2 hours devoted to the Alexander technique. The vocal training curriculum was not interrupted for performance requirements. In addition to required course meetings, students were expected to practice voice exercises outside the classroom.

Within the voice curriculum, students progressed through exercises that aimed to develop detailed proprioceptive awareness and understanding of the anatomy and physiology of breathing coordination and sound making. The voice instruction utilized imagery, kinesthetic tools, and muscular release exercises with a stated goal of undoing habitual patterns of tension and overeffort. A variety of exercises were used that promote ease and efficiency in voice production. A central goal was for students to learn to "do more" with less effort and develop greater voice strength and stamina. In addition, the students explored resonance and were encouraged to develop a greater capacity for vocal range and expressivity.

Questionnaire

Before acoustic and aerodynamic measures were collected, subjects were required to complete the VHI-10 questionnaire, as described and validated by Rosen et al.[8] This questionnaire was selected because it has been validated and widely used as a tool to detect self-perceived voice handicap before and after vocal intervention.

Voice Acoustic Procedures

All voice acoustic and aerodynamic data were collected and analyzed in the Yale Speech and Swallow Center. A comprehensive battery of tasks was performed to make a thorough assessment of voice acoustics and aerodynamics. Acoustic data were collected with the KayPENTAX Visi-Pitch IV (model 3950; PENTAX Medical Company, Lincoln Park, New Jersey) with voice recordings collected on Real-time Pitch to obtain MPT (maximum phonation time), MF_0 (mean fundamental frequency), and MF_0V (MF_0 during voicing). The Multi-dimensional Voice Program was used to further analyze the raw sample recording to obtain RAP (relative average perturbation) and shimmer.

MPT was collected by instructing subjects to sustain the vowel /a/ at a comfortable pitch and loudness for as long as possible with a single breath. MF_0, the rate of vocal cord vibration per second (Hz), was subsequently extracted by the Real-time Pitch module from the MPT voice recording. MF_0V was obtained by instructing subjects to recite a sample text passage from *Oedipus the King*, by Sophocles, and measuring the associated fundamental frequency.

The raw voice sample recording used to obtain MF_0 was then imported into the Multi-dimensional Voice Program, which calculated the associated RAP and shimmer—to evaluate the variability of the pitch and peak-to-peak amplitude within the voice sample, respectively.

Voice Aerodynamic Procedures

Aerodynamic data were collected with the KayPENTAX Phonatory Aerodynamic System (PAS; model 6600, PENTAX Medical Company). VC (vital capacity) was obtained with the Vital Capacity Protocol, which instructs the subject to inhale maximally, to place the PAS mask firmly against the face for a tight seal, and then to exhale maximally.

MEA (mean expiratory airflow) was obtained by measuring the volume of air used during sustained phonation at a comfortable pitch and loudness. The Voicing Efficiency Protocol was used to obtain MEAV (MEA during voicing) and AR (aerodynamic resistance). For this protocol, the subjects were asked to take a breath and then repeat the syllable *pa* 5 to 7 times on a single breath, with a repetition goal rate of 1.5 to 2 syllables per second. From this recording, 3 similar consecutive instances of /pa/ were analyzed with the PAS software. AR and MEAV were calculated by the PAS software based on measurements of air pressure and airflow level during the plosive consonant "p" and vowel "a,"

Table 1. All Subjects.

	Mean ± SD			
	Pretraining (n = 14)	Posttraining (n = 13)	Difference	*P* Value
Aerodynamic measures				
VC, L	4.00 ± 0.6	4.18 ± 1.0	0.18	.56
MEA, L/s	0.25 ± 0.1	0.17 ± 0.1	−0.08	.01[a]
MEAV, L/s	0.19 ± 0.1	0.15 ± 0.1	−0.04	.10
AR, $cmH_2O/(L/s)$	48.0 ± 39	38.0 ± 18	−10.0	.39
MPT, s	13.77 ± 5.7	13.85 ± 5.9	0.08	.37
Acoustic measures				
Mean F_0, Hz	146.7 ± 42	150.5 ± 42	3.8	.03[a]
Mean F_0V, Hz	168.3 ± 52	166.8 ± 53[b]	−1.5	.55
RAP, %	0.70 ± 0.5	0.60 ± 0.4	−0.10	.43
Shimmer, %	0.33 ± 0.2	0.26 ± 0.1	−0.07	.33
VHI-10	7.29 ± 2.9	7.08 ± 4.5[b]	−0.21	.89

