

# The Effect of a Singing Protocol on Identified Vocal Inefficiencies of a Post-Menopausal Singer: A Case Study

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## Abstract

The purpose of this case study was to assess over the course of 12 weeks the effect of a researcher-designed singing protocol on the documented vocal inefficiencies of a 63 year old post-menopausal singer, as measured by pre- and post-laryngeal examinations, spectral analyses, and written reports by both participant and voice teacher. At the beginning of the study, the participant displayed laryngeal and pharyngeal muscle tension, and reported difficulty accessing higher frequencies with hoarseness and effortful vocal production. During weeks 2 to 11, the participant attended a weekly voice lesson and practiced five days each week with a vocal exercise tape consisting of seven exercises, with the instruction to sing only the given exercises during this period of time. Post-protocol assessments during week 12 indicated reduced laryngeal and pharyngeal muscle tension, less effortful vocal production, more accurate fundamental frequencies, and more positive self-reports. Though she had previously transitioned to singing the alto part in her choir due to vocal discomfort, following the protocol the participant rejoined the second soprano section of that choir.

## Introduction

Numerous research studies focus on speech issues for aging people, but comparatively few studies examine the aging singer (for example, Verdonck, 2004; Benninger, Jacobson, & Johnson, 1994; Linville, 2001; Xue, 2003). Still fewer specifically target the aging *female* singer (Davis, 2000, Peppard, 1990) who experiences the effects of menopause and hormonal loss (Abitbol, 1999; Houden & Austin, 1991), in addition to factors typically associated with aging in general.

The aging of major body systems – neurological, circulatory, and respiratory – has been reported to increase problems in vocal production (Baker, Ramig, Sapir, Luschei, & Smith, 2001). Among others, Gambino, Malmgren, Gacek (1990) and Choo, Malmgren, Rosenberg (1990) examined the recurrent laryngeal nerve and the superior laryngeal nerve in aging voices. Their studies appeared to show the possibility of substantial age-related changes in the form of neuropathy. Leden and Alessi (1994) noted that age-associated neurologic diseases, such as stroke and Parkinson's Disease, were detrimental to the voice. Bach, Lederer, Dinolt (1941), Orlikoff (1991), and Mueller, Sweeney, and Baribeau (1984), and others, reported that the aging circulatory system in the body resulted in a decrease in blood supply to the larynx. Baker, *et al.* (2001), and Awan (2004) indicated that respiration in older individuals required more respiratory support in order to achieve adequate levels of airflow and air pressure for speech. They further reported that the expiratory airstream could be affected negatively by age-related differences in the intrinsic laryngeal muscles.

Researchers have found general aging traits in the laryngeal structure as well as these larger body systems. Biever and Bless (1989) related results from videostroboscopic examinations that indicated elderly women's laryngeal function was characterized by greater aperiodic vocal fold

vibration, incomplete glottal closure, mucosal wave alterations, and reduced amplitude when compared to younger women's vocal function. Stemple (2000) reported that geriatric men and women often complained of voice weakness and fatigue, partly due to a decrease in muscle fibres, a stiffening of the vocal fold cover, cross-linking of fibres in the lamina propria, and continued calcification of the laryngeal cartilages. Kahane (1987) stated that ossification of the larynx began after the fifth decade of life for women. Kahane (1990) argued further that the epithelium also attached less firmly to the lamina propria underneath, affecting the whole structure, which increased perturbation during phonation. Hirano, Kurita, and Sakaguchi (1981) reported that the epithelium increased progressively in females, particularly after the age of 70.

Though there has been little study on the cricothyroid muscle in this regard, Linville (2001) stated that the cricothyroid muscle hypertrophied as it compensated for atrophy in other intrinsic muscles. Baker, *et al.* (2001) reported that increased laryngeal muscle activity, particularly from the cricothyroid, occurred when individuals attempted a higher vocal dynamic level. The thyroarytenoid muscle showed significant changes which included atrophy, decrease in fiber diameter, and degeneration (Kersing, 1986; Sato & Tauchi, 1982). Segre (1971) suggested that the tight enarthrosic joint, formed by the arytenoids and the cricoid, showed the impact of aging through a loosening of the capsule and the erosion of joint surfaces. As a result, the approximation of the arytenoids was jeopardized.

