Journal of Speech Pathology & Therapy

Gorham-Rowan, et al., J Speech Pathol Ther 2016, 1:1
DOI: 10.4172/2472-5005.1000103

Research Article Open Access

# The Effect of a Vocal Loading Task on Vocal Function Before and After 24 Hours of Thickened Liquid Use

**Mary Gorham-Rowan**[1*], **Alyson Berndt**[2], **Matthew Carter**[1] and **Richard Morris**[3]

[1]*Valdosta State University, 1500 N. Patterson St. Valdosta, Georgia*

[2]*University Hospital, Augusta, GA*

[3]*Florida State University, 600 W. College Avenue, Tallahassee, Florida*

[*]**Corresponding author**: Mary Gorham-Rowan, HSBC 2132, Department of Communication Sciences and Disorders, Valdosta State University, Valdosta, Georgia, USA, Tel: +1 229-333-5800; E-mail: mmgorhamrowan@valdosta.edu

**Received Date**: October 07, 2015, **Accepted date**: January 07, 2016, **Published Date**: January 14, 2016



## Abstract

**Objective:** To determine the effect of a vocal loading task on vocal function before and after 24 hours of thickened liquid use.

**Methods:** Seven healthy adults, ages 19 to 52 years of age, were recruited as participants. Baseline data regarding daily food/liquid intake and urine specific gravity levels (USG) as a marker of hydration were obtained. Participants then completed a vocal loading task, which consisted of 3 × 10 repetitions of a sustained vowel task at 65 dB to 75 dB SPL. Voice recordings and subjective ratings of vocal fatigue and muscle soreness were obtained prior to and following the vocal loading task for both the pre-thickened liquid and post-thickened liquid experimental session. The voice samples were analyzed for changes in fundamental frequency, loudness, and perturbation measures.

**Results:** There was a significant main effect of vocal loading on vocal loudness as well as subjective ratings of vocal fatigue and muscle soreness; all parameters were higher post-vocal loading. There was also a significant main effect of thickened liquid use on jitter, as jitter levels were substantially lower post-thickened liquids.

**Conclusion:** The objective and subjective changes reported by the participants' post-vocal loading are consistent with prior reports concerning normal adaptive responses to greater vocal demands and increased muscular effort. A brief period of thickened liquids does not appear to affect vocal function.

## Introduction

Thickened liquids are the most frequently used compensatory interventions for individuals with dysphagia to reduce or eliminate their risk of aspiration [1-3]. Because of the increase in viscosity, thickened liquids travel through the oropharynx at a slower rate, which is thought to contribute to greater control of the liquid bolus and provides increased time to trigger the pharyngeal swallow. Improved control of the bolus provides additional time to complete the processes needed to close and protect the airway and reduces the possibility that liquid will enter the airway [1,4]. However, limited evidence is available to support the concept that the consumption of thickened liquids results in positive health outcomes with regards to pneumonia [5]. The available data suggest that thickened liquids may be beneficial for some individuals but not others. Logemann et al. [6] reported that while the use of thickened liquids reduced or eliminated aspiration in some patients with dementia, there were still a large percentage of patients for whom thickened liquids were ineffective. Rather, higher liquid viscosity was associated with an increased incidence of adverse outcomes, including a greater risk of aspiration pneumonia, longer hospital stays, and mortality [3]. Several reports have demonstrated that individuals who are placed on thickened liquid diets fail to meet minimum fluid intake requirements and thus are at risk for dehydration [7-9]. Patients often report that they don't like the thickened liquids; they refuse to drink them which mean that they reduce their overall fluid intake [10]. Other possible factors to the reduction in fluid intake include the beverage preferences of the patient and incorrect preparation of thickened liquids [1,7,11].

