Speech Science Research Project Report

**Introduction**

 In recent literature it has become evident that vocal warm-ups have a positive effect on overall vocal quality. A quasi-experimental study focused on the effects of vocal warm-up and cool-down on voice quality in teachers. Eighteen participants with an average age of 44.29 years were split into an experimental (n=8) and control (n=10) group. The experimental group performed vocal warm-up prior to class and vocal cool-downs after class, while the control group did neither and only rested after teaching. Pre- and post-test auditory-perceptual evaluations, self-reported discomfort and acoustic analysis, including shimmer, jitter, fundamental frequency, noise and glottal-to-noise excitation ration, were compared in both conditions. This study found no statistical significance between the experimental and control groups, however it did find an improvement in voice quality, as well as a reduction in reported discomfort after vocal warm-up in 63.15% of participants (Fabbron et al., 2019).

In a single-blind, randomized study containing 31 teachers aged 20-60 years-old, participants were divided into a vocal warm-up group (n=14) and a breath training group (n=17). The intervention lasted a total of 6 weeks and data was collected before and after intervention. Participants self-rated voice quality and a computerized voice analysis was performed, including fundamental frequency, shimmer, jitter, noise, and glottal-to-noise excitation ratio. The results of the study showed that both interventions had a positive impact on voice quality. It was shown that vocal warm-up resulted in more frequently reported voice improvement and ease of speech, as well as a statistically significant decrease in fundamental frequency. It was suggested that the reduction in fundamental frequency seen in this study suggests a protecting effect from the vocal warm-up and a reduction in vocal fold vibration cycles, potentially reducing friction and fatigue (Carvalho et al., 2015).

 One aspect of vocal warm-up is hydration of the vocal mechanism. An experimental within-subjects research study aimed to find the effects of superficial hydration, which refers to the inhalation of a water solution, in relation to vocal quality both with and without systemic hydration, or the ingestion of water. The study contained 24 female singers with an average age of 21.38 years. Participants were randomly assigned to the superficial hydration only (n=12) or the superficial + systemic hydration (n=12) group. Both groups were instructed that no eating or drinking was permitted 2-hurs prior to testing and received a nebulization of 3 mL of isotonic saline solution before, during a break and after the 1-hour rehearsal. The superficial + systemic hydration group also drank 500 mL of water over the course of the 1-hour rehearsal in addition to the nebulization treatment. Self-reported vocal fatigue, perceptual analysis, maximum phonation time, and acoustic analysis including shimmer, jitter, noise-to-harmonics ratio and fundamental frequency, were conducted pre- and post-rehearsal. It was found that while the results regarding acoustic parameters of voice were not conclusive, the combination of superficial and systemic hydration resulted in a reduction of perceived breathiness in singer performance (Abdoola et al., 2021).

A within-subject quasi-experiment was conducted with 12 female future professional singers ages 18-32. Participants were assigned either the experimental group, in which they could drink water 30 minutes prior to testing and were required to drink 750 mL of water over the course of the 2-hour rehearsal, or the control group, in which they could not drink water 2 hours prior to rehearsal or during rehearsal. Pre- and post-test data was acquired of which perceptual and acoustic analysis, including jitter, shimmer, fundamental frequency and harmonic ratio, were conducted. The results of this study displayed an increase of jitter in the control group, along with an increase in fundamental frequency and maximum phonation time in the experimental group. A reduction in the maximum frequency was observed from pre- to post-test in the control group and an increase in the experimental group. The decrease in the control group is indicative of vocal fatigue paired with hypohydration resulting in further decline in elasticity and viscosity of the vocal folds. It was concluded that systemic hydration leads to positive effects on both perceptual and acoustic qualities in professional singers (Cloete et al., 2017).