Arthritis, a frequent problem in aging bodies, has been studied in regards to the larynx as well. Paulsen and Tillmann (1998) examined the occurrence of arthritis in the cricoarytenoid joint in  $N=42$  CAJs (13 men and 18 women, aged 42 to 98 years). Osteoarthritis in this joint was demonstrable in people aged 40 or older, increasing to 50% in the elderly. Paulsen and Tillmann compared this condition to arthritis in limb joints and stated that it possibly impaired gross positional and postural movements in the arytenoid cartilage. They suggested further that increased subglottal pressure was potentially necessary to overcome age-related stiffness in the vocal folds, and that glottal closure was compromised. Sapienza and Dutka (1996) pointed to arthritis of the cricoarytenoid joint, possibly causing thinning and irregularities in the articular surfaces.

For women, menopause with its inevitable loss of hormones was a contributing factor in the aging voice. Abitbol (1999) tested  $N=100$  menopausal women and reported that there was a slight loss of *staccato* speed, and loss of intensity on the extremes of vocal range, decreased range, and a loss of formants in the high tones. These findings supported the complaint of the tested singers that they first noticed their vocal deterioration in high pitches and *pianissimos*. Further, the researcher indicated that, when compared with cervical smears, vocal fold smears showed the same mucosal subatrophy with basophils and a significant reduction of glandular cells. This comparison showed a correlation between the reduction of mucous in the larynx and the same mucosal reduction in the female reproductive system, often associated with menopause. Many studies (Brown, Morris, Hollien, & Howell, 1991; Honjo & Isshiki, 1980, Abitbol, Abitbol, & Abitbol, 1999, Hirano, Kurita, & Sakaguchi, 1989, to list a few) have shown that fundamental pitch is lowered by loss of estrogen. Linville (1987) reported that the most notable moment of fundamental frequency reduction in the woman's voice occurred when that woman has finished menopause.

In an effort to study the effect of voice therapy in female singers in this period of life, Mueller (1990) evaluated the voice of elderly patients before and after voice therapy, and found that all patients remarked on the improvement in their voices. Stemple (2000) reported success with geriatric patients when using a systematic vocal exercise program as a means of strengthening voice production. He indicated that such a program improved the relationships

of the three subsystems of voice production: respiration, phonation, and resonance. Parks (2006) found singers over the age of 60 showed statistically significant improvement in a number of vocal abilities, including range and breath, after 10 weeks of voice instruction. Davis (2000) conducted a study on the change of vibrato rate in the female voice over the age of 50, and included a voice protocol as well. She reported that positive change occurred in the vibrato rate of her participants ( $N=21$  women between the ages of 53 to 74) when using a targeted practice. Given practice tapes, the study divided the women into two groups: one group using non-singing, isometric-isotonic exercises called vocal function exercises; and the other group using standard singing exercises. They were each asked to practice with their tapes daily, after being given a lesson to describe how to use them. All subjects filled out a voice usage questionnaire, kept a daily practice log, and had pre-, mid-, and post-testing sessions. Davis reported that the structured practice routine itself made the difference in the vibrato rate. Both types of exercises were found to be effective, with the vocal function exercises being slightly more so, though statistically non-significant.

The purpose of this case study is to assess, over the course of 12 weeks, the effect of a researcher-designed singing protocol on the documented vocal inefficiencies of a post-menopausal singer, as measured by pre- and post-laryngeal examinations by an otolaryngologist, spectral analyses, and written reports by both participant and voice teacher. To that, the following research questions guided this investigation:

1. Is there an observable difference between pre- and post-laryngeal examinations, as determined by an otolaryngologist?
2. What do the pre- and post-visual inspections of sung spectral data, as viewed through VoceVista software, suggest with respect to possible effects of the singing protocol on the acoustical dimensions of this singer's vocal production?
3. What do journal entries, short-answer questionnaires, and survey forms by both participant and voice teacher suggest with respect to the particular protocol used?

## Method

### Participant

This 63 year old, Caucasian, petite, astute, energetic woman was a lifelong choral singer who had always considered herself a soprano. "Mary" had taken voice lessons with her choral conductor for a year prior to the study, as well as intermittent lessons throughout her singing life, and believed she had learned to inhale appropriately for a singer's breath. She possessed a good ear and was a fairly proficient sight-reader. In recent years previous to this study, she had begun singing alto in her choir as she experienced more vocal difficulty. Through a pre-study self-evaluation she reported her problems were as follows: (a) difficulty with high notes, (b) effortful voice production, (c) throat tightness, (d) *passaggio* breaks, and (e) hoarseness. Though she stated that these inadequacies had been more acute in the last two to three years, she had never been satisfied with her singing technique, and, therefore, had never ventured into solo singing. At this point, she found her voice unreliable, particularly in the *passaggi*, breaking at odd times and her high range (head voice) virtually absent.

Mary had never seen a physician regarding voice problems previously, nor did she consider herself a sufferer of allergies. A non-smoker, she kept regular waking and sleeping hours and

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was recently retired. Typical of a choral singer, she found her voice usage to be athletic twice a week – at a weekly rehearsal and on Sundays.

