THE IMPACT OF EXPIRATORY MUSCLE STRENGTH TRAINING ON VOCAL FATIGUE

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ABSTRACT

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Vocal fatigue is a recurring problem, particularly prevalent within females when speaking for long periods of time for their professions. This increased risk of vocal fatigue in females seems to have connection to speech breathing and breath support, possibly because of the smaller lung capacity that females typically have when compared to males along with other physiological differences. Due to this possible connection, the following research question was presented: Will strengthening the pulmonary system show a decrease in the occurrence of vocal fatigue? It was hypothesized that after expiratory training exercises, vocal fatigue rate will be reduced within female participants. In addition, it was hypothesized that the breathing training could serve as a preventative measure in vocal fatigue with continued use. To test this hypothesis, data was collected from ten women of a shorter than average body height and weight range to enhance the possible smaller lung effect. The participants completed a preliminary data collection, a month-long breathing intervention with an expiratory muscle strength training device, and a post intervention data collection. Results indicated that both participant self-perceived vocal fatigue rating decreased and standard deviation of fundamental frequency increased after intervention. These results can indicate a trend of decreased vocal fatigue symptoms within participants after use with an expiratory muscle strength trainer.

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INTRODUCTION

Within the working world of the United States, many professionals rely on the use of voice to communicate efficiently and maintain a level of success in a variety of workplaces. More than 25% of the working population report that heavy voice use is required within their occupations (Hunter, Tanner & Smith, 2010). Due to the importance of voice to these professions, there is an increased risk for voice problems to negatively affect one's job. Voice disorders can include a range of problems, including vocal fatigue.

Research shows females to be more commonly affected by vocal fatigue than men. This is due to a combination of attributes, such as the difference in anatomy and physiology. In addition to females, occupational voice users have a higher than normal incidence of voice problems due to the reliance of voice within the daily workplace. The combination of occupational voice use and high occurrence in females have caused vocal fatigue to be common within predominately female occupational workplaces (i.e. schools, call centers). Vocal fatigue, especially within the lives of working females, can have detrimental effects on both qualities of life and job performances (Hunter, Tanner & Smith, 2010). An additional challenge is the lack of an efficient treatment method, or specific definition to outline the complexities of this phenomenon (Welham & Meaclagan, 2003).

DEFINING VOCAL FATIGUE

Vocal fatigue is a complex problem that has yet to gain a universally accepted definition. In some instances, vocal fatigue is used as a symptom of another voice disorder, while other instances have shown it described as its own diagnosis or a behavior a vocalist uses to compensate for an underlying pathology. The difficulties of defining vocal fatigue arise due to the phenomenon being most commonly reported by the patient who has the internal sense of vocal effort or vocal tiredness and an understanding of how it feels, which does not create an operational definition of vocal fatigue but rather creates a subjective understanding of it (Solomon, 2008). Clinically, an operational definition is necessary to diagnose and compare data across studies.

Solomon surveyed persons who have reported vocal fatigue and discovered a way to define the phenomenon based on six main symptoms that were reported (2008). "Those symptoms . . . include (1) increased vocal effort and discomfort, (2) reduced pitch range and flexibility, (3) reduced vocal projection or power, (4) reduced control of voice quality, (5) an increase in symptoms across the speaking day, and (6) improvement after resting" (Solomon, 2008, p. 254-255). In addition, when defining vocal fatigue, it is important to examine the underlying causes. The main etiologies include: neuromuscular fatigue, increased vocal fold viscosity, reduced blood circulation, non-muscular tissue strains, and respiratory muscle fatigue due to prolonged voice use (Welham & Maclagan, 2003). Due to the variety of etiologies and symptoms, it is crucial that a suitable treatment or management becomes developed to aide in the rising population who are facing problems of vocal fatigue.

PREVIOUS STUDIES ON VOCAL FATIGUE

Previous studies have been conducted to understand: how vocal fatigue is induced, its physiologic attributes, and the resulting self-perception of people who present with symptoms. The results of research studies that focus on these questions of vocal fatigue have provided data along with explanations that help to better understand the complex phenomenon.

The first concept that is important in inducing vocal fatigue is the task of vocal loading.

Remacle et al. (2012) consider vocal loading to be “the acoustic power integrated over time, depending on the amount of voicing” (p. 178). Within their study, vocal loading was done based on an effect of both duration and intensity levels on voice. Duration within this study referred to the voicing time required of an individual, while the intensity referred to the amplitude of the vocal fold oscillations due to an increase in vocal intensity; which can be due to an increase in background noise, room acoustics, number of listeners, and distances between listeners and speakers (Remacle, Finck, Roche, & Morsomme, 2012). Remacle and colleagues discovered that duration of vocal loading significantly affected fundamental frequencies, feeling of phonation effort, vocal fatigue, and laryngeal discomfort. Intensity of vocal load did show similar results within the fundamental frequency but did not give as strong of a predictor of vocal fatigue.

In a similar study, to attempt to answer the question of how to induce vocal fatigue, Whitling (2016) developed test conditions for a vocal loading task that would induce vocal fatigue without causing any long-term damage to the vocal function. The participants in this study were healthy individuals without any voice training or voice disorders in the past. For this task participants, would phonate through loud reading, only stopping to breathe or drink water, which for health reasoning was only permitted for a maximum time of 30 minutes. The approach that Whitling and colleagues took was the idea that vocal fatigue is dependent on the individual and will differ in time depending on endurance and other factors. This reasoning lead this study to terminate the task phase if they felt distinct discomfort in the throat, showed evidence of vocal fatigue within their speech, or if the 30 minutes was up. This activity successfully attained vocal fatigue within individuals, without causing any permanent damage to the voice function (Whitling, 2016). The amount of time it took for each participant to become vocally fatigued varied greatly in this study, indicating once again, the complex nature of defining after how much vocal local vocal fatigue is likely to occur.

Finally, an important consideration for attempting to quantify fatigue due to vocal loading are the measurements of both subjective and objective measures, in a hybrid type approach. There is a long history of such an approach (i.e. Popolo, et al 2011, Hunter & Titze, 2009) where both subjective and objective measures are collected. By combining both the objective and subjective collections in a hybrid approach, researchers can gain insights into the correlation between physiologic changes of the vocal folds with subjective complaints of vocal fatigue (Bastian, Keidar, & Verdolini-Marston, 1990). Bottalico, Graetzer, and Hunter (2016) expanded this idea into gathering self-rated responses from participants after a series of vocal loading tasks. The self-rated questions were: how effortful was it to speak in this condition, how well were you able to control your voice, how comfortable were you speaking in this condition, and how clearly did you perceive your own voice in this condition? Scores were measured on a Likert scale with one extreme response being “not at all” and the other being “extremely”. These self-reported subject responses were compared to many other self-perceived questionnaires used in previous research.

Each of these studies provide some insight on the phenomenon of vocal fatigue. Based on these three studies, it is evident that when addressing vocal fatigue in experimental conditions, aspects such as vocal load, preservation of current laryngeal functions, and acoustical settings need to be considered to gain a clearer insight on vocal fatigue.

THE GENDER DIFFERENCE

Statistics show that females face a significantly higher risk than males do for experiencing voice problems, with females at a 46% risk for life-time voice problems when compared to 37% of men (Roy, Merrill, Thibeault, Fray, & Smith, 2004). The high incidence in females have been postulated to be due to differences such as laryngeal physiology, the endocrine system, pulmonary usage, respiratory control and management, and lung capacity (Hunter, Tanner & Smith, 2011). These differences can help to explain the gap that is found between male and female occurrence of vocal fatigue.

Previous studies indicate a link between vocal fatigue and respiratory report. In a meta-analysis, it was found that male lungs appear to have a higher static recoil during exhalation than female. This discovery suggests that when females exhale or produce speech that they require "a higher percentage of lung volume use to create an equivalent lung pressure, a necessary driving force of vocal fold vibration" (Stathopoulos & Sapienza, 1993). By using a higher percentage of lung volume, women may be at risk of having respiratory muscles fatigue earlier than they would in males. In addition, women generally would have more breath per word than males which would result in the need for more breath support than what males would require. Within this study, some women did not appear to compensate with increased use of respiratory muscles or higher lung volume, but rather compensated with an increased laryngeal adduction. Similarly, by increasing more contact force per unit area of the vocal folds this can create a higher risk of vocal fatigue (Maxfield, Hunter & Graetzer, n.d).

ROLE OF RESPIRATION IN SPEECH

The energy of voice production comes from the respiratory system. So, while there are many factors to consider with vocal fatigue, one of the more important factors is adequate breath support and the condition of a patient's respiratory system. Good breath support is critical to produce optimal speech production, likewise the respiratory system is critical for many specifics of speech including marking stress, producing an utterance of a certain length, and pausing both for emphasis and for syntactically appropriate locations (White, 2013). Previous studies elaborate on the importance of respiration and the correlation that exists between voice disorders and respiratory factors. For example, decreasing lung volume increases the closed quotient in the glottal cycle which is not an efficient sound source (Iwarsson, Thomasson, & Sundberg, 1998). This also has shown more recently in examples of where data from 122 teachers showed that the Vocal Fatigue Index was a predictor to several spirometry measures in female teachers (no relationship was found among male teachers) (Maxfield, et al 2016). Related to this, a previous unpublished study in our laboratory conducted by Gavigan (Gavigan & Hunter, 2016), showed that healthy college female students seem to have a relationship between lung function measures from a spirometer and increased in vocal fatigue during a prolonged speaking task.

Based on this information, it is important to consider whether strengthening the respiratory system would increase the ability to produce optimal speech. Solomon discovered that well-trained vocalists are typically less vulnerable than untrained voice users are to symptoms of vocal fatigue (2008). It has been discussed that well-trained vocalists will utilize phonatory techniques rather than compensatory efforts when using voice for a long period of time. Is it possible that a phonatory techniques could be developed in relation to the respiratory system? Pitts and colleagues found that an expiratory muscle strength trainer was beneficial to increasing laryngeal closure to decrease the risk of aspiration in a set of patients (2009). With laryngeal strength being an important part of speech production as well, it would be beneficial to examine if an expiratory muscle strength trainer could be utilized in the same manner of phonatory techniques are within well-trained voice users to decrease the symptoms of vocal fatigue.

EXPIRATORY STRENGTH TRAINERS

There are many different types of respiratory muscle strength training devices (RMST) that are used to improve the strength of inspiratory muscles and/or expiratory muscles (Sapienza & Troche, 2012). For this study the focus is placed on an expiratory muscle strength training device, which is specially used to strengthen expiratory muscles that are used in speech. This device was chosen based on the evaluation of what type of muscles are involved in the speech processing. Due to the dependence of expiration during speech, by targeting expiratory muscles in training, speech should be more affected.

Two important concepts that determine the effectiveness of the treatment is the stimulus intensity and the frequency. The stimulus intensity is defined within the device as the "load", which is determined on the device itself. The load can be determined by the expiratory muscle strengths that the patients already have. The load needs to be set to a challenging level, otherwise the muscles will not be encouraged to grow and strengthen. The next component is the frequency, which is in regard to how many times a week a patient will need to use the device. Based on a study done by Anand, El-Bashiti and Sapienza (2009) it was determined that the most efficient way to strengthen respiratory muscles is to set the frequency to five sets of five breaths, 3 times a week (n/a). Within this study the experimenters compared results when the frequency of times per week were changed to either one, three, or five days a week. Participants who only participated one time a week did not show good results, and participants who participated five times a week showed a lack of motivation and seemed overwhelmed by the frequency of the task (Anand, El-Bashiti & Sapienza, 2009). Selecting an appropriate stimulus intensity and frequency for respiratory devices should be considered critical within experiments.