The increased risk of dehydration has numerous implications for rehabilitative function, including that of voice production. Specifically, hydration status has been associated with alterations in phonation threshold pressure (PTP), which refers to the minimum lung pressure needed to initiate and sustain vocal fold vibration and may be used as a physiological measure of phonatory effort [12,13]. A number of studies have suggested that systemic dehydration increases vocal fold viscosity, which contributes to an increase in PTP and phonatory effort [13-15]. In contrast, hydration may lower PTP and improve phonatory function as shown in speakers following a vocally fatiguing task and in individuals with nodules and polyps [16,17].

Although systemic dehydration is known to affect vocal fold function, it is not known if the use of thickened liquids contributes to measurable and observable changes in the voice. Given the correlation between thickened liquids and dehydration, as well as the relationship between hydration status and vocal function, the aim of this study was to determine if vocal function would change in association with the use of thickened liquids.

## Methods

### Participants

Approval from the Valdosta State University Institutional Review Board was obtained prior to enrollment of participants in the study. Four female and three male speakers, 19 to 52 years of age, volunteered to complete the study. Participants were required to exhibit a normal voice quality, have no history of voice disorders, and be free from cold or allergy symptoms on the day of testing. Given that the protocol for the study included pre-experimental fasting sessions, physical exercise, and a potential change in liquid/food intake [18], precautions were taken to insure that the volunteers were healthy enough to participate in the study. Precautionary measures included establishing exclusionary criteria such as history of fainting, a history of high blood pressure, diabetes, hypoglycemia, cardiac disease, kidney or urinary tract problems, and/or a history of seizure disorder.

### Experimental protocol

**Baseline data:** Prior to the initiation of the period of thickened liquid use, baseline data were collected from each participant. Participants were directed to keep a log of all foods/liquids consumed during the 24 hours prior to the use of thickened liquids and during the 24-hour period of thickened liquid intake. The intake logs were examined as an index of food/water consumed prior to and during the period of thickened liquid use.

Each participant was also asked to provide a urine sample upon arriving for the experiment; this sample was used to measure urine specific gravity (USG) using a clinical refractometer (Atago, USA, Inc., Bellevue, WA). Measurement of urine specific gravity is frequently completed in research studies concerning the effects of hydration on athletic performance, and is considered to be a practical, noninvasive, and reliable parameter of hydration [19]. According to Casa et al. [20], the National Athletic Trainer's Association recommends a urine specific gravity level of 1.020 g/ml prior to initiating exercise. This level was used as a benchmark of adequate hydration in the current study.

**Acoustic recordings:** Each participant's voice was recorded prior to and immediately following the experimental voice tasks. Prior to the initial recordings, the participants completed a series of warm-up exercises that included five trials each of humming, glissando, and lip trills. Specific tasks that were recorded for subsequent analysis included sustained production of the vowel /a/ and reading of the first two sentences of the rainbow passage. Three trials of each task were obtained at a comfortable pitch and loudness level. All recordings were completed in a sound treated booth and were digitized directly into a desktop computer using the Computerized Speech Lab (Model 4500, KayPENTAX). A constant mouth-to-microphone distance of 6 cm was maintained using an ATM AudioTechnica omnidirectional headset cardioid condenser microphone. The pre-voice and post-voice recordings of the sustained vowels were analyzed for fundamental frequency (F0), vowel relative loudness level (RLL-V), and noise-to-harmonic ratio (NHR) using the MultiDimensional Voice Program software. The pre-voice and post-voice recordings of the rainbow passage were analyzed for speaking fundamental frequency (SFF), speaking relative loudness level (RLL-S), cepstral peak prominence (CPP), and the ratio of low spectral energy to high spectral energy (L/H ratio) using the Analysis of Dysphonia and Speech in Voice software.

**Subjective ratings of vocal fatigue/muscle soreness:** Participants were asked to rate the perceived level of vocal fatigue and muscle soreness prior to and following the vocal loading task using a 100 mm visual analog scale. These ratings were completed prior to the initiation of the thickened liquid protocol and repeated at the final recordings session.