The participant was taking a number of medications and supplements, including a form of hormone replacement therapy that she had taken in various dosages since 1994. These medications and supplements were: a. Hormone replacement Combipatch 50/140, b. Lisinopril 20 mg, c. Hydrochlorothiazide 25 mg for blood pressure regulation, d. Aspirin 81mg, e. Vitamin D 800IU, f. Multi-Vitamin, g. Vitamin C 500 mg, h. Calcium 1260 mg, i. Vitamin B-6 200 mg, and j. Melatonin 300 mcg. She drank caffeinated (three daily) and alcoholic beverages (approximately one daily), but also hydrated with at least five water beverages daily. She exercised regularly and reported overall good health.

### Assessment phase: Procedures and equipment

Before participation, the participant had a consultation and a videostroboscopic examination by an otolaryngologist who reported no abnormal physiological problems, with some evidence of mild acid reflux disease. He noted that there was substantial pharyngeal wall tension in her singing as well as excessive muscular tension within the larynx. This tension appeared greater in higher registrations. Her vocal folds were completely healthy in appearance, with the presence of some thick mucous (Figure 1).



*Figure 1. Participant's vocal folds exhibiting general health with mucous.*

For assessing acoustically-measured voice production, we used the spectral tool VoceVista, a software program that displayed a spectrogram and other acoustic analyses. The sample sung by the participant was comprised of three exercises (Figure 2). The third exercise, a descending triad, she inadvertently converted at times to descending seconds, so both are notated in Figure 2.

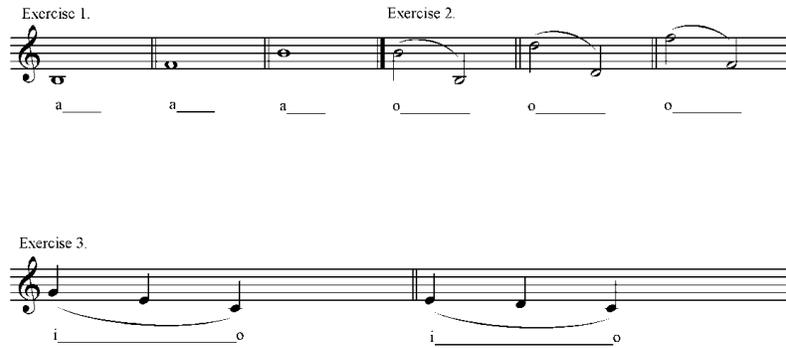


Figure 2. VoceVista pre- and post-test exercises.

A Sony Electret condenser microphone was used to record into a Compac, Presario V3000 computer. The microphone was held approximately 4 inches from the subject's mouth, and the recordings were made in a typical instructional setting: a quiet room with a piano with only the subject and instructor present, though no specific sound-proofing was employed.

The participant completed a self-evaluation form rating her perceived vocal quality, breath control, range, and vocal and general health on a Likert-type scale 1 to 7. She also completed a vocal health history questionnaire.

### Protocol phase: Design

The researcher for this study was also the voice teacher for the singing protocol. At her first session following the spectrogram analysis, the participant was given a taped recording of seven exercises to be practiced five days a week. These exercises centered on the middle and lower female voice, using pitches from G<sub>3</sub> to the Bb<sub>4</sub>. Pitches were chosen for ease of production on this first visit, after some experimenting to find where the subject was the most vocally comfortable. Initially, her vocal production was effortful and limited in range from A<sub>3</sub> to C<sub>5</sub>, which she seemingly managed by means of extrinsic/intrinsic muscle push. She was advised by the researcher to sing approximately 10 minutes of the taped exercises per day at first, not going beyond what was comfortable. As time progressed, she could expand the practice time. The regularity, frequency, and consistency of practice were viewed as a vital part of the singing protocol, in addition to the exercises themselves.

At her initial lesson, Mary demonstrated that she had a good grasp on inhalation, but no understanding of *appoggio*, the balanced action of gently resisting the airflow at the epigastric area while providing a consistent airstream to the vocal folds. She worked on this concept through lip trills as well as a sighing, descending 5<sup>th</sup> exercise to connect the sense of breath and body engagement to her phonation. Before she tried the descending 5<sup>th</sup> /i-u-i-u-i/ exercise, she was asked to explore some siren sounds on /u/. Initially, she had no idea of how to produce the siren sound and engage her head voice. As some freedom and breath connection evolved, she was instructed to use her arm in a circular motion to help her visualize the pattern, and provide a kinesthetic aid to her vocalizing.