 Another form of vocal warm-ups are semi-occluded vocal tract exercises (SOVT). A quasi-experimental study focused on the effects of SOVT used as a vocal warm-up exercise for 11 male singers averaging 26.5-years-old. Participants performed 3 SOVT exercises (lip trills, humming and straw phonation) for a total of 20 minutes and acoustic measures were taken before and after the exercises. An electromyography evaluation of the suprahyoid and infrahyoid regions, as well as acoustic measurements were conducted during several vocal tasks. The results show a reduction in root mean squared for all vocal tasks and decrease in acoustic parameters following vocal warm-up. These results are indicative of a reduction in the relaxation of laryngeal muscles and vocal tract and subsequently comfortable phonation (Latifi et al., 2021).

 In a pre-test post-test study including 25 women between the ages of 18 and 25, the use of straw phonation as a potential warm-up exercise was examined. Participants were instructed to perform straw phonation exercises for 3 cycles. Maximum phonation time, self-perceived vocal quality and acoustic measures including shimmer, jitter, fundamental frequency, noise-to-harmonics ratio and soft phonation index were recorded pre- and post-test. An increase in maximum phonation time was seen post exercise, along with a significant improvement in fundamental frequency, first, second and fourth formant and self-perceived voice quality. These results suggest an improvement in voice quality due to a reduction in stress and effort related fatigue to the vocal folds (Bhat et al., 2020).

**Methods**

*Participant*

This study focused on one participant, VJ who is a 61-year-old female and currently works as a legislative aid. The participant does not have any history of neurological or vocal problems and her typical voice quality was not observed to demonstrate any breathiness, harshness, hypernasality, etc. The exclusion criteria for this study included the need to take any medication immediately after waking up or regularly taking any medication that has a drying effect. The participant did not have any allergies or upper respiratory issues on the days they were recorded.

*Tasks*

The following three warm-up conditions were evaluated: (1) Hydration only – drink 500 ml water over 30 minutes; (2) SOVT only – blow bubbles through a straw into a cup of water for 3 minutes; (3) Hydration + SOVT – condition 1 followed by condition 2. The participant was observed on three different mornings, with one warm-up condition being completed each morning. Each morning of testing followed the same schedule: the pre-measure sample was recorded immediately after waking up and after 30 minutes the post-measure sample was recorded. During the 30 minutes in between the pre- and post-measurement sample recordings the participant engaged in one of the three warm-up conditions. In the first condition, hydration only, the participant drank 500 ml of water over the course of the 30 minutes. The second condition, SOVT only, required the participant to rest for 30 minutes then blow bubbles through a straw into a cup of water (~5cm from the top) and the post-measure sample was recorded immediately following the exercise. In the third condition, Hydration + SOVT, the participant was instructed to drink 500 ml of water over the course of the 30 minutes, followed by the SOVT exercise of blowing bubbles for 3 minutes and the post-measure sample was again recorded immediately after the exercise was completed. The participant was instructed to follow several measures in the morning as a control, including no showering, no eating, no caffeine, no talking, no water on non-hydration days, no physical exercise. They were also told to not drink any water after 9pm the night prior to recording.

*Recording*

All samples were recorded using Zoom. Enhancements, such as echo cancellation were turned off and the original sound option was enabled. Due to location of the clinician at the time of the study, the clinician and participant were able to be in-person during recordings. Zoom was used strictly as a means to record the samples. Each pre- and post-measure recording contained both a voiced and unvoiced sentence, “we were away a year ago” (voiced) and “Peter will keep at the peak” (unvoiced). The audio file was split into two separate files, each containing one sentence and labeled accordingly. During recording, the clinician held up a card with the sentences written out and the participant was instructed, prior to recording, that they would say one sentence, followed by a pause, then say the second sentence.

*Data analysis* - Analysis of the pre- and post-measures were completed using Praat software. Each audio file was uploaded into Praat, trimmed down to exclude and silence or instructions before/after the sample, and then analyzed for voice quality and fundamental frequency. Voice quality was measured through the use of a cepstral analysis, which analyzes connected speech, and fundamental frequency was acquired through the “get pitch” function in Praat. The voice quality pre- and post-measures for each sentence type/warm-up condition were reported in decibels (dB) and the difference between the two was calculated. For fundamental frequency ($f\_{0}$), the measures were reported in Hertz (Hz) and only collected for the sentence “we were away a year ago”. Differences in $f\_{0}$ were calculated and reported in semitones.