PREVIOUS STUDIES ON EXPIRATORY STRENGTH TRAINERS

Expiratory muscle strength trainers have been shown in studies to be beneficial in aspects ranging from swallowing disorders to voice production. The type of effect that expiratory muscle strength trainers can have on a patient are similar to limb muscle strength-training. Use of the device has been suggested to improve functions of breathing, coughing, swallowing, and speech (Anand, El-Bashiti, & Sapienza, 2009). Because these devices can be used for both breathing and speech functions, it can be found to be a suitable therapeutic intervention.

A study done by White (2013) found that after use an expiratory muscle strength trainer, participants with Parkinson's disease showed significant progress in speech rate and laryngeal valving efficiency. By increasing expiratory muscle strength, the participant's vocal folds seemed to have more control over the amount of air that was escaping during speech. By controlling the amount of air escaping during speech, participants could produce longer utterances. Overall it was discovered that respiratory patterns translate directly to speech patterns. By including treatment of respiratory patterns within interventions, speech patterns can be improved as well (White, 2013).

Likewise, within a meta-analysis three cases were examined in which expiratory muscle strength trainers were used to promote speech production and vocal function (Laciuga, Rosenbek, Davenport, & Sapienza, 2014). In the first case, devices were used a female who was diagnosed with Lance-Adams syndrome. After use with the expiratory muscle strength trainer, there was a reported progress in maximum phonation time, speech intelligibility scores, and communicative effectiveness. The second case in which expiratory muscle strength trainers showed progress in individuals with multiple sclerosis. The main result of the training in patients with MS were seen in the increase of speech rates, which were defined by words per minute of the individual. In addition, scores taken from the Amyotrophic Lateral Sclerosis Severity Scale showed a decrease in the impact of dysarthria, while score from the voice- related quality of life surveys also showed greater improvements prior to training. Finally, results from using the device with professional voice users showed that “the expiratory muscle strength trainer may serve as an important element of voice therapy to increase sub-glottal pressure, improve vocal loudness, and reduce voice-related degree of disability” (Laciuga, Rosenbek, Davenport, & Sapienza, 2014). The results from these studies show that option of using an expiratory muscle strength trainer for speech production and vocal function during therapy interventions should be considered.

RESEARCH QUESTIONS AND HYPOTHESIS

This study builds on both the knowledge of the influence of the respiratory system on resilience to vocal load (reduction of vocal fatigue), in addition to the efficiency of treatments that include expiratory muscle strength training. Links between vocal fatigue and a limited or underutilized respiratory system have been implied within previous studies. Likewise, expiratory muscle strength training has shown progress in individuals with many different symptoms, and would likely improve vocal fatigue. By combining these two ideas, a new idea can be generated. The question motivated from these ideas is the following: Can the rate of vocal fatigability be reduced due to expiratory strength training using an EMST device?

When considering this question, it is hypothesized that respiratory muscle training will reduce the amount of vocal fatigue due to a prolonged reading task. To test this hypothesis, it is assumed that the comparison of the fatigability during a baseline prolonged speaking task (vocal loading) and a second task will show a greater ability to not fatigue after a month-long period of use with an expiratory muscle strength trainer. Subjects will be females who are shorter than average, likely having smaller than average lung volume and potentially exacerbating the lung effect. Each individual will receive their own expiratory muscle strength training device, which will be adjusted to the individual's lung strength to ensure for accurate muscle build in everyone.

METHODS AND RESEARCH PLAN

In order to answer the research question, subjects participated in two subsequent thirty-six-minute vocal loading tasks surrounding a month long respiratory training plan. To be involved in the study, participants had to have average to great lung support with no history of asthma or breathing problems. In addition, individuals were required to pass a hearing screening and pulmonary function exam. SPSS statistical software was utilized to develop the results. The statistical approaches used were Kolmogorov-Smirnov and Shapiro-Wilk to test for normality.

RESEARCH PARTICIPANTS

As previously mentioned, there is a gender difference that correlated females to have a higher prevalence of vocal fatigue symptoms. For the purpose of this study, only females were included with the purpose to show more extreme results than if males were included. IRB approval was gained prior to the recruitment of participants. Females were then recruited through Michigan State's campus, making the age range to qualify between 18 and 30 years of age. In addition, to having an EMST device with similar in load intensity for each participant, each female was required to be between 115-140 lbs. and shorter than 63 inches. These ranges were developed using data on average height and weight of American women. For the range of 18-30 years of age, woman shorter than 63 inches with a weight between 115-140 lbs. are in the 25th percentile. Personal observations and experiences guide to the insight of the smaller 25th percentile of women complaining of vocal fatigue more often than others. By maintaining a consistency in range for each individual, the results are expected to be somewhat consistent for everyone.

If participants identified a history that included problems with hearing, pulmonary functioning, or anatomical differences they were excluded from the study. Hearing was tested through a hearing screening, whereas pulmonary functioning was determined through spirometry and a visual assessment where researchers watched for diaphragmatic, thoracic, clavicular, and/or paradoxical breathing. Anatomical differences were determined per participant interview. Participants were informed that the study was a two-part commitment and that they were expected to return for a secondary portion of assessment a month later, those who could not commit to two sessions were excluded. Additionally, those who presented other difficulties during the vocal loading task (i.e. reading difficulties) were excluded. Questionnaires were given to each participant to gather additional demographic and health information (i.e. allergies, GERD, ethnicity, illnesses), but was not used as an exclusion criterion.

SUBJECTS

Ten participants who fit the criteria were recruited for this study. Two of the participants did not return for the second portion of the study, and their results were not used. There was a technological error while recording pre-vocal loading task portion of data with one of the participants, so that participant's pre-loading and post-loading task was eliminated. Of the seven whose data was kept and used, all participants average lung age from the pulmonary function test was 24 years of age. Five out of seven of the participants were Caucasian ethnicities, with the other ethnicities being Native American and Asian. Of the seven participants all were within the ages of 18-22. Table one represents an overview of the participants included. Additional specific participant data can be found in appendix 16.

Table 1: Overview of participants gather through the initial pulmonary function test.

Participant	Age	Height	Ethnicity	Weight	Lung age
1	20;6	60	Caucasian	140	24
2	22;6	62	Caucasian	119	24
3	21;0	61	Caucasian	134	24
4	21;1	62	Caucasian	125	24
5	20;0	61	Caucasian	115.1	24
6	20;4	61	Caucasian	118	24
7	20;0	61	Caucasian	120	24
8	20;0	62	Caucasian	115	24
9	20;6	61	Native American	120	24
10	18;2	61	Asian	115	24

PROCEDURES

The study was essentially split into 3 parts total. The first part of the study was a preliminary testing day including a vocal loading task. The participants were screened and baseline measures were collected. The second part of the study was a month-long duration. During this month the participant was required to complete at home exercises with a provided respiratory training device. Participants were monitored during this month and received verbal and visual instructions with an individual handout. The third part of the study included the same measures as the first portion, to be used as comparison.

DAY 1 (TX0): SCREENING AND BASELINE MEASURES

On the first day (Tx0), each participant completed a consent form, which explained each portion of the study. Participants were asked, via surveys, of any voice problems and/or voice handicaps, in addition to surveys regarding general participant information and characteristics (See Appendix 4-7). There was a hearing screening, spirometry test, and assessment of breath support. During these screenings and surveys, researchers gathered non-fatiguing data from the participant by asking the participant to rate their current level of vocal fatigue on a scale of 0-10 (0 being no symptoms of vocal fatigue or poor vocal quality, 10 being maximum).

After the screenings, the participants went through preliminary vocal measures to gather baseline voice and speech data. The vocal measures included: counting to 5, producing maximum phonation times on a steady vowel ‘ah’, producing a vowel-consonant-vowel (“afa”) three times, and reading the rainbow passage. Once the preliminary vocal measures were collected the participant began the vocal loading task. Reaper and LingWAVES software were utilized to collect data during the thirty-six-minute vocal loading task which contained: self-ratings of vocal fatigue, steady vowel phonations, short vowel-consonant-vowel productions, and three reading passages. During these tasks the participants were required to produce tasks at a predetermined loudness level. The readings and tasks were presented to the participant via PowerPoint, with an arrow on the side of the screen indicating if the participant needs to increase loudness. To prevent harm to the participant, each individual was told that they can quit at any time if the task is uncomfortable. Additionally, individuals were prompted to drink water (set amount in a small cup) on a three-minute interval. When the tasks are completed the participants went through post vocal measures, to be compared to the preliminary vocal measures. This portion included the same tasks at the beginning: counting to 5, producing maximum phonation times, producing a vowel-consonant-vowel ("afa"), and reading the rainbow passage. After this, participants left the sound booth and were provided instruction with an Expiratory Muscle Strength Trainer (EMST150).

INTERVENTION: EXPIRATORY MUSCLE STRENGTH TRAINING

Each participant received an Expiratory Muscle Strength Training- EMST150 (Aspire LLC). Because all the participants were a certain height and weight range, the load was similar for everyone. To establish the load for each participant, researchers used data gathered from spirometry and calculate a load that is 75% of the participant's maximum expiratory pressure. Once the load was established, participants were instructed to do 3 sets of 5 repetitions 3 days a week for a month-long duration. The 3 sets of 5 repetitions were to be done within one sitting close to the same time each day, with a 1-2-minute rest in between sets. At the end of each week, the participants were instructed to increase the load by a quarter spin or more if previous load lacked difficulty. The participant's each received a log sheet to document use of the device and changes in load, in addition to written instructions.

DAY 2 (TX1): CONCLUDING DATA COLLECTION

One month after consistent use with the EMST150, the participants were required to come back to the lab for concluding data collection. The participants first completed a spirometry task, which were used as comparison to Tx0 spirometry results. Participants then completed the same tasks, for vocal measures and vocal loading tasks, as Tx0. The participants served as their own control, as their data collected here was compared to the baseline data. The participants were then compensated and thanked for completion of the study.

MEASURES

In order to establish the EMST150 as a potential intervention for vocal fatigue symptoms due to a vocal loading task, it was necessary to focus the measurements of both vocal fatigue and pulmonary functioning of each participant post and prior to intervention. The research plan aimed to answer the question between pulmonary strengthening and the effect on vocal fatigue. The participants completed both non-fatiguing and fatiguing tasks in each session (Day 1 and Day 2), which many measures were collected. The main three sets of data that were analyzed within this study were the subjective information, acoustical analysis of fundamental frequency, maximum phonation times, and pulmonary function test. First, the subjective vocal fatigue ratings from the participants during the vocal loading tasks were compared. Second, the objective lengths of participants producing “ah” (maximum phonation time) were compared from the first portion and the second portion. Third, the variation of the standard deviation of fundamental frequency (which previously has been shown to change with vocal loading) from the pre- and post-reading task. The independent variable of this study is the training intervention that each participant completed with the EMST150. The dependent variables are the measurements of self-ratings of vocal fatigue, the maximum phonation times, variations of dB SPL, and the spirometry results.