Resonance was introduced in the second lesson by explaining the concept of registers – chest, middle, and head – with the idea that one has to lighten the weighty feeling of the voice as one ascends. Mary explored the idea of imagining the focus of the voice to be small and central with an easy production, thinking of this sound in the eye area more and more as the

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pitch ascended. This image was used to help her sense the resonance travelling from the chest register and moving up the vocal tract, rather than at the glottal source. Her default production was perceived by the voice teacher to be primarily thyroarytenoid muscle-based, with chest register predominant in all pitch areas. Considerable jaw and tongue tension was present as she had consistently replaced breath connection with jaw, tongue, and extrinsic muscle support.

All seven exercises were explored at each lesson except for the first where only the initial four were introduced, due to the time constraints and a desire on the part of the researcher not to overwhelm the participant. Several lessons were video-taped for reliability purposes. Verbal instructions were given at each lesson, reinforcing positive progress. Demonstrations were occasionally used, with slight adjustments made to the exercises as needed. The participant continued her weekly choir practice, but agreed, otherwise, to practice only the specific exercises given with her tape. She did not practice solo songs until the study was complete.

After her fifth weekly lesson, the participant was given a new tape with the same exercises. Range was extended in each to reflect her vocal development over the weeks of study ( $F_3$  to  $G_5$  for most of the exercises). These exercises, both beginning and with modification (second examples when a pair are given), are represented in Figure 3.

Exercise 1.                      Exercise 2.                      Exercise 3.

bbbb (lip trill)                      sigh                      si - a                      i - u - i - u - i

Exercise 4.                      Exercise 5.

mi - va - mi - va - mi                      mi - ya ha ha ha ha ha

Exercise 6.                      Exercise 7.

i - ya                      i - ya                      mi - me - ma - mo - mu

Figure 3. Singing protocol exercises used five days a week.

In summary, the study extended over 12 weeks and included two laryngeal examinations, 10 weeks of instruction and practice, and 2 spectrograms. Each week the participant kept a journal, rating vocal freedom, breath control, and vocal health weekly on a Likert-type scale from 1 to 7, as well as recording specific notes on what she observed about her daily practice.

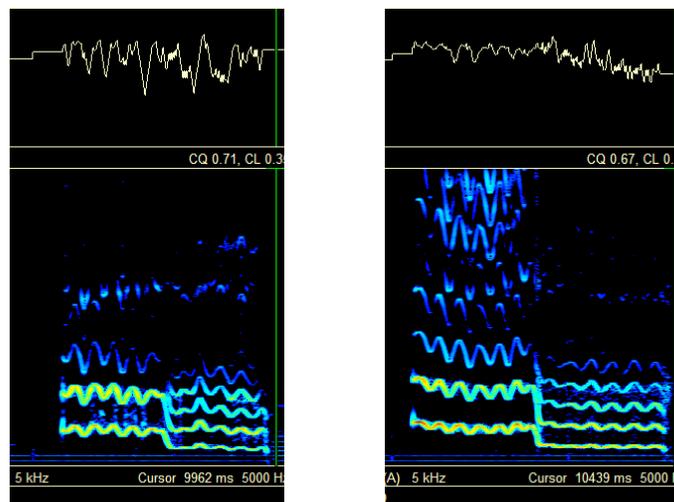
### Post-Protocol Phase: Evaluation

At the conclusion, a follow-up videostroboscopic examination by the otolaryngologist was administered. The second spectrogram on VoceVista was made, employing the same exercises used in the first, to chart any changes that may have occurred. Additionally, the participant completed a post-self-evaluation form, consisting of the same questions as the pre-self evaluation. A post-study questionnaire was administered, querying the effectiveness of the protocol from the point of view of the participant.

## Results

Results are organized according to the research questions posed for this investigation. Research question one inquired about observable differences between pre- and post-laryngeal examinations by an otolaryngologist. Results indicated observable differences in pharyngeal/laryngeal muscular tension. Previously, there was considerable inappropriate tension to close the glottis and phonate, particularly in high frequencies. The otolaryngologist noted that this tension was absent in the re-examination. He also noted that the vocal folds had become slightly bowed, allowing for breathiness to occur. Though bowing was not the desired outcome, he stated that freeing tensions had resulted in glottal gapping – a positive step in his view, as well as one to be expected in the limited time frame. His recommendation was for the participant to continue technical vocal instruction with a singing voice teacher to learn to engage properly the appropriate musculature for glottal closure.