**Vocal loading task:** After the initial recordings were obtained, participants were asked to sustain the vowel /a/ three times at a comfortable loudness for as long as possible. The average of three trials was determined in order to obtain the experimental phonation time (EPT) Seventy-five percent duration of EPT was calculated to determine the length of phonation for the experimental vocal endurance task [21], which was adapted from a vocal exercise described by LaGorio and colleagues [22]. The task consisted of 3 sets of 10 repetitions of the sustained vowel /a/ at 75% duration of EPT; all repetitions were completed at a loudness level of 65-75 dB SPL. Loudness levels were monitored continuously throughout the task using a hand-held sound pressure level meter (CEM DT-805) at a distance of 30 cm. Participants were given 5 seconds rest between each repetition, with 30 seconds rest between each set of 10 repetitions. Following completion of the third set of 10 repetitions, the participants' voices were rerecorded in the manner previously described. The order of the recorded voice samples (/a/ vs. the rainbow passage) was counterbalanced across participants and between recordings.

**Thickened liquid diet:** Once baseline data had been collected, participants were provided with a supply of commercial thickening agent and provided with instructions concerning its use. A brief training session during which participants practiced administration of thickener into a cup of water was included. The participants were instructed to consume only thickened liquids for 24 hours; thickened liquids included milkshakes, smoothies, or any thin liquid mixed with a commercial thickening agent, such as Thick-It. No restrictions on food intake were made. At the conclusion of the period of thickened liquid intake, a urine sample was again collected to measure urine specific gravity and the participants repeated the same pre-experimental vocal loading tasks.

**Data analysis:** A series of repeated measures ANOVAs were used to analyze changes in the acoustic and cepstral parameters pre-thickened liquids vs. post-thickened liquids as well as pre-vocal loading vs. post-vocal loading. Examination of changes in subjective ratings of vocal fatigue and muscular soreness were also completed using a repeated measure ANOVA. All analyses were completed using SPSS 16.0.

## Result

Demographic and physiological data are presented in Table 1. Six of the participants exhibited an increase in USG following the 24 hour period of thickened liquid intake, thus indicating a decrease in hydration [20].

### Acoustic data

Mean and standard deviation for the acoustic and cepstral parameters obtained from the sustained vowel and connected speech tasks are presented in Table 2 and 3. The results of the repeated measures ANOVA revealed a significant main effect of vocal loading for RLL-V ($F(1,6)=7.13$, $p=0.037$, $\eta 2=0.543$). Pre-vocal loading RLL-V ($x=60.18$ dB; $sd=5.60$) was significantly lower than post-vocal loading RLL-V ($x=64.10$ dB; $sd=3.30$). No significant main effect of vocal loading was found for $F_0$ (F(1,6)=0.490, p=0.510, $\eta^2$=0.075) or NHR (F(1,6)=0.257, p=0.630, $\eta^2$=0.041). Similarly, there was no significant main effect of vocal loading upon any of the acoustic or cepstral parameters obtained during connected speech [(SFF: (F(1,6)=5.091, p=0.065, $\eta^2$=0.459); RLL: (F(1,6)=0.533, p=0.493, $\eta^2$=0.082); CPP: (F(1,6)=3.060, p=0.131, $\eta^2$=0.338); L/H Ratio: (F(1,6)=5.203, p=0.063, $\eta^2$=0.464)].

| Participant | Age | Sex | BMI | Pre USG (g/ml) | Post USG (g/ml) |
|---|---|---|---|---|---|
| 1 | 25 | F | 18.8 | 1 | 1.018 |
| 2 | 20 | M | 20.4 | 1.002 | 1.01 |
| 3 | 19 | F | 21 | 1.014 | 1.02 |
| 4 | 52 | M | 23.1 | 1.022 | 1.005 |
| 5 | 24 | M | 23 | 1.02 | 1.024 |
| 6 | 23 | F | 21.4 | 1.004 | 1.022 |
| 7 | 23 | F | 23.4 | 1.009 | 1.02 |