RESULTS

Collected data were analyzed and compared. As mentioned earlier, only seven of the participant's data were included in this analysis. As mentioned in the dependent variables section, the main results that are being analyzed for this study are the maximum phonation times, subjective ratings of vocal fatigue, variations of the standard deviation of fundamental frequency, and results of pulmonary function tests pre- and post- use of the EMST150. The following chart shows the statistic, difference and significance that were calculated in order to prove normality of the data.

Table 2. Statistical Analyses proving normality of fundamental frequency mean (f0), standard deviation of fundamental frequency (f0_std), interquartile range of fundamental frequency, standard deviation of pitch (Po_std), interquartile range of pitch (P0_IQR), decibel mean (dB_mean), and interquartile range of decibels (dB_IQR).

Test of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
F0_mean	.153	14	.200*	.963	14	.769
F0_std	.108	14	.200*	.963	14	.772
F0_IQR	.149	14	.200*	.943	14	.463
P0_std	.203	14	.122	.908	14	.148
P0_IQR	.119	14	.200*	.950	14	.568
dB_mean	.145	14	.200*	.956	14	.660
dB_IQR	.192	14	.175	.895	14	.096

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

In addition to tests for normality, the general linear model was used to show both: differences within-subjects in the self-report of vocal fatigue along the vocal loading task, and the between-subjects self-report of vocal fatigue post-intervention. First presented are overall subject results of the pulmonary function tests and average values from the pre- and post- intervention tasks. Next presented are data from objective measures and statistical analysis of the metrics obtained.

PULMONARY FUNCTION TEST

Within the spirometry test, data was collected on forced vital capacity (FVC), forced expiratory volume within the first second (FEV1), peak expiratory flow (PEF), and a fraction indicating forced expiratory volume within the first second divided by forced vital capacity (FEV1/FVC). The FVC identified the total amount of air that can be exhaled after a maximal inspiration. The FEV1 demonstrates the amount of air that a participant exhales within the first second. The PEF showed the maximum amount of airflow in liters exhaled. Finally, the FEV1/FVC showed a ratio of the lung size that can be exhaled in one second. Table 2 represents the spirometry data from 7 participants.

Table 3: Overview of Spirometry Results

Participant	FVC (TX0)	FVC (TX1)	FEV1 (TX0)	FEV1 (TX1)	PEF (TX0)	PEF (TX1)	FEV1/FVC (TX0)	FEV2/FVC (TX1)
P1	2.85	3.2	2.85	2.81	5.02	4.34	97%	88%
P2	2.63		2.42		3.5		91%	
P4	3.42	3.24	3.37	3.05	4.98	4.76	99%	94%
P5	2.76	2.43	2.41	2.43	5.1	5.28	87%	80%
P7	2.86	3.36	2.47	3.15	3.56	4.9	86%	94%
P9	3.23	3.32	3.06	3.28	3.7	3.93	95%	99%
P10	4.37		4.2		8.07		96%	

As seen within table 3, the spirometry results were mixed. Two participants' second data collection (P2, P10) were not valid and were excluded from the results. The participants showed inconsistent gains or decreases within the results.

MAXIMUM PHONATION TIMES

Each of the 7 participants were required to produce three sets of maximum phonation times (MPT) "AH" prior and post vocal loading tasks within both pre- and post-treatment sessions. The three sets of phonation times were then averaged.

Table 4: The averages of 3 maximum phonation times (MPT) in seconds of participants. Tx0 represents the first day of data collection, pre-intervention, where Tx1 represents the second day of data collection, post-intervention. A represents pre-vocal loading task, and B represents post-vocal loading task.

Participant	Tx0-A	Tx1-A	Tx0-B	Tx1-B
P1	16	22	20	23
P4	6	12	8	9
P5	11	10	10	10
P6	11	12	10	15
P7	15	14	10	19
P9	14	10	9	11
P10	16	21	16	32

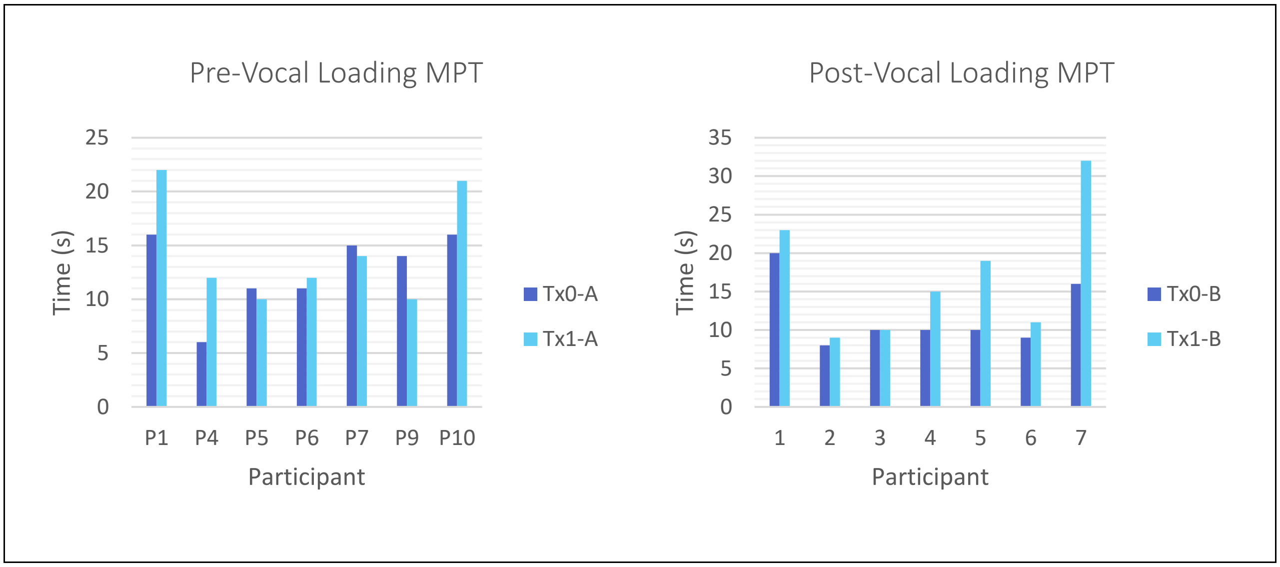


Figure 1: On the left side participant's pre-vocal loading maximum phonation times are compared within pre-intervention (tx0) and post intervention (Tx1) tasks. On the right side participant's post-vocal loading maximum phonation times are compared within pre-intervention (tx0) and post-intervention (tx1) tasks.

As shown within table 4, the MPT of the participants showed mixed results. When comparing the pre-vocal loading results within both sessions, 4 out of 7 participants showed an increase in average duration (seconds). Likewise, when comparing the post-vocal loading results from both sessions, 6 out of 7 participants showed an increase in average duration; while the other participant did not show a difference.

SUBJECTIVE SELF-RATINGS

Recall the participants were required to state their vocal fatigue ratings between 0-10, 0 being no fatigue and 10 being maximum amount of fatigue, during the prolonged speaking task. The results from the first day of data collection, prior to therapy, and the results from the second day of data collection, post-therapy, were compared. The figures below show the results.

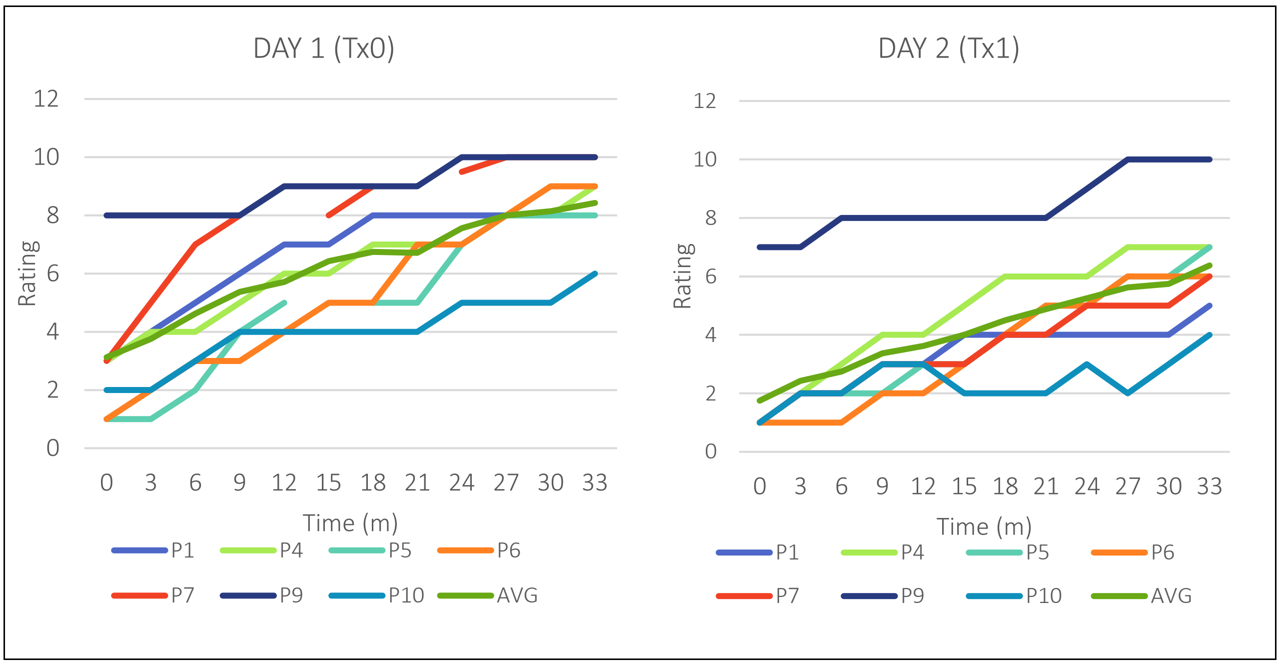


Figure 2: Average Self-Ratings during the vocal loading task by participant. Left side shows all subject ratings for the pre-intervention task. Right side shows all subject ratings post-intervention task.