Research question two asked what the spectral software, VoceVista, might reveal in terms of vocal inefficiencies and the possible effects of the singing protocol. It was employed at the beginning of the study, and repeated at the conclusion. In her initial attempts, pitch was given for the three exercises, but her ability to reproduce and/or maintain pitch was inconsistent. A descending triad was converted to either a mixture of a third with a second, or to descending seconds. Because of the inability to produce a lighter mechanism, Mary often sang the given pitches that were higher than  $Bb_4$  as much as a whole tone lower. The spectrogram showed noise elements in many tones as well as glottal attacks and releases. In freezing the spectrogram frame of a single exercise on the vowel /a/ on descending octave fs, there was a lack of overtones pictured as recorded on VoceVista (Figure 4).



Figures 4 and 5. VoceVista pre-study spectrogram (left) and post-study spectrogram (right) on a section of the vowel /a/ on descending octave fs.

In contrast, there were marked differences in the follow-up spectrogram (Figure 5). Pitch was better-achieved each time and well maintained throughout the exercise. The descending triad was sung accurately. Glottal attacks and releases were infrequent. Noise was still an element due to some aspirate tones, but overtones were nicely present in viewing the vowel /a/

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in the descending *f* octaves (Figure 5). The two spectrogram frames in Figures 4 and 5 represent the same exercise, and the same place in the exercise, only 12 weeks apart.

Research question three queried what journal entries and other reports by the participant and teacher would indicate regarding the singing protocol. Mary kept a weekly journal that contained four questions, three of which used a Likert-type scale: (a) How would you rate the freedom in your singing voice this week? (b) How would you rate your breath control this week? and (c) How would you rate your overall vocal health this week? In question number one, “freedom” referred to how easy and tension-free the vocal production felt to the participant. In question two, “breath control” referred to the sensation on the part of the participant that she had sufficient air on which to sing her exercises, and that she was successful in distributing this air across the demands of the exercise. In question three, “vocal health” referred to the feeling of wellness in her vocal production – a lack of congestion, soreness, fatigue, or hoarseness. Number one of the seven-degree scale was labelled “not very free,” number four was “moderately free,” and seven was “very free” in the first question. Questions two and three used the same scale but number one was labelled “poor;” number four, “moderate;” and number seven, “good.” These results can be viewed in Figure 6.

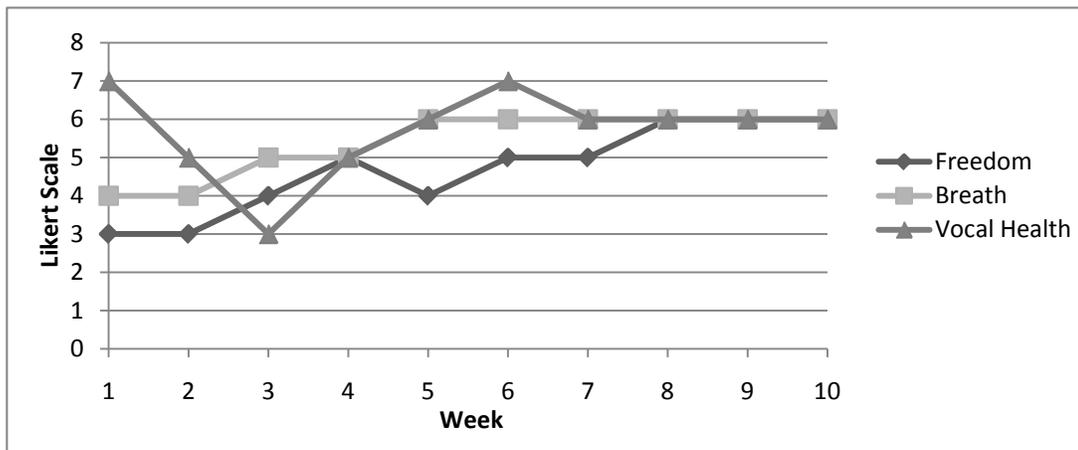


Figure 6. Weekly voice journal responses by participant.

There was also opportunity for written comments on the journal page. Mary was diligent in writing comments that included:

- “I experience more success when I think about moving air and relaxing my jaw rather than producing a good tone... (personal communication, Week 1).”
- “In the *staccato*, it helps to touch the first note lightly... (personal communication, Week 2).”
- “Italian vowels – I found a forward ‘Ah, (yea!) and it helped the ‘oh’ also... (personal communication, Week 3).”
- “Surprised that higher notes are generally easier than some lower notes in the transition range – and sounded better... (personal communication, Week 4).”
- “No new observations – highest notes a stretch – sometimes I get them, sometimes, not... (personal communication, Week 5).”
- “I am not sure the exercise is translating sufficiently to the offending muscles. I suspect I’m just impatient... (personal communication, Week 6).”