**Results**

Table 1 compares the results obtained from a Cepstral analysis of the pre- and post-measure samples for each sentence type (Away vs. Peter) in the hydration only, SOVT only, and hydration + SOVT warm-up conditions. Voice quality was observed to decrease from pre-measurement to post-measurement in all warm-up conditions. The data reflects this in the negative value calculated for difference between the pre- and post-measurement values and a much larger difference was seen in the SOVT only warm-up condition. The “Away” sentence type was observed to have higher values for all pre- and post-measurement data and a greater difference overall in both the SOVT only condition as well as the hydration + SOVT condition. On the other and, the “Peter” sentence type resulted in lower overall values, but a greater difference in the hydration only condition. The “Peter” sentence type in the hydration + SOVT condition resulted in the least overall difference, while the “Away” sentence type in the SOVT only condition resulted in the greatest overall difference.

Table 2 compares the data acquired from the fundamental frequency analysis of the pre- and post-measurement for only the “Away” sentence type in the hydration only, SOVT only, and hydration + SOVT warm-up conditions. The post-measurement $f\_{0}$ values were found to be greater than the pre-measurement $f\_{0}$ values in both the hydration only and the hydration + SOVT conditions, while the opposite was true for the SOVT only condition.

Table 1

*Summary of Cepstral Analysis for Voice Quality*

|  |  |  |  |
| --- | --- | --- | --- |
| Warm-Up Condition(Sentence Type) | Pre-Measurement (dB) | Post-Measurement (dB) | Difference (dB) |
| Hydration(Away) | 9.20 dB | 8.82 dB | -0.38 dB |
| Hydration(Peter) | 6.50 dB | 5.82 dB | -0.68 dB |
| SOVT(Away) | 11.45 dB | 10.19 dB | -1.26 dB |
| SOVT(Peter) | 7.33 dB | 6.20 dB | -1.13 dB |
| Hydration + SOVT(Away) | 10.14 dB | 9.60 dB | -0.54 dB |
| Hydration + SOVT(Peter) | 5.98 dB | 5.75 dB | -0.23 dB |

Table 2

*Summary of Fundamental Frequency Analysis for “We were away a year ago”*

|  |  |  |  |
| --- | --- | --- | --- |
| Warm-Up Condition | Pre-Measurement (Hz) | Post-Measurement (Hz) | Difference (semitones) |
| Hydration | 186.28 Hz | 192.96 Hz | 0.61 semitones |
| SOVT | 183.84 Hz | 177.18 Hz | -0.64 semitones |
| Hydration + SOVT | 180.07 Hz | 192.04 Hz | 1.11 semitones |

**Discussion**

 This study evaluated the effects of different vocal warm-up strategies, hydration only, SOVT only and hydration + SOVT, on vocal quality and fundamental frequency. The results of a cepstral analysis on pre- and post-measurement samples overall depicted a decrease in vocal quality across all warm-up conditions. This could have been due to participant specific factors or environmental factors, such as background noise or varying distance from the microphone. It appears that the SOVT only condition had the worst effect on vocal quality, as well as fundamental frequency, making it the least effective strategy. The participant reported feeling fatigued after the SOVT exercise, which may have contributed to these results. The hydration only and the hydration + SOVT conditions both had similar effects on vocal quality, but the combination condition had a greater effect on fundamental frequency. According to the results of this study, the combination hydration + SOVT strategy was found to be the most effective in improving fundamental frequency and one of the least detrimental to voice quality. This combination may be most effective because the hydration allows for reduced fatigue of the vocal tract during the SOVT exercise and the participant was able to better benefit from the exercise.

**References**

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