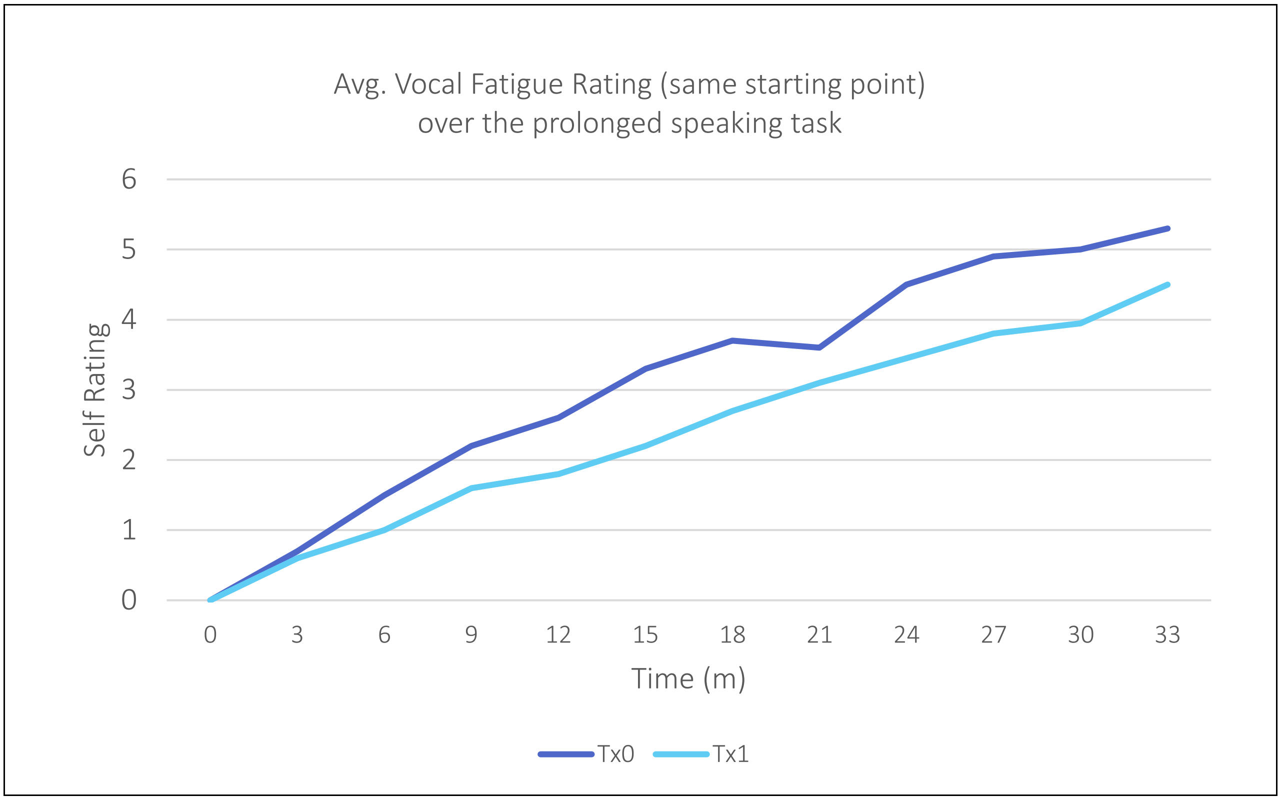


Figure 3: Average Self-Ratings during the vocal loading task, showing average pre- intervention ratings (Tx0) and post intervention ratings (Tx1)

As can be seen in Figures 1 and 2, the participants' self-perceived vocal fatigue ratings increased as the vocal loading task went on but decreased overall when day 1 and day 2 were compared. More individual results can be found in Appendix 17. When the data was examined using the General Linear model analysis via SPSS software, there was a trend between subjects to self-report lower vocal fatigue after the intervention program. This analysis remains consistent with the subjective information gathered during the vocal loading task. The following graph represents the General Linear model analysis.

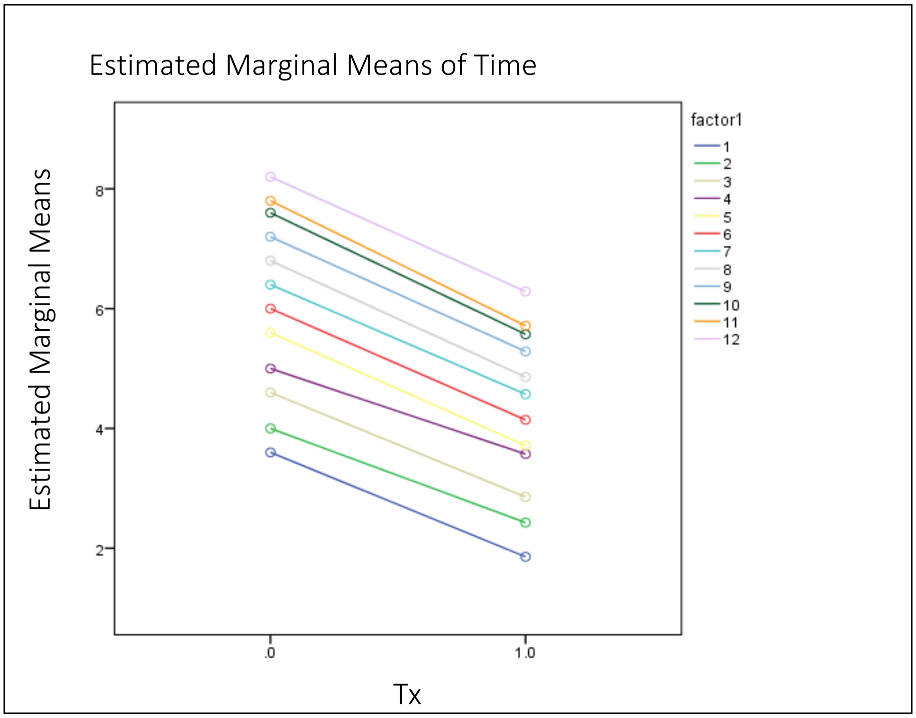


Figure 4: The General Linear Models of participant's self-rating of vocal fatigue. The x axis of 0 represents the first day of vocal loading prior to intervention, and 1 represents the second day of vocal loading after intervention. The Estimated marginal means are the ratings 0-10 that participants provided when prompted to rate their vocal fatigue. The factors are the three-minute intervals.

As shown with the General Linear Models of participant's self-rating of vocal fatigue, each factor (average of the prompted vocal fatigue ratings) decreased after the intervention.

CHANGE IN STANDARD DEVIATION OF FUNDAMENTAL FREQUENCY

Change in standard deviation of fundamental frequency from pre to post vocal loading task for Tx0 and Tx1 was also analyzed using the Generalized Linear Models. From this analysis, the change in standard deviation of the fundamental frequency was shown to increase after the treatment program. The following chart identifies the analysis created from the SPSS statistical software.

Table 5: The data used to analyze the standard deviation of the fundamental frequency. The parameters used were 1 and 0 which identify pre-treatment (0) and post-treatment (1). B represents the magnitude of change from the standard deviation that the fundamental frequency changed.

Parameter	B	Std. Error	Wald-Chi Square	Hypothesis Test Difference	Significance
(Intercept)	49.83	4.32	133.04	1	.00
[tx=1.0]	8.434	6.11	1.90	1	.17
[tx=.0]	0[a]	.	.	.	.
(Scale)	261.34[b]	69.84			

Dependent Variable: F0_std
Model: (intercept), tx
a. Set to zero because this parameter is redundant
b. Maximum likelihood estimate

As the table shows, the fundamental frequency of the participants increased by a more than 8 hz which shows a relationship between increase of fundamental frequency after the intervention with the EMST. The significance presented after the therapy, 0.167, indicate that the difference was trending within the participants though not statistically significant.

DICUSSION

Expiratory muscle strength training resulted in mixed responses from the participants. The pulmonary function results did not show a significant change within forced vital capacity, forced expiratory volume in the first second, peak expiratory flow, or forced expiratory volume in the first second divided by the forced vital capacity. While improvement was an initial assumption, there are many possible reasons why there was no documented changes within the pulmonary function results. One of the possibilities is that all of the women were healthy without any pulmonary functioning difficulties, making it hard to see extreme results or changes from use of an EMST. Additionally, many of the studies done with EMST devices are done with populations that have some kind of disorder. Pulmonary strengthening has been shown with use of the EMST150 device, but other means of measurement aside from the pulmonary function test should be done within future studies to assess this.

The next results that did not show general change or significance were the maximum phonation times. A difficulty in accessing the maximum phonation times were the intra-variations that take place with within-subject studies. Each participant was compared against their own MPT within the first day of the study. Because of this there can be confounding conditions (i.e. time of day, health condition that day) could have made the results less reliable. However, individually, there were positive improvements in some of the participants but it is unclear which is a real change and which is just variability.

The third set of results show that the standard deviation of the fundamental frequency tends to increase after the treatment program. A study done by Laukkanen and colleagues (2006) showed that an increase in fundamental frequency might indicate an increase in voice production muscles. The voice production muscles that could have been altered within this study could have been the oral pharyngeal and respiratory muscles done with the intervention. The dynamic change within the standard deviation of the fundamental frequency was consistent with the time that the person is speaking, and remained constant with the self-perceived vocal fatigue ratings. This can represent a decrease in vocal fatigue symptoms.

Lastly, the fourth set of data examined was the self-perceived vocal fatigue ratings from the participants. When participants came back for the secondary portion of data collection, the averages (figure 3) show an overall decrease in vocal fatigue ratings throughout the vocal loading task. An important consideration with these results is that the study was a within-subject style design, so each participant's understanding of vocal fatigue determined their prompted self-ratings within the vocal loading task. Because vocal fatigue lacks a simple definition, by having the participants compare their own vocal fatigue ratings against one another this measurement is a more reliable subjective measurement. In addition, within written and verbal feedback from participants, many reported feeling less vocal fatigue symptoms after use of the EMST150.

Likewise, there have been studies that indicate because vocal fatigue is such a complex phenomenon that acoustical measures are not always the most reliable measurement of change. For example, within a study analyzing vocal fatigue self-ratings with acoustical measures, it was found that although acoustical measures did not show significance that "mental" fatigue decreased. In addition, the findings of this study showed that it is challenging to identify acoustical changes within relatively healthy individuals (Laukkanen, Ilomaki, Leppanen & Vilkman, 2008). These findings remain consistent with this study and prove additional limitations when using a relatively healthy population.

More research needs to be done to better understand the phenomenon of vocal fatigue and the relation between an intervention with an EMST device. This study could be reduplicated in many ways using a control group, an increase in sample size, and conducting intervention sessions within a controlled environment. One of the limitations of this study was the lack of control within the at-home exercise. Although participants were provided a log and came in contact with researchers throughout the month-long intervention, it was challenging to ensure that each individual was using the EMST correctly. Other considerations for future studies should be in the consideration of assessment. Vocal fatigue can be assessed in many ways, and this study had other ways of measurement for acoustical analyses that could have been used. Additionally, other manners of assessing pulmonary strength and functioning after use of the EMST150 could have been considered.

CONCLUSION

The results of this study identify that the use of the low-cost intervention of the expiratory muscle strength trainer device may be beneficial in reducing vocal fatigue symptoms. Although future research needs to be done to further extend the reliability and validity of this study, the results show here are a beginning step with the introduction of using an expiratory muscle strength trainer device for patients with vocal fatigue voice problems. The results within the self-perceived vocal fatigue identify that patients feel less of the harsh symptoms which can be a motivator to introduce this type of intervention for every day professionals. Work places that require moderate-maximal voice use every day would be suitable places to aid workers.

APPENDIX

APPENDIX A: Consent Form

Research Participant Information and Consent Form

You are being asked to participate in a research study. Researchers are required to provide a consent form to inform you about the research study, to convey that participation is voluntary, to explain risks and benefits of participation, and to empower you to make an informed decision. You should feel free to ask the researchers any questions you may have concerning this project.

Study Title: The Impact of Expiratory Muscle Strength Training on Vocal Effort
Researcher and Title: Rachel Burtka, Graduate Student at MSU
Department and Institution: Department of Communicative Sciences and Disorders
Address and Contact Information: 113 Oyer, East Lansing 48823, 517.353.8641
Sponsor: Michigan State University

1. PURPOSE OF RESEARCH

You are being asked to participate in this study to help researchers gain a better understanding of the effect of respiratory muscle strength exercises on vocal effort during a prolonged speaking task.

2. ELIGIBILITY CRITERIA

It is expected that you have no significant vocal complaints and are in good physical and mental health.