- “Unrelated frustration and distraction had a negative impact on my practice... (personal communication, Week 7).”
- “I hear a subtle difference in tone with a happy face - or is it my imagination? Or maybe it’s easier tone (personal communication, Week 8)?”
- “Curious thing, I can nearly always remember the starting pitch. ‘Me-Vah’ - first time through exercise no cracking on ascending sequences (it’s a miracle!)... (personal communication, Week 9).”
- “‘Me-Vah’ - Faster sequence helps to not target top note and makes the entire exercise easier . . . (personal communication).

Weekly comments were written by the teacher as well:

- “My first thoughts are that she has consistently replaced breath connection with jaw and tongue tension, and this observation was mentioned but needs to be revisited at subsequent lessons . . . (personal communication, Week 1).”
- “Small, centered, even thin tone appears to be the direction to use for now . . . (personal communication, Week 2).”
- “We experimented with using different consonants to begin the exercise, but returned to the vowel alone as the most successful . . . (personal communication, Week 3).”
- “Range has increased dramatically. The lower-pitched tape is no longer as useful, so a new one will be needed for next week . . . (personal communication, Week 4).”
- “On /mi-va/ we particularly worked the body/breath connection, encouraging her to be aware of her lower abdomen and epigastric area as part of the ‘team’ for singing . . . (personal communication, Week 5).”
- “In order to make room for the breath to be the initiator of her tone, she has to release the control she currently exerts with the muscles of her throat and jaw . . . (personal communication, Week 6).”

We worked on more abdominal engagement in the transitions from pitch to pitch. By so doing, “Mary” was gently urging her breath to engage prior to the new note being sung. This is extremely successful in getting her to release tension and achieve a better head tone... (personal communication, Week 7).”

- “Though progress isn’t as fast or consistent as she would like, I think it is quite rapid, and there is noted improvement. Her *staccato* exercise is extending to high C, and even D at times, with ease... (personal communication, Week 8).”
- “Reviewed Mary’s journal where she, for the first time, marked all her questions with the rating of 6, 7 being ‘very free’... (personal communication, Week 9).”
- “She is able to show considerable progress, especially in her upper middle range (personal communication).”

As the weeks progressed, Mary’s range expanded in all the exercises, particularly in the *staccato*. In this fashion, she easily vocalized to the D<sub>6</sub> in the last two lessons. The rapid connection of breath/muscle management to tone in *staccato* showed an improvement in coordination. Her tone quality became easier, sometimes breathy, which she understood was a step toward healthier production, rather than an end in itself. The slight vocal fold bowing

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noted in the final physical examination indicated that the muscles that had been adducting the folds previously had released some of their hold. New and proper intrinsic muscle use had not had time to form, but would be the next logical step. Her earlier tendency toward glottal attacks lessened considerably, and she was able to begin to produce *legato* phrasing within sustained exercises.

The participant also completed a post-self-evaluation form that was identical to the pre-self-evaluation form. It also employed a Likert-type scale with number 1 being “poor,” number 4 being “moderate,” and number 7 being “good.” The results can be viewed in Figure 7. The question regarding singing range was qualified differently from the other questions. Number 1 was “narrow,” number 4 was “medium,” and number 7 was “wide.” Answers to all questions were rated the same or better than the pre-test form in the post-test form (Figure 7).

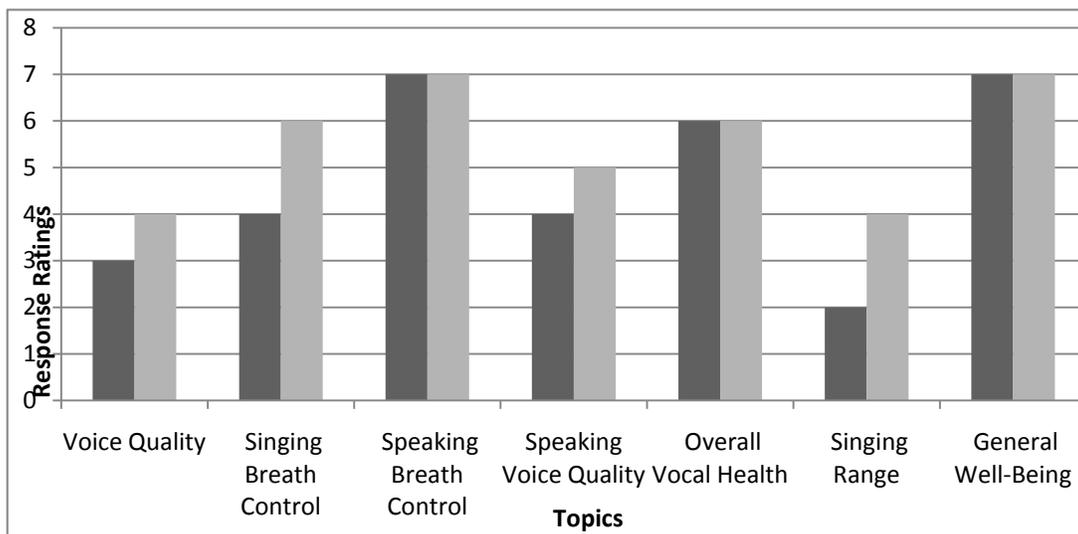


Figure 7. Pre- and post-self evaluation comparisons by participant.