Abbreviations: AR, aerodynamic resistance; MEA, mean expiratory airflow; MEAV, mean expiratory airflow during voicing; mean F_0, mean fundamental frequency; mean F_0V, mean fundamental frequency during voicing; RAP, relative average perturbation; VC, vital capacity; VHI-10, Voice Handicap Index–10.
[a]$P < .05$.
[b]For this measure, n = 12.

respectively. Glottal pressure, which is used to calculate AR, is approximated by measuring intraoral pressure at the release of the plosive ''p.''

Statistical Analysis

Descriptive statistics and the results of voice parameters and questionnaires were calculated for the total study population and according to male and female sex. Statistical significance between the actors' acoustic data before and after training was determined with a paired 2-tailed Student's t test. $P < .05$ was considered statistically significant. All statistical analysis was performed with Microsoft Excel.

Results

Subjects

A total of 14 first-year drama students were evaluated in August 2015, at the beginning of the academic year, and in April 2016, at the end of the academic year. There were 7 female and 7 male subjects included in the study. The mean (SD) age of all subjects at the initial evaluation was 24.9 (2.3) years. The mean age of the male subjects was 25.3 (1.8) years, and that of the female subjects was 24.6 (2.8) years. One female subject failed to complete the posttraining VHI-10 questionnaire, acoustic measures, and aerodynamic measures; 1 male subject failed to complete the posttraining VHI-10 questionnaire; and 1 male subject is missing a posttraining data point for MF_0. Missing data points were excluded from analysis.

Aerodynamic and Acoustic Measures and VHI-10

Table 1 summarizes mean aerodynamic and acoustic measures and VHI-10 scores for all subjects pre- and posttraining. **Tables 2** and **3** summarize the findings by male and female sex, respectively. Among all subjects, the mean (SD) MEA decreased significantly after voice training from 0.25 (0.1) L/s to 0.17 (0.1) L/s (P = .01). There was also a significant increase in mean MF_0 during comfortable sustained phonation after voice training, from 146.7 (42) Hz to 150.5 (42) Hz (P = .03). Among all subjects, there were no statistically significant changes in mean VC, MPT, RAP, shimmer, AR, or VHI-10 score.

In the male subgroup, there was a statistically significant increase in mean (SD) VC after vocal training, from 4.27 (0.7) L to 4.83 (0.5) L (P = .01). There were no other statistically significant changes among the measured parameters in the male subgroup.

In the female subgroup, there were no statistically significant differences in the VHI-10, aerodynamic, or acoustic measures after vocal training.

Discussion

During the 8-month interval between pre- and posttraining voice measurements, the subjects not only underwent vocal training but also were preparing for and performing in theater. Therefore, the data presented in this study represent change in voice characteristics as a result of training and as an outcome of significant vocal use over a period of 8 months. The perceived positive impact of training on the voice must be considered as counteracting some likely detrimental impact from performance. In the present study, we found among all subjects that aerodynamic and acoustic measurements of voice, represented by MEA and MF_0, changed significantly after 8 months of vocal training.

The aerodynamic measures of voice yield important information about respiratory and laryngeal function. For example, increased MPT, though not statistically significant in the present study, suggests increased respiratory control and phonatory endurance. Prior studies of professionals

Table 2. Male Subjects.

	Mean ± SD			
	Pretraining (n = 7)	Posttraining (n = 7)	Difference	*P* Value
Aerodynamic measures				
VC, L	4.27 ± 0.7	4.83 ± 0.5	0.56	.01[a]
MEA, L/s	0.24 ± 0.2	0.17 ± 0.1	−0.07	.08
MEAV, L/s	0.23 ± 0.1	0.19 ± 0.0	−0.04	.16
AR, $cmH_2O/(L/s)$	31.4 ± 17.4	24.6 ± 4.2	−6.8	.35
MPT, s	13.77 ± 6.0	14.89 ± 6.5	1.12	.25
Acoustic measures				
Mean F_0, Hz	109.9 ± 18.0	116.1 ± 17.7[b]	6.2	.17
Mean F_0V, Hz	123.3 ± 30.0	119.7 ± 23.7	−3.6	.29
RAP, %	0.53 ± 0.3	0.56 ± 0.4	0.03	.80
Shimmer, %	0.25 ± 0.1	0.27 ± 0.1	0.02	.54
VHI-10	8.42 ± 2.9	7.83 ± 5.2[b]	−0.59	.93