- You must be a female between 18-30 years of age.
- You must be one of the following:
    - A shorter height than 5 feet 2 inches and less than 140 lbs,
    - A height between 5 feet 2 inches and 5 feet 6 inches and between 115-170 lbs
    - A taller height than 5 feet 6 inches and more than 145 lbs.
- No history of prior or current voice or speech problems requiring medical intervention (including voice or speech therapy).
- Native English speaker
- You will be asked about items which might affect your speech production (e.g. hearing, reflux, breathing).

3. ALTERNATIVE OPTIONS

There are no alternative procedures, but you have the option not to participate in this research study.

4. WHAT YOU WILL DO

There will be a brief screening process prior to the reading task. During the screening process, you may be asked to do some or all of the following:

- Complete questionnaires about your voice and voice use.
- Answer questions about your vocal habits and history of vocal fatigue.
- Asked about current medication related to asthma, allergies or heartburn; if you don't want to respond to these questions, you don't have to answer if you don't want to.
- Complete a short hearing screening to ensure that your hearing is within the normal age appropriate ranges.

- Complete a pulmonary function test using a device (spirometer) to assess your lung function, this may be repeated up to three times. For this test, you will be asked to breathe in deeply and blow into a device to collect measurements about your lung ability. Also, your breathing while speaking will be observed (no devices used) to indicate how you breath while speaking.

After the screening tasks, you will be asked to complete three simple vocal tasks before beginning the reading task. The first task will be to produce a vowel ("ah") and a soft pitch glide that consists of reaching a high, squeaky voice, then holding it for several seconds with effort. The next task will be to complete a short scripted speech task consisting of reading a prompted passage.

Next, you will be requested to produce a speech sample that consists of a reading task in a soundproof room used for recordings. You will be fitted with a microphone that goes loosely around your neck and one that goes on your head (similar to headphones). During prolonged speaking task, you will be asked to read for about 30 minutes following the promptings on a computer screen. Sometimes you will be prompted to speak louder, sometimes softer. Every three minutes you will be asked to drink a small cup (30 mL) of water. Finally, after the prolonged speaking task, you will be asked to complete the vowel, pitch glide, and short scripted speech task (reading task as previously done).

You will be asked throughout the tasks to rate your current level of vocal fatigue by completing a prompted sentence, "My current vocal fatigue level is a ___" and self-rating your voice on a 1-10 scale.

5. POTENTIAL BENEFITS

While the program in which you are being asked to participate may have no immediate benefit for you, it may benefit others by increasing our knowledge of factors affecting measures of speech and vocal function.

6. POTENTIAL RISKS

There is minimal risk involved in this research program and the procedures should cause you no undue discomfort. Likely your voice will experience some fatigue but this should resolve with some nominal vocal rest. Except for the spirometer, other devices to be used are similar to those found in singing studios, linguistic laboratories, and speech production laboratories. They include such items as microphones and surface microphones that go on the neck (to detect speech use in noise). An ear microphone and recorder may be used to record the sound you are surrounded by. While the pulmonary function test is unlikely to cause injury, breathing hard may cause some discomfort.

If there is anything in the screening that does not make you a good subject for our study, you will be remunerated for your time (see below) and no further participation is needed. If you are not healthy enough to participate (for example, if you have a cold or are hoarse from cheering at a sports activity), or if one of the screening procedures indicates that you might not match the level of communication function we are looking for (for example, your hearing is limited), you may be asked to not participate further.

The testing performed in this project is not intended to find abnormalities, the protocol does not diagnose illness and we do not refer to health care providers. Data collected do not comprise a diagnostic or clinical study. Undetected vocal abnormalities are rare but it is possible that the investigators may perceive a vocal abnormality during the initial screening. If this occurs, you will be advised to consult with a licensed physician to determine whether a health examination would be prudent.

7. PRIVACY AND CONFIDENTIALITY

The data for this study are being collected confidentially. Neither the researchers nor anyone else will be able to link data to you. The data for this project will be kept confidential. Data from this study will be stored in a locked cabinet in a locked room or a password protected computer in the locked laboratory. All information will be kept for at least three years after the close of the study. Only trained researchers under the jurisdiction of this project and Human Research Protection Program will have access to the data collected in the study. Information about you will be kept confidential to the maximum extent allowable by law. Although we will make every effort to keep your data confidential there are certain times, such as a court order, where we may have to disclose your data. Identifying information will not be attached to any of your individual responses or recordings when reporting results from the surveys. You will not be asked to give your name or any other information during the recording that will allow you or your place of employment to be identified. All results will be kept in a secured location accessibly only to those involved in the study. The results of this study may be published or presented at professional meetings, but the identities of all research participants will remain anonymous. By participating, you agree to allow audio recordings of your speech.

8. YOUR RIGHTS TO PARTICIPATE, SAY NO, OR WITHDRAW

Participation is voluntary. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled. You have the right to say no. You may change your mind at any time and withdraw. You may choose not to answer specific questions or to stop participating at any time. Whether you choose to participate or not will have no effect on your grade or evaluation.

9. COSTS AND COMPENSATION FOR BEING IN THE STUDY

As an incentive to participate, people who participate in this research will be offered $10 per hour of participation (up to 2 hours or $20) for each of the two data collection days. Additionally, participants will be offered $5 for every exercise for performing the exercises (approximately 20 minutes each day), for 12 total exercise days or $60. In all, full participation could result in $100 of incentive.

10. THE RIGHT TO GET HELP IF INJURED

In the unlikely event that you are injured as a result of your participation in this project, Michigan State University will assist you in obtaining emergency care, if necessary, for your research related injuries. If you have insurance for medical care, your insurance carrier will be billed in the ordinary manner. As with any medical insurance, any costs that are not covered or in excess of what are paid by your insurance, including deductibles, will be your responsibility. The University’s policy is not to provide financial compensation for lost wages, disability, pain or discomfort, unless required by law to do so. This does not mean that you are giving up any legal rights you may have. You may contact Dr. Eric Hunter at 517.353.8641 with any questions or to report an injury.

11. CONTACT INFORMATION

If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher(s):

- Rachel Burtka, Graduate Student at Michigan State University, East Lansing, MI 48824, (248)719-2467, burtkar1@msu.edu
- Dr. Eric Hunter Ph.D., Michigan State University, 113 Oyer, East Lansing, MI 48823, (517)353-8641, ejhunter@msu.edu

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432- 4503, or e-mail irb@msu.edu or at Olds Hall, 408 West Circle Drive #207, MSU, East Lansing, MI 48824.

12. DOCUMENTATION OF INFORMED CONSENT

Your signature below means that you voluntarily agree to participate in this research study.

________________________________ ________________________________

Signature Date

You will be given a copy of this form to keep.

At times, it is useful to use recordings in teaching or presenting research. Therefore, we would like to ask for special permission to use your recordings in those contexts. Your name would not be associated with the recording. If you do not give permission, it will not affect your ability to participate in the research. If you agree to allow your voice recordings (audio or video) to be part of scientific reports and presentations, please indicate:

☐ Yes ☐ No Initials____________

A signature is a required element of consent – if not included, a waiver of documentation must be applied for.

This consent form was approved by a Michigan State University Institutional Review Board. Approved 8/23/17– valid through 8/22/18. This version supersedes all previous versions. IRB# 17-861

APPENDIX B: IRB Approval

MICHIGAN STATE UNIVERSITY

Revision Application Approval

September 26, 2017

To: Eric Hunter
1026 Red Cedar Road
Room 113, Oyer Speech & Hearing Building
East Lansing, MI 48824

Re: **IRB# 17-861** Category: EXPEDITED 6, 7
Revision Approval Date: September 21, 2017
Project Expiration Date: August 22, 2018

Title: The Impact of Expiratory Muscle Strength Training on Vocal Effort (CGA#136350)

The Institutional Review Board has completed their review of your project. I am pleased to advise you that **the revision has been approved**.

This revision includes the addition of Olivia Sowa to the study.
The review by the committee has found that your revision is consistent with the continued protection of the rights and welfare of human subjects, and meets the requirements of MSU's Federal Wide Assurance and the Federal Guidelines (45 CFR 46 and 21 CFR Part 50). The protection of human subjects in research is a partnership between the IRB and the investigators. We look forward to working with you as we both fulfill our responsibilities.

Renewals: IRB approval is valid until the expiration date listed above. If you are continuing your project, you must submit an ***Application for Renewal*** application at least one month before expiration. If the project is completed, please submit an ***Application for Permanent Closure***.

Revisions: The IRB must review any changes in the project, prior to initiation of the change. Please submit an ***Application for Revision*** to have your changes reviewed. If changes are made at the time of renewal, please include an ***Application for Revision*** with the renewal application.

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to the human subjects, notify the IRB office promptly. Forms are available to report these issues.

Please use the IRB number listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

If we can be of further assistance, please contact us at 517-355-2180 or via email at IRB@msu.edu. Thank you for your cooperation.

c: Lady Catherine Cantor Cutiva, Olivia Sowa, Rachel Burtka, Mark Berardi, Russell Banks

Office of Regulatory Affairs
Human Research Protection Programs

Biomedical & Health Institutional Review Board (BIRB)

Community Research Institutional Review Board (CRIRB)

Social Science Behavioral/Education Institutional Review Board (SIRB)

4000 Collins Road
Suite 136
Lansing, MI, 48910
(517) 355-2180
Fax: (517) 432-4503
Email: irb@msu.edu
www.hrpp.msu.edu

APPENDIX C: Research Plan

DAY 1-

D1a. Consent

A consent form must be signed by each participant prior to beginning the study. The form includes any risks and benefits from the study. Once subjects agree to the consent form the experiment began as follows.

D1b. Surveys

Surveys were completed to gather additional information. There were questions from the Vocal Fatigue Index (VFI), Vocal Handicap Index (VHI), Big Five Inventory (BFI-10), and Voice-Related Quality of Life (V-RQOL). These surveys were given to the participants prior to the study as a baseline collection. The surveys collected information on the vocal and pulmonary health of the participants, in addition to demographics, self-ratings, and subject characteristics. The surveys were combined and analyzed using Qualtrics, an online survey portal.

D1c. Hearing screening

A quick bilateral hearing screening of 25 dB at frequencies 500 hZ, 1,000 hZ, 2,000 hZ,, and 4,000 hZ was completed. Participants failing to respond to any of these frequencies were excluded from the study.

D1d. Pulmonary function test

An electronic spirometer was used to assess each participant's lung function. A computer-based program, CareFusion, recorded pulmonary data. The pulmonary data collection occurred both in Day 1 and Day 2 of the study. Norms of pulmonary measurement taken from Gavigan's study (2016) was used to determine normalcy.

The participants were instructed to “Inhale as deeply and quickly as you can. Then without pausing in between, exhale as fast and hard as you can, pushing all the air out of your lungs. Begin whenever you are ready”. The experimenter provided coaching and motivation to promote the best possible effort. The participant was required to have three successful attempts that are within 5% of one another, which CareFusion measured. The measures that were collected are: forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), peak expiratory flow (PEF), and a ratio was gathered by dividing expiratory volume in the first second by the forced vital capacity (FEV1/FVC).