The post-study questionnaire addressed how the participant perceived the effectiveness of the singing protocol. This questionnaire used a different scale. The first four questions were rated as follows: (a) not at all, (b) very little, (c) somewhat, (d) quite a bit, and (e) a lot. Her responses were “a lot” to the following queries: (a) To what extent did the weekly lessons and vocal exercises improve your voice? (b) To what extent did the weekly lessons and vocal exercises make it easier to talk and/or sing? (c) To what extent did you comply with a weekly practice schedule? To the question, “To what extent did the weekly lessons and vocal exercises make your voice clearer?” she responded, “quite a bit.” There were three short answer questions as well. General comments to the final short-answer questions included:

All the exercises were helpful. I can't say any single exercise was more helpful

than the others. I enjoyed some more than others, such as EE OO and the Italian vowels. ME VAH was the most difficult... I have learned to better control my breath... I have also learned having a relaxed jaw and throat is critical. I am more aware when tension is present and sometimes able to successfully release my jaw (personal communication).

## Discussion

The primary result of this study is that the singer experienced demonstrable vocal improvement after a 10-week protocol of regular, routine, targeted exercise. Inefficiencies due to lack of proper vocal technique, coupled with the effects of aging, improved in the doctor's evaluation of laryngoscopic examinations, in spectral analysis, and in the views of both participant and researcher. As Mary demonstrated an understanding of the role of breath and release of inappropriate tensions, improper and excessive laryngeal/pharyngeal tension was reduced, as well as perceived jaw and tongue tension. Concepts that proved to be helpful were: (a) a small, thin, centered, even tone, (b) freely spinning, moving breath envisioned as the cushion and engine for her tone, (c) releasing jaw and tongue tension while moving around the room and singing, helping her engage her breathing musculature, (d) imagining her tone in the head/eye areas, lightening any weightiness as she ascended, and (e) releasing the tip of her tongue toward her lower bottom teeth in a gentle way.

Future research might include studies with a longer time frame and more attention to validating specific vocal function exercises. Though current research literature points to aging singers needing regular vocal exercise either to maintain vocal health or reverse vocal inefficiencies, the duration, frequency, and content of such exercises remain underinvestigated.

This single case study might also prompt future research with a much broader scope of participants. If so, it would be helpful to consider a study that examined classifications of the aging voice. For example, the earliest microscopic changes of aging effects would be Class 1; then, as they progress - Class 2, 3, and so on. Such a system does not currently exist, and it could help categorize the different levels of aging with an eye to prevention and delay of vocal deterioration.

For post-menopausal singers, hormone replacement therapy is a complicated and important issue. Future studies might focus on separating the various kinds of hormone replacement, or lack thereof, with an eye to which therapies, if any, are the most effective. Female singers could be studied in classifications such as: (a) No hormone replacement, (b) Natural (homeopathic) hormone replacement, and (c) Hormone replacement in women who have had their ovaries removed - this last category particularly would include women in their 20s, 30s, 40s, and so on.

This neglected group of singers may benefit from focused research on the effects of menopausal hormone loss and deterioration due to aging. Armed with healthy vocal techniques and a regular practice regimen, post-menopausal singers like Mary can derive enjoyment from making positive contributions to choirs and other singing pursuits, rather than experience frustration. One can imagine choirs and musical productions everywhere benefiting from the renewed beauty and vigour of these singers.

## References

- Abitbol, J., Abitbol, P., & Abitbol, B. (1999). Sex hormones and the female voice. *Journal of Voice*, 13(3), 424-46.
- Awan, S. (2006). The aging female voice: Acoustic and respiratory data. *Clinical Linguistics and Phonetics*, 20(2/3), 171-180.
- Bach, A. C., Lederer, R.L., & Dinolt, R. (1941). Senile changes in the laryngeal musculature. *Arch Otolaryngol*, 34, 47-56.
- Baker, K., Ramig, L., Sapir, S., Luschei, E., & Smith, M. (2001). Control of vocal loudness in young and old adults. *Journal of Speech, Language, and Hearing Research*, 44(2), 297-305.