Abbreviations: AR, aerodynamic resistance; MEA, mean expiratory airflow; MEAV, mean expiratory airflow during voicing; mean F_0, mean fundamental frequency; mean F_0V, mean fundamental frequency during voicing; RAP, relative average perturbation; VC, vital capacity; VHI-10, Voice Handicap Index–10.
[a]$P < .05$.
[a]For this measure, n = 6.

Table 3. Female Subjects.

	Mean ± SD			
	Pretraining (n = 7)	Posttraining (n = 6)	Difference	*P* Value
Aerodynamic measures				
VC, L	3.74 ± 0.4	3.43 ± 0.8	−0.31	.17
MEA, L/s	0.25 ± 0.1	0.17 ± 0.1	−0.08	.09
MEAV, L/s	0.14 ± 0.1	0.12 ± 0.0	−0.02	.43
AR, $cmH_2O/(L/s)$	64.6 ± 49.3	53.7 ± 15.2	−10.9	.60
MPT, s	13.8 ± 5.9	12.6 ± 5.5	−1.2	.47
Acoustic measures				
Mean F_0, Hz	183.5 ± 18	190.6 ± 17	7.1	.14
Mean F_0V, Hz	213.2 ± 15	213.9 ± 20	0.7	.89
RAP, %	0.87 ± 0.5	0.65 ± 0.4	−0.22	.35
Shimmer, %	0.40 ± 0.3	0.26 ± 0.1	−0.14	.28
VHI-10	6.14 ± 2.5	6.33 ± 4.0	0.19	.80

Abbreviations: AR, aerodynamic resistance; MEA, mean expiratory airflow; MEAV, mean expiratory airflow during voicing; mean F_0, mean fundamental frequency; mean F_0V, mean fundamental frequency during voicing; RAP, relative average perturbation; VC, vital capacity; VHI-10, Voice Handicap Index–10.

undergoing vocal training programs found increased MPT to be the most prominent change to occur after training[3]; however, this finding is not consistent across all such studies.[9] Whether in terms of the entire group or the female and male subgroups, the subjects in our study had no significant change in mean MPT after the 8-month training period.

The male subgroup in this study had increased VC after vocal training. VC is the sum of tidal volume and inspiratory and expiratory reserve volumes. Interestingly, increasing VC has also been observed in choir singers when compared with nonsingers, people who attend yoga class regularly, and people who have engaged in respiratory muscle training.[10] In a study by Irzaldy et al of choir singers, the increased VC was theorized to be from the expiratory phase of the respiration, which plays the biggest role in physically producing voice. Likewise, in the present study, we may interpret an increased VC to be the result of vocal training that may have positive effects on the diaphragm from regular exercise. However, the claim that vocal training causes increased VC needs further investigation. This change was seen in only the male subgroup, and the available aerodynamic data are not detailed enough to determine which aspect of respiration accounts for the increase in VC. In addition, some of the variation in VC may be test-retest variability.

After vocal training, the total subjects of the present study did have a statistically significant decrease in MEA during comfortable sustained phonation. There was no statistically significant change that occurred to MEAV in the total, female, or male group. The difference in mean MEA (a decrease of 0.08 L/s among total subjects) before and after training is considered to be greater than the expected variation in young, healthy populations of men and women.[11] Therefore, these findings are not only statistically significant but clinically significant as well.

These findings reveal that one of the most significant changes in the way that professionals undergoing formal voice training use their voices may be in glottal efficiency. The significant reduction in MEA is evidence that the actors are using less air to produce sustained phonation, thereby extending the efficiency of their larynx and reducing effort. This would presumably be of great benefit to professionals from whom prolonged speech or song is required, possibly accompanied by action on the stage and bodily movement. To our knowledge, this finding has not been reported before, but it illustrates the aerodynamic benefits of vocal training. Interestingly, the authors of a separate study between nonactors and actors with at least 3 years of formal vocal training found a significant increase in MEA during sustained comfortable phonation among the trained actors.[6] In that context, the authors explained that lower glottal resistance or high subglottic pressure among the trained actors could account for the difference. Increased laryngeal tension, such as that seen in muscle tension dysphonia, can also account for decreases in MEA[3]; however, such patterns of aerodynamic change are usually accompanied by significantly shorter MPT, which was not observed in our subjects.[12] The Alexander technique is a prominent aspect of the vocal training curriculum in this study and places an emphasis on relieving muscle tension. Our findings seem to be consistent with a decrease in MEA as a result of reduced effort, improved glottal efficiency, and not increased laryngeal muscle tension.