D1e. Breathing screening

A respiratory assessment was given to measure different breathing types of each participant. The breathing types include: diaphragmatic (inhalation with the diaphragm being pulled outward), thoracic (inhalation with the chest expanding outwards), clavicular (inhaling with the clavicle rising to accumulate space), and paradoxical (compressing the chest rather than expanding during inhalation). Participants who showed clavicular or paradoxical breathing were excluded from the study due to breathing type abnormality. Non-speech breathing can be: oral-nasal, nasal-nasal, and oral-nasal, which was marked. Adequacy between respiration and voice coordination was marked too.

D1f. Non-fatiguing task

A non-fatiguing task was used as a control for the participant’s fatiguing task to be compared to. In both the controlled and experimental portions of the study, the participants attended to the same software program that monitors the vocal loading tasks. Participants were asked to remain completely silent, except for responding to questions given by the experimenter. The participant completed a breathing screening (D1e), hearing screening (D1c), and pulmonary function task (D1d) during this time. At four different times within this task, the participant were asked to read the phrase "My vocal fatigue level is…", and rate their current vocal fatigue level. 0 will signify no vocal fatigue present, while 10 will represent a great level of fatigue.

D1g. Vocal measures

Vocal measures came in subjective and objective measures. Recordings were taken during the tasks, and acoustical measures were analyzed by the experimenter.

Subjective data: This included a self-rating that the participant filled out indicating her fatigue level throughout the non-fatiguing and fatiguing tasks. The self-reports included a range of 0-10 for the participant to indicate current level of vocal fatigue; 0 representing no vocal fatigue and/or poor vocal quality symptoms, 10 representing a great level of vocal fatigue and/or poor vocal quality.

Objective data: included the recordings of each participant during the duration of the study. Participants were required to wear a recording device during the tasks. These tasks included: counting to 5 holding out the "I" in five (i.e. "fiiiiiive), producing steady vowel "ah" three times for as long as the participant can, producing a vowel-consonant-vowel ("afa") three times, and reading the rainbow passage. Measurements were taken via Reaper software which takes data such as: fundamental frequency, speech level, and perturbation measures. Changes in standard deviations were measured before and after the fatiguing task.

D1h. Fatiguing tasks

The tasks within this portion were designed to elicit vocal fatigue from each participant, without causing any long-term damage. Each participant completed a thirty-six minute vocal loading task. LingWAVES and Reaper software were used to record and analyze each participant's vocal loading tasks. LingWAVES was used to record participant's during the vocal loading tasks, and additionally was used for participant's view during the tasks to indicate a desired loudness level. The participants had clear instruction for this task, and reading materials were provided. Reaper was used to record the entirety of the preliminary practice tasks, vocal loading tasks, and post loading tasks.

The participants were seated in a sound-proof booth, with a microphone 50 cm away, and the reading material and SPL levels were presented on a screen. During the vocal loading task, the participants alternated every six minutes between 66.0 dB and 72.0 dB, which is based on the ISO standard of normal and raised speech levels (ISO 9921, 2003). The experimenter provided explicit instructions via PowerPoint and LingWAVES informing the participant to read the provided material with an engaging voice. The participants were notified by a big blue arrow if they fell below a desired SPL level, in which case an arrow remained on the screen until the participant reached a certain loudness level. During this task, the participant was asked to complete the phrase "My vocal fatigue level is….", with a rating of 0-10. The subjective ratings were an indicator of fatigue in the analysis.

D1i. Vocal measures

These tasks are described in D1g.

DAY 2-

D2a. Pulmonary function test

The pulmonary function test was identical the first day, refer to D1d.

D2b. Vocal measures

The vocal measures were identical to the first day, refer to D1g.

D2c. Fatiguing task

The fatiguing task was identical to the first day, refer to D1h.

D2d. Vocal measures

The vocal measures were identical to the first day, refer to D1i.

APPENDIX D: Vocal Fatigue Index

These are some symptoms usually associated with voice problems. Circle the response that indicated how frequently you experience the same symptoms.

0- never, 1- almost never, 2- sometimes, 3- almost always, 4- always

Part 1

1. I don't feel like talking after a period of voice use.	0	1	2	3	4
2. My voice feels tired when I talk more.	0	1	2	3	4
3. I experience increased sense of effort with talking.	0	1	2	3	4
4. My voice gets hoarse with voice use.	0	1	2	3	4
5. It feels like work to use my voice.	0	1	2	3	4
6. I tend to generally limit my talking when I know I have to talk more.	0	1	2	3	4
7. I avoid social situations when I know I have to talk more.	0	1	2	3	4
8. I feel I cannot talk to my family after a work day.	0	1	2	3	4
9. It is effortful to produce my voice after a period of voice use.	0	1	2	3	4
10. I find it difficult to project my voice with voice use.	0	1	2	3	4
11. My voice feels weak after a period of voice use.	0	1	2	3	4

Part 2

12. I experience pain in the neck at the end of the day with voice use.	0	1	2	3	4
13. I experience throat pain at the end of the day with voice use.	0	1	2	3	4
14. My voice feels sore when I talk more.	0	1	2	3	4
15. My throat aches with voice use.	0	1	2	3	4
16. I experience discomfort in my neck with voice use.	0	1	2	3	4

Part 3

17. My voice feels better after I have rested.	0	1	2	3	4
18. The effort to produce my voice decreases with rest.	0	1	2	3	4
19. The hoarseness of my voice gets better with rest.	0	1	2	3	4

APPENDIX E: Voice Handicap Index-10

Instructions: These are statements that many people have used to describe their voices and effects of their voices on their lives. Circle the response that indicates how frequently you have the same experience.

0- never, 1- almost never, 2- sometimes, 3- almost always, 4- always

1. 1. My voice makes it difficult for people to hear me. 0 1 2 3 4
2. I run out of air when I talk. 0 1 2 3 4
3. People have difficulty understanding me in a noisy room. 0 1 2 3 4
4. The sound of my voice varies throughout the day. 0 1 2 3 4
5. My family has difficulty hearing me when I call them throughout the house. 0 1 2 3 4
6. I use the phone less often than I would like to. 0 1 2 3 4
7. I'm tense when talking to others because of my voice. 0 1 2 3 4
8. I tend to avoid groups of people because of my voice. 0 1 2 3 4
9. People seem irritated with my voice. 0 1 2 3 4
10. People ask, "What's wrong with your voice?" 0 1 2 3 4

APPENDIX F: Big Five Inventory- 10

Instructions: How well do the following statements describe your personality?

1= disagree strongly 2= disagree a little
3=neither agree nor disagree 4= agree a little
5= agree strongly

I see myself as some who…

1. Is reserved	1	2	3	4	5
2. Is generally trusting	1	2	3	4	5
3. Tends to be lazy	1	2	3	4	5
4. Is relaxed, handles stress well	1	2	3	4	5
5. Has few artistic interests	1	2	3	4	5
6. Is outgoing, sociable	1	2	3	4	5
7. Tends to find fault with others	1	2	3	4	5
8. Does a thorough job	1	2	3	4	5
9. Get nervous easily	1	2	3	4	5
10. Has an active imagination	1	2	3	4	5

APPENDIX G: Voice Related Quality of Life Index

Instructions: We are trying to learn more about how a voice problem can interfere with your day to day activities. On this paper, you will find a list of possible voice-related problems. Please answer all questions based upon what **your** voice has been like over the past **two weeks**.

Considering both how severe the problem is when you get it, and how frequently it happens, please rate each item below on how "bad" it is (that is, the **amount** of each problem that you have). Use the following scale for rating the amount of the problem:

1 = None, not a problem 2 = A small amount 3 = A moderate (medium) amount

4 = A lot 5 = Problem is as "bad as it can be"

Because of my voice,

1. I have trouble speaking loudly or being heard in noisy situations.	1 2 3 4 5
2. I run out of air and need to take frequent breaths when talking.	1 2 3 4 5
3. I sometimes do not know what will come out when I begin speaking.	1 2 3 4 5
4. I am sometimes anxious or frustrated (because of my voice).	1 2 3 4 5
5. I sometimes get depressed (because of my voice).	1 2 3 4 5
6. I have trouble using the telephone (because of my voice).	1 2 3 4 5
7. I have trouble doing my job or practicing my profession (because of my voice).	1 2 3 4 5
8. I avoid going out socially (because of my voice).	1 2 3 4 5
9. I have to repeat myself to be understood.	1 2 3 4 5
10. I have become less outgoing (because of my voice).	1 2 3 4 5

APPENDIX H: Respiration Assessment

Type of breathing		Score	
		Present	Absent
Diaphragmatic	The belly pushes out with an inhale		
Thoracic	During inhale the chest expands to accommodate the air that has been sucked into the lungs		
Clavicular	During inhale the clavicle goes up to accommodate the air that has been sucked into the upper part of the lungs		
Paradoxical	The chest compresses on the inhale rather than expands and vice versa		

Oral-Oral	
Nasal-Nasal	
Oral-Nasal	

Type of respiration cycle in non-speech:

Adequate	
Not Adequate	

Coordination of respiration-voice:

APPENDIX I: Rainbow Passage Part I

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach his friends say he is looking for the pot of gold at the end of the rainbow.

APPENDIX J: Rainbow Passage Part II

Throughout the centuries people have explained the rainbow in various ways. Some have accepted it as a miracle without physical explanation. To the Hebrews it was a token that there would be no more universal floods. The Greeks used to imagine that it was a sign from the gods to foretell war or heavy rain. The Norsemen considered the rainbow as a bridge over which the gods passed from earth to their home in the sky. Others have tried to explain the phenomenon physically. Aristotle thought that the rainbow was caused by reflection of the sun's rays by the rain. Since then physicists have found that it is not reflection, but refraction by the raindrops which causes the rainbows.

Appendix K: Marvin Williams Passage

Marvin Williams is only nine. Marvin lives with his mother on Monroe Avenue in Vernon Valley. Marvin loves all movies, even eerie ones with evil villains in them. Whenever a new movie is in the area, Marvin is usually an early arrival. Nearly every evening Marvin is in row one, along the aisle.

APPENDIX L: Stella Passage

Please call Stella. Ask her to bring these things with her from the store: Six spoons of fresh snow peas, five thick slabs of blue cheese, and maybe a snack for her brother Bob. We also need a small plastic snake and a big toy frog for the kids. She can scoop these things into three red bags, and we will go meet her Wednesday at the train station.

APPENDIX M: Day 1 (Tx0) Protocol

DAY 1 PROTOCOL INSTRUCTIONS

SUBJECT NUMBER: ________________
DATE: ___________________________
TIME: ___________________________

SCREENINGS:

□ Seat the subject

"Please read and sign this consent form. Let me know if you have any questions."

Hand subject consent form & provide a take-home copy as well

□ Non-fatiguing tasks

"Before we begin, between each screening and survey task, you will be asked to rate your current vocal fatigue. I want you to read the following script "My vocal fatigue level is _____", with your current vocal fatigue on a scale of 1 being no level of fatigue and 10 being the greatest amount of fatigue. You cannot rate 0 or greater than 10. Other than that during the next tasks I would like you to talk as little as possible, until I redirect you to rate your vocal fatigue level. Please use post it notes or hand gestures to communicate other than that."

Provide accessible post it notes and script reading "My current vocal fatigue level is ____"- when participants rate themselves write the rating on the provided line.

□ Ask subject to complete surveys via Qualtrics questionnaire- (which includes: VHI, VFI, BFI-10, V-RQOL)

"Use this time to completely fill out the questionnaires on this online survey."

https://msu.co1.qualtrics.com/jfe/form/SV_3U9HoswDO6b6YER

PROMPT VOCAL FATIGUE RATING- _____

□ Hearing screening: Make sure earphones are present, turn on audiometer.