- Biever, D.M., & Bless, D.M. (1989) Vibratory characteristics of the vocal folds in young and geriatric women. *Journal of Voice*, 13, 120-131.
- Brown, W.S., Morris, R. J., Hollian, H., & Howell, E. (1991). Speaking fundamental frequency characteristics as a function of age and professional singing. *Journal of Voice*, 5, 310-315.
- Choo, D., Malmgren, L.T., & Rosenberg, S.I. (1990). Age-related changes in Schwann cells of the internal branch of the rat superior laryngeal nerve. *Otolaryngol Head Neck Surgery*, 103, 628-636.
- Davis, D.C. (2000). A study of the effects of two kinds of vocal exercises on selected parameters in the singing voices of women over age fifty. *Dissertations Abstracts International*, (UMI No. 9984723).
- Gambino, D.R., Malmgren, L.T., & Gacek, R.R. (1990). Age-related changes in the neuromuscular junctions in the human posterior cricoarytenoid muscles: A quantitative study. *Laryngoscope*, 100 (3), 262-268.
- Hirano, M., Kurita, S., & Sakauchi S. (1989). Aging of the vibratory tissue of human vocal folds. *Acta Otolaryngol*, 10 (5-6), 428-433.
- Honjo, I., & Isshiki, N. (1980). Laryngoscopic and voice characteristics of aged persons. *Arch Otolaryngol*, 106, 149-150.
- Houden, H., & Austin, S. (1991). The effects of estrogen replacement therapy in the menopausal singing voice. *Journal of Research in Singing and Applied Vocal Pedagogy*, 14(2), 41-50.
- Kahane, J. C. (1987). Connective tissue changes in the larynx and their effects on the voice. *Journal of Voice*, 1(1), 27-30.
- Kahane, J.C. (1990). Age-related changes in the peripheral speech mechanism: Structural and physiological changes. Proceedings of the Research Symposium on Communicative Sciences and Disorders and Aging (ASHA Reports No. 19, pp. 75-87). Rockville, MD: American Speech-Language-Hearing Association.
- Kersing, W. (1986). Vocal musculature, aging and developmental aspects. In J. Kirchner (Ed.), *Vocal fold histopathology*, San Diego, CA: College Hill Press, 11-16.
- Leden, H. von, & Alessi, D.M. (1994). The aging voice. In M.S. Benninger, B.H. Jacobson, & A.F. Johnson (Eds.), *Vocal Arts Medicine*, (pp. 269-280). New York, NY: Thieme Medical Publishers, Inc.
- Linville, S.E. (1987). Acoustic perceptual studies of aging voice in women. *Journal of Voice*, 1, 44-48.
- Linville, S.E. (2001). *Vocal aging*. Australia; San Diego, CA: Singular Thomson Learning.
- Mueller, P.B. (1990). Improvement of the aging voice through application of pushing exercises. *Proc International Association Logopedics Phoniatrics*, 2, 411-413.
- Mueller, P.B., Sweeney, R.J., Baribeau, L.J. (1984). Acoustic and morphologic study of the senescent voices. *Ear, Nose, and Throat Journal*, 63, 292-295.
- Orlikoff, R.F. (1991). The atherosclerotic voice. *ENT J*, 69, 833-837.
- Parks, S.S. (2006). The effect of a 10-week individual and class voice program on the range, breath and overall vocal performance of singers over the age of sixty. University of Minnesota, 144 pages, AAT 3243367.
- Paulsen, F.P., & Tillmann, B.N. (1998). Degenerative changes in the human cricoarytenoid joint. *Archives of Otolaryngology - Head and Neck Surgery*, 124(8), 903-906.
- Peppard, T. (1990). Effects of aging on selected vocal characteristics of female singers and non-singers. The University of Wisconsin - Madison, 236 pages, AAT 9108736.
- Sapienza, C.M., & Dutka, J. (1996). Glottal airflow characteristics of women's voice production along an aging continuum. *Journal of Speech and Hearing Research*, 319, 322-328.

- Segre, R. (1971). Senescence of the voice. *EENT Monthly*, 50, 223-227.
- Stemple, J., Glaze, L., & Klaben, B.G. (2000). *Clinical Voice Pathology*. Canada, San Diego: Singular Publishing Group.
- Verdonck-de Leeuw, I.M., & Mahieu, H.F. (2004). Vocal aging and the impact on daily life: a longitudinal study. *Journal of Voice*, 18(2), 193-203.
- Xue, S.A., & Hao, G.J. (2003). Changes in the human vocal tract due to aging and the acoustic correlates of speech production: A pilot study. *Journal of Speech, Language, and Hearing Research*, 46(3), 689.