In terms of acoustic measures of voice, among all subjects we found a significant increase in mean F_0 after the 8-month training period. This difference of 3.8 Hz after training reflects that the actors increased their pitch during sustained voicing, but a related increase was not found with the speaking protocol (MF_0V). The reason for the increase in average fundamental frequency among the subjects in this study is unclear. The increase in MF_0 is small but may represent changes in voice resonance or suggest that after training the actors are finding increased glottal efficiency at higher pitches during sustained voicing. However, the clinical significant of this change is debatable. A previous study of test-retest reliability of MF_0 in healthy adults demonstrated an expected range of variation of 19.81 to 24.26 Hz (minimum difference) between test encounters.[11] In summary, across our study population, there was a statistically significant decrease in MF_0, but the average decrease in pitch may be considered of small clinical significance.

Our data show that the voice perturbation variables measured in this study were not significantly changed after the training period, despite heavy voice use during the 8-month interval. By comparison, in a study of actors before and after training in a hygienic laryngeal release technique, Roy et al found that several acoustic measures, including shimmer, had improved significantly after the training period.[2] In contrast, Walzak et al found a significant increase in shimmer for all participants after 12 months of training.[9] As suggested by other authors, it is possible that voice training provides protection against the detrimental effects of vocal violence that may lead to poorer voice quality, as would be expected in perturbation variables.[2] Therefore, the finding that perturbation measures did not worsen over time may reflect a stabilizing effect of training. However, without a control arm of the present study (ie, acting students without a voice training curriculum), we cannot be certain.

A study by Timmermans et al found that after 9 months of voice training, a group consisting of stage actors, musical actors, and radio presenters showed significant improvements in DSI (dysphonia severity index) and Voice Handicap Index, suggesting an overall improvement in voice quality.[13] By comparison, our actors showed no significant difference in their VHI-10 score before and after voice training, suggesting that they have no perceived improvement or worsening of overall voice quality and subjective satisfaction with their voices.

There are limitations to this study. One limitation is that there is no control arm that would elucidate the natural history of vocal changes among actors without a vocal training curriculum. A second limitation is that this is a single-center study of students at a single professional school of drama; it is likely that there is substantial variation in the voice-training curricula among various schools, which could lead to different outcomes in changes of acoustic and aerodynamic measures after training. A third limitation is the relatively small sample size, which likely limits the statistical power of our analysis. Finally, the VHI-10 is a voice handicap assessment instrument that is typically used to evaluate patients presenting with voice complaints. The study population of the present research was without laryngeal pathology and was not presenting for voice complaints; therefore, the VHI-10 may have limited sensitivity to discriminate for change before and after vocal training within this population. In the future, an alternative validated questionnaire specific to performers may be selected to evaluate subjects' self-perception of voice function, which may be of use in detecting more subtle differences before and after training.

Conclusion

This study aimed to measure the effect of formal voice training on student actors' voices during professional training in the dramatic arts. We found improvements in voice aerodynamics that seem to indicate enhanced glottal efficiency after training and increased VC in male subjects.

The present study also found an increased average fundamental frequency among the actors during sustained voicing and no changes in jitter and shimmer despite frequent performance. We plan to continue to follow these actors and more as they continue their studies, to examine how these parameters of voice may change further during their education, as it is still unclear how the voice will change with further training.

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Author Contributions

Jacob I. Tower, acquisition, analysis, and interpretation of data, statistical analysis, drafting of the manuscript; **Lynn Acton**, acquisition, analysis, and interpretation of data, critical revision of the manuscript; **Jessica Wolf**, study concept and design, critical revision of the manuscript; **Walton Wilson**, study concept and design, critical revision of the manuscript; **Nwanmegha Young**, study concept and design, study supervision, critical revision of the manuscript.

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