Mark results on following screening form using 25dB

LEFT EAR	RIGHT EAR
☐ 500 Hz	☐ 500 Hz
☐ 1,000 Hz	☐ 1,000 Hz
☐ 2,000 Hz	☐ 2,000 Hz
☐ 4,000 Hz	☐ 4,000 Hz

□ Pulmonary Function Test:

- Pre-check: turn on computer, having testing tubes nearby, be sure spirometer is plugged into computer and turned on.

- Enter participant's number into the software and begin exam:
    - "First I will provide you with instructions to follow the test. I will then model the procedure for you, if you have any questions at this point please ask. I will then place a nose plug on your nose, and you will inhale as much and deeply as you can. Then, exhale as fast as you can pushing all the air out of your lungs. Do not pause in between the inhalation and the exhalation. Feel free to use the rest of your body in order to move as much air as possible."
    - Offer the participant a copy of the PFT results.

OFFER A SIP OF WATER

PROMPT VOCAL FATIGUE RATING- ______

□ Breathing Screening: identifies types of breathing.

Mark results on respiration screening form

Type of breathing		Score	
		Present	Absent
Diaphragmatic	The belly pushes out with an inhale		
Thoracic	During inhale the chest expands to accommodate the air that has been sucked into the lungs		
Clavicular	During inhale the clavicle goes up to accommodate the air that has been sucked into the upper part of the lungs		
Paradoxical	The chest compresses on the inhale rather than expands and vice versa		

Type of respiration cycle in non-speech:

Oral-Oral	
Nasal-Nasal	
Oral-Nasal	

Coordination of respiration-voice:

Adequate	
Not adequate	

OFFER A SIP OF WATER

PROMPT VOCAL FATIGUE RATING- ______

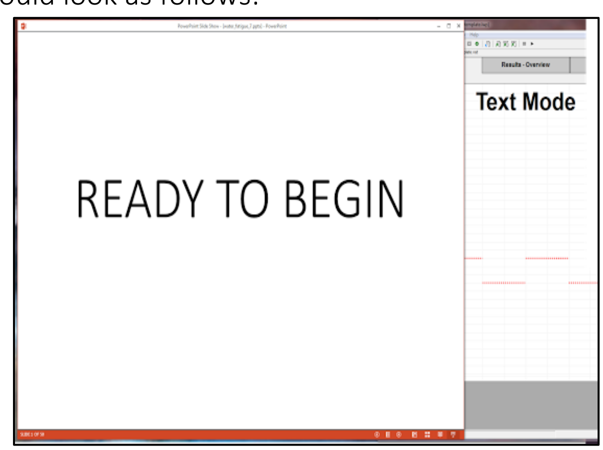
VOCAL LOADING TASKS

□ Pre-check:

- Are computers on and logged in?
- Is equipment present and working- microphones in sound booth, recording devices both in and outside the sound booth?
- Are water and water cups full and available next to participant's seat?
    - Fill water with about 2 bottles per person.
- Did participant sign the consent form and understand they can leave at any point?

□ Equipment check:

1. Turn on equipment inside sound booth- power 1 (power strip), power 2 (sound level meter), and clicker. Make sure the clicker is within easy reach of the participant.
    a. Check batteries on power 2 (sound level meter)- there will be a warning for low batteries.
2. Have programs on computer in lab up- (lingWAVES, PowerPoint, Reaper).
    a. Reaper
        i. Z:\fatigue protocol\fatigue_project_template.RPP
        ii. Put ID number (m or f to identify sex, with participant number)- in the upper left double click ID# to insert information.
        iii. Note the record button on the bottom left.
    b. Start lingWAVES
        i. Z:\fatigue protocol\fatigue template.lwp
            1. This will open a template that is ready to go.
        ii. Note green circle button at the top is the record button.
    c. Open PowerPoint
        i. Z:\fatigue protocol\Powerpoints
        ii. Water_fatigue_7.pptx
3. Align PowerPoint and LingWAVES on screen for participant (use screen and duct tape on far upper left for reference). LingWAVES should be open on the bottom on PowerPoint. Open LingWAVES to fit half of the screen and move over to left side until the green record button is in the middle of the tape mark. Lay PowerPoint on top of LingWAVES, open to the height of the screen and over to the tape mark).
    a. Screen should look as follows:



□ Participant instructions: go through the following ensuring no questions along the way.

1. Make sure participant is seated in an upright posture in booth.
    a. "Get into a comfortable seated position. Try to stay in an upright posture and limit movements during tasks to avoid the microphone moving".
    b. Adjust sound-level meter (SLM) to be string length nose distance away from participant.
2. Adjust screen to preferred distance from participant.
    a. "Let me know which distance you are comfortable with the screen. You should be able to clearly read the screen with no difficulty."
    b. Make sure PowerPoint is on top of LingWAVES and the arrow is present when LingWAVES turns on.
3. Put microphone around participant's ears.
4. Show the participant how to get a cup of water.
    a. "One big push will fill the cup, watch as I do it. Each time you are prompted to drink on the screen you are to fill the water cup and drink it. I would recommend filling the cup right after you finish it to make it easier next time you are prompted to drink."
5. Show the participant the click and which button to push.
    a. "You click this button to move forward in the PowerPoint to your desired pace. The PowerPoint will indicate whether or not to click when done with a slide".
6. Begin the PowerPoint and go through the practice tasks (DO NOT RECORD YET):
    a. Inform them that there will be an arrow on the right side that they want to disappear
        i. "You want to speak loudly enough that the big arrow disappears".
    b. The PowerPoint will then go through the following examples:
        i. Vocal fatigue level
            1. "As previously done in between tasks, I want you to rate your current vocal fatigue level. With 1 being 1 being no level of fatigue and 10 being the greatest amount of fatigue."
        ii. Steady vowel phonation and vowel-consonant-vowel
            1. "The next two tasks are going to be producing 'ah' and 'afa'. First you will produce 'ah' for about 3-5 seconds in a comfortable extended tone for as long as the 'ah' is present on the screen. After that you will see 'afa' on the screen, you will produce 'afa' in a shorter comfortable tone without changing pitch. For example: 'ahhhhh' 'afa'- *provide examples"
        iii. 2 readings
            1. "Read through the next readings in a comfortable pitch."

2. “Note that on the last slide it says not to click to advance. When you get to this slide repeat the passage until the slide automatically changes. You may or may not have to repeat this slide, it is completely dependent on your pace”.

7. Exit sound booth to begin Reaper recording.
    a. Have participant give 3 loud “Hey’s” to test for acoustics.
        i. “Pretend you are saying hey to someone in the outdoor lab area, loudly and clearly.”
        ii. INSERT PARTICIPANT NUMBER IN REAPER.
8. Re-enter sound booth, shut the outer door to begin vocal measures.
    a. State date, time and participant number (DO NOT mention actual name)
9. Begin PowerPoint pre-tasks:
    a. “When you are ready you are going to complete some initial tasks. The PowerPoint will indicate what you should do, it will be similar to the practice tasks.”
    b. Tasks:
        i. Count to five drawing out the “I” in five
        ii. Extended “ah”
        iii. “Afa”
        iv. Rainbow passage
10. Ready to begin.
    a. “Do you have any questions? I will do the rest of my communicating with you through the intercom. Give me a thumbs up to let me know when you are ready and I will tell you to begin by clicking the clicker which will start the PowerPoint.”
11. When the participant gets to the first slide and is drinking water, begin LingWAVES and click back to the PowerPoint so it is layered on top.
    a. NOTE: failure to click back on the PowerPoint will result in the clicker not working when participant clicks it!

□ Data collection- participant tasks, **equipment: PowerPoint, LingWAVES and Reaper**

- Task 1:
    - Drink water
- Task 2:
    - Self-rating of vocal fatigue
- Task 3 & 4:
    - “Aaaah” extended productions x3 in a comfortable voice and “afa” x3 in a comfortable voice
- Task 5:
    - Marvin Williams Passage- loudness guided by arrows to indicate desired loudness (which will stay consistent through task 9)

- Task 6:
    - o Stella Passage
- Task 7:
    - o "Aaaah" extended productions
- Task 8:
    - o Rainbow Passage
- Task 9:
    - o Rainbow Passage Part 2

*Participants will go through a cycle of these 9 tasks until time limit is complete.

- Researchers during this time will remain outside the sound booth, only entering if signaled by participant. Ensure all recordings are working functionally throughout collection.

□ Post data-collection:

1. When PowerPoint is complete, LingWAVES will automatically shut off.
2. Participant will be guided through the following post vocal loading tasks:
    - i. Count to five drawing out the "I" in five
    - ii. Extended "ah"
    - iii. "Afa"
    - iv. Rainbow passage
3. When they have finished the rainbow passage, instruct them via intercom that you will be re-entering the room.
4. Turn off Reaper and go in sound booth.
5. Thank participant and bring them outside booth for instructions on at home use of respiratory training device.
    - a. "Thank you for coming today. We are finished with the tasks for today, now I am going to confirm your date for the second portion of this study and provide you with your respiratory training device."

□ Introduction to respiratory training plan:

1. Use spirometry results to determine load on the participant's expiratory muscle strength training device (EMST150).
    - a. "We will now discuss your pulmonary function test results and establish a load for your device."
2. Set the load on the participants EMST150 and demonstrate use on your own device.
    - a. "Watch as I show you: first you place the nose clip over your nose. You are going to want to place the device in your mouth behind your teeth, and make a tight seal with your lips, you can hold or press the sides of your cheeks if necessary. Then you are going to take a deep breath in and do not breathe out. You want to use your chest muscles to breathe out hard and fast to push air through the device. This should only take a few seconds." *show example*
    - b. "After you complete the first repetition you are going to rest for a minimum of

15-30 seconds. Then repeat this 5 time to complete one set- which we call a 5 breath cycle. After you have done a full 5 breath cycle rest 1-2 minutes and then complete another. You will have 3 sets of 5 breath cycles for a total of 15 breaths."

   c. "You can go ahead and show me an example to make sure you understand the directions." *have participant do 2 repetitions*
   d. "At the end of every week you are going to move the knob a quarter to the right, or more if you feel it was too easy or none at all if the current load remained challenging".

3. Provide at home instructions and logging sheet.
   a. "I am giving you instructions and my contact information should you forget anything. Use this logging sheet to indicate repetitions with tally's, time of day, and date you used it to help keep track of use. Indicate any other feelings of fatigue or ease in the comments."
   b. "At the beginning of each week indicate if you cleaned the device and what the starting number is.
4. Questions or concerns.
   a. "I will be contacting you weekly to ensure no confusion or questions."
5. Compensation and good-bye!
   a. Make sure participant knows date of return and instructions fluently.

□ Post-participant:

1. Open fatigue protocol folder (which should be on the desktop), to save files in the data folder.
2. Save data and close out files.
   a. LingWAVES-
      i. Right click and copy the first LingWAVES file name in the data folder (to make it easier to save the new file under the right label) OR use the saved name and change the first part to the appropriate participant name.
      ii. Press save.
   b. Reaper-
      i. Files will automatically save within Z:\fatigue protocol\Data
         1. DOUBLE CHECK files are saved in z-drive before exiting.
         2. There should be 6 files per participant.

APPENDIX N: Day 2 (Tx1) Protocol

DAY 2 PROTOCOL INSTRUCTIONS

SUBJECT NUMBER: ___________________
DATE: ________________________________
TIME: ________________________________

"Hello and welcome back to our study. This will be the final day of the study. Thank you for your continued participation. Do you have any questions before we begin?"

□ Pulmonary Function Test:

- Pre-check: turn on computer, having testing tubes nearby, be sure spirometer is plugged into computer and turned on.
- Enter participant's number into the software and begin exam:
    - "First I will provide you with instructions to follow the test. I will then model the procedure for you, if you have any questions at this point please ask. I will then place a nose plug on your nose, and you will inhale as much and deeply as you can. Then, exhale as fast as you can pushing all the air out of your lungs. Do not pause in between the inhalation and the exhalation. Feel free to use the rest of your body in order to move as much air as possible."
    - Offer the participant a copy of the PFT results.

□ Participant instructions: go through the following ensuring no questions along the way.

1. Make sure participant is seated in an upright posture in booth.
    a. "Get into a comfortable seated position. Try to stay in an upright posture and limit movements during tasks to avoid the microphone moving".
    b. Adjust sound-level meter (SLM) to be string length nose distance away from participant.
2. Adjust screen to preferred distance from participant.
    a. "Let me know which distance you are comfortable with the screen. You should be able to clearly read the screen with no difficulty."
    b. Make sure PowerPoint is on top of LingWAVES and the arrow is present when LingWAVES turns on.
3. Put microphone around participant's ears.
4. Show the participant how to get a cup of water.
    a. "One big push will fill the cup, watch as I do it. Each time you are prompted to drink on the screen you are to fill the water cup and drink it. I would recommend filling the cup right after you finish it to make it easier next time you are prompted to drink."
5. Show the participant the click and which button to push.

a. "You click this button to move forward in the PowerPoint to your desired pace. The PowerPoint will indicate whether or not to click when done with a slide".

6. Begin the PowerPoint and go through the practice tasks (DO NOT RECORD YET):
    a. Inform them that there will be an arrow on the right side that they want to disappear
        i. "You want to speak loudly enough that the big arrow disappears".
    b. The PowerPoint will then go through the following examples:
        i. Vocal fatigue level
            1. "As previously done in between tasks, I want you to rate your current vocal fatigue level. With 1 being 1 being no level of fatigue and 10 being the greatest amount of fatigue."
        ii. Steady vowel phonation and vowel-consonant-vowel
            1. "The next two tasks are going to be producing 'ah' and 'afa'. First you will produce 'ah' for about 3-5 seconds in a comfortable extended tone for as long as the 'ah' is present on the screen. After that you will see 'afa' on the screen, you will produce 'afa' in a shorter comfortable tone without changing pitch. For example: 'ahhhhh' 'afa'- *provide examples"
        iii. 2 readings
            1. "Read through the next readings in a comfortable pitch."
            2. "Note that on the last slide it says not to click to advance. When you get to this slide repeat the passage until the slide automatically changes. You may or may not have to repeat this slide, it is completely dependent on your pace".
7. Exit sound booth to begin Reaper recording.
    a. Have participant give 3 loud "Hey's" to test for acoustics.
        i. "Pretend you are saying hey to someone in the outdoor lab area, loudly and clearly."
        ii. INSERT PARTICIPANT NUMBER IN REAPER.
8. Re-enter sound booth, shut the outer door to begin vocal measures.
    a. State date, time and participant number (DO NOT mention actual name)
9. Begin PowerPoint pre-tasks:
    a. "When you are ready you are going to complete some initial tasks. The PowerPoint will indicate what you should do, it will be similar to the practice tasks."
    b. Tasks:
        i. Count to five drawing out the "I" in five
        ii. Extended "ah"

iii. "Afa"
iv. Rainbow passage

10. Ready to begin.
    a. "Do you have any questions? I will do the rest of my communicating with you through the intercom. Give me a thumbs up to let me know when you are ready and I will tell you to begin by clicking the clicker which will start the PowerPoint."
11. When the participant gets to the first slide and is drinking water, begin LingWAVES and click back to the PowerPoint so it is layered on top.
    a. NOTE: failure to click back on the PowerPoint will result in the clicker not working when participant clicks it!

□ Data collection- participant tasks, **equipment: PowerPoint, LingWAVES and Reaper**

- Task 1:
  - Drink water
- Task 2:
  - Self-rating of vocal fatigue
- Task 3 & 4:
  - "Aaaah" extended productions x3 in a comfortable voice and "afa" x3 in a comfortable voice
- Task 5:
  - Marvin Williams Passage- loudness guided by arrows to indicate desired loudness (which will stay consistent through task 9)
- Task 6:
  - Stella Passage
- Task 7:
  - "Aaaah" extended productions
- Task 8:
  - Rainbow Passage
- Task 9:
  - Rainbow Passage Part 2

*Participants will go through a cycle of these 9 tasks until time limit is complete.

- Researchers during this time will remain outside the sound booth, only entering if signaled by participant. Ensure all recordings are working functionally throughout collection.

□ Post data-collection:

1. When PowerPoint is complete, LingWAVES will automatically shut off.
2. Participant will be guided through the following post vocal loading tasks:
   i. Count to five drawing out the "I" in five
   ii. Extended "ah"
   iii. "Afa"

    iv. Rainbow passage
3. When they have finished the rainbow passage, instruct them via intercom that you will be re-entering the room.
4. Turn off Reaper and go in sound booth.
5. Thank participant and compensate.
    a. “Thank you for coming. If you follow me outside the sound booth I will compensate you and send you on your way!”

□ Post-participant:

1. Open fatigue protocol folder (which should be on the desktop), to save files in the data folder.
2. Save data and close out files.
    a. LingWAVES-
        i. Right click and copy the first LingWAVES file name in the data folder (to make it easier to save the new file under the right label) OR use the saved name and change the first part to the appropriate participant name.
        ii. Press save.
    b. Reaper-
        i. Files will automatically save within Z:\fatigue protocol\Data
            1. DOUBLE CHECK files are saved in z-drive before exiting.
            2. There should be 6 files per participant.

APPENDIX O: Expiratory Muscle Strength Trainer Protocol

EMST TRAINING INSTRUCTIONS:

Complete **3 sets of 5 repetitions, 3 times a week** for a month-long duration. Use the provided data sheet to log daily use of your Expiratory Muscle Strength Trainer (EMST150). Comments can include any feelings of fatigue, ease, or difficulty. Use the following example as reference.

Date	Time	Set 1 (5 breaths)	Set 2 (5 breaths)	Set 3 (5 breaths)
8/21/17	9:00	|||||	|||||	|||||
	12:00	|||||	|||||	|||||
	3:00	|||||		

Comments: “I began to feel tired towards the end of the third set”.

First week of training:

Pick a time of day where you have time to train and are not likely to feel tired. It is recommended to pick the same time each day. You can sit or stand during exercise, although sitting is recommended. For the first week of training the EMST150 should remain at the initial setting established with the researcher, and only after week one the levels can be adjusted.

1. Positions the nose clip over nose.
2. Take a deep breath in and don’t breathe out.
3. Place the mouthpiece in your mouth, behind your teeth, and make a tight seal with your lips around it, holding or pressing the sides of your cheeks if necessary.

4. Using your chest and stomach muscles, breathe out hard and fast to push air through the device. This effort should only take a few seconds.
5. Rest for a minimum of 15-30 seconds. DO NOT skip resting in between training breaths, as it is important to allow your muscles time to prepare before the next set.
6. Repeat this exercise five times (steps 1-5), then take a break for 1-2 minutes. We call this a 5-breath trial.
7. After the 1-2 minute break, do another five- breath trial (step 1-5), and then take another 1-2 minute break.
8. Complete three five-breath trails for a total of 15 training breaths.
9. STOP training if you start to feel lightheaded at any point.
10. Record the date and the time you complete exercises, as well as tally marks for each repetition.

At the end of the first week of training, move the knob on the device by a quarter turn to the right to begin the second week of training. If you feel you can turn the knob to a higher level, do so, but remember air should always move freely through the device without great effort.

<u>Weeks 2, 3 and 4</u>

Continue with training as described in Week 1, adjusting the device settings at the end of each week. Log use and comments throughout weeks.

Data logging sheets:

Week 1:

Date	Time	Set 1 (5 breaths)	Set 2 (5 breaths)	Set 3 (5 breaths)

Comments:

Week 2:

Date	Time	Set 1 (5 breaths)	Set 2 (5 breaths)	Set 3 (5 breaths)

Comments:

Week 3:

Date	Time	Set 1 (5 breaths)	Set 2 (5 breaths)	Set 3 (5 breaths)

Comments:

Week 4:

Date	Time	Set 1 (5 breaths)	Set 2 (5 breaths)	Set 3 (5 breaths)

Comments:

APPENDIX P: Participant Information

Participant	
RBF01	• Currently on medications for asthma, allergies, and/or heartburn • Always feels that "My voice gets hoarse with voice use"
RBF04	• No medications that would alter vocal quality • No caffeine use
RBF05	• No voice complaints • 1 caffeine beverage a day • No heartburn, reflex, or medications
RBF06	• 1 caffeine beverage daily • No voice complaints
RBF07	• Has heartburn, allergies, and is on medication that can alter voice • 1 caffeine beverage a day • Always feels that "People have difficulty understanding me in a noisy room" • Never feels like "The effort to produce my voice decreases with rest" • Never feels like "The hoarseness of my voice gets better with rest"
RBF09	• Has allergies and is currently on allergy medication • 1 caffeine beverage a day • Almost always feels that "My voice makes it difficult for people to hear me" • Always feels that "People have difficulty understanding me in a noisy room" • Always feels that "My family has difficulty hearing me when I call them throughout the house" • Always feels that: "I find it difficult to project my voice with voice use" • Always feels that "I experience pain in the neck at the end of the day with voice use"
RBF10	• Seasonal allergies • No voice complaints

APPENDIX Q: Subjective Vocal Fatigue Information

Time	P1		P2		P4		P5		P6		P7		P9		P10	
	Tx 0	Tx 1	Tx 0	Tx 1	Tx 0	Tx 1	Tx 0	Tx 1	Tx 0	Tx 1	Tx 0	Tx 1	Tx 0	Tx 1	Tx0	Tx 1
0	3	1	4	1	3	1	1	1	1	1	3	1	8	7	2	1
3	4	2	4	1	4	2	1		2	1	5	2	8	7	2	2
6	5	2	5	2	4	3	2	2	3	1	7	2	8	8	3	2
9	6	3	5	2	5	4	4	2	3	2	8	3	8	8	4	3
12	7	3	5	3	6	4	5	3	4	2		3	9	8	4	3
15	7	4	6	4	6	5		3	5	3	8	3	9	8	4	2
18	8	4	7	4	7	6	5	4	5	4	9	4	9	8	4	2
21	8	4	7	5	7	6	5	5	7	5		4	9	8	4	2
24	8	4	7	5	7	6	7	5	7	5	9.5	5	10	9	5	3
27	8	4	7	5	8	7	8	6	8	6	10	5	10	10	5	2
30		4	7	5	8	7	8	6	9	6	10	5	10	10	5	3
33		5	7	6	9	7	8	7	9	6	10	6	10	10	6	4

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