**Table 1:** Demographic and urine specific gravity (USG) levels for the participants.

There was no significant main effect of thickened liquid intake for any of the acoustic parameters for sustained vowel phonation [$F_0$: (F(1,6)=0.391, p=0.555, $\eta^2$=0.061), RLL-V (F(1,6)=4.703, p=0.073, $\eta^2$=0.439); NHR (F(1,6)=2.779, p=0.147, $\eta^2$=0.317)]. Similar to the findings obtained for vocal loading, there was no significant main effect of thickened liquid intake for any of the acoustic or cepstral measures obtained during connected speech [SFF: (F(1,6)=0.002, p=0.969, $\eta^2$=0.000); RLL: (F(1,6)=0.001, p=0.973, $\eta^2$=0.000); CPP: (F(1,6)=0.000, p=0.995, $\eta^2$=0.000); L/H Ratio: (F(1,6)=0.005, p=0.947, $\eta^2$=0.001)].

There was no significant loading x thickened liquid for the sustained phonation task [$F_0$ (F(1,6)=1.091, p=0.337, $\eta^2$=0.154), RLL (F(1,6)=0.230, p=0.230, $\eta^2$=0.648); NHR (F(1,6)=0.007, p=0.935, $\eta^2$=0.001)].

| Condition | $F_0$ (Hz) | RLL (dB) | NHR (dB) |
|---|---|---|---|
| Pre VL/Pre TL | 183.30 (195.21) | 60.18 (5.60) | 12 (.02) |
| Post VL/Pre TL | 190.94 (75.96) | 64.08 (3.10) | 12 (.03) |
| Pre VL/Post TL | 195.15 (83.60) | 62.65 (4.92) | 11 (.02) |
| Post VL/Post TL | 196.36 (88.77) | 65.49 (4.34) | 11 (.02) |

**Table 2:** Mean and standard deviation (SD) data for the acoustic measures obtained from sustained vowel phonation pre-vocal loading and post-vocal loading (VL) according to thickened liquid (TL) intake.

### Subjective ratings of vocal fatigue/muscles soreness

There was a significant main effect of vocal loading on ratings of vocal fatigue (F(1,5)=12.069, p=0.018, $\eta^2$=0.707). Pre-vocal loading ratings (M=10.92, SD=13.26) were significantly lower than post-vocal loading rating (M=37.71, SD=23.75). There was no significant main effect of thickened liquids for the vocal fatigue ratings (F=2.879, p=0.151, $\eta^2$=0.365). There was no significant loading x thickened liquid for the vocal fatigue ratings (F=0.576, p=0.482, η2=0.103). These data are depicted in Figure 1.

| Condition | $F_0$ (Hz) | RLL (dB) | CPP (dB) | L/H Ratio (dB) |
|---|---|---|---|---|
| Pre VL/Pre TL | 153.89 (55.71) | 54.10 (3.96) | 6.33 (1.07) | 29.95 (3.16) |
| Post VL/Pre TL | 154.20 (53.69) | 56.20 (7.42) | 6.47 (.92) | 30.37 (3.35) |
| Pre VL/Post TL | 157.20 (54.13) | 55.28 (2.41) | 6.27 (.91) | 29.73 (2.69) |
| Post VL/Post TL | 157.10 (54.31) | 54.92 (3.32) | 6.53 (.83) | 30.53 (2.69) |

**Table 3:** Mean and standard deviation (SD) data for the acoustic and cepstral data obtained from the Rainbow Passage pre-vocal loading and post-vocal loading according to thickened liquid intake.

There was a significant main effect of vocal loading on ratings of muscle soreness (F(1, 5)=9.771, p=.026, $\eta^2$=0.661). Pre-vocal loading ratings (M=12.17, SD=15.07) were significantly lower than post-vocal loading rating (M=22.08, SD=19.39). There was no significant main effect of thickened liquids for the muscle soreness ratings (F=0.050, p=0.832, $\eta^2$=0.010). There was no significant loading × thickened liquid for the muscle soreness ratings (F=0.139, p=0.725, $\eta^2$=0.027). These data are depicted in Figure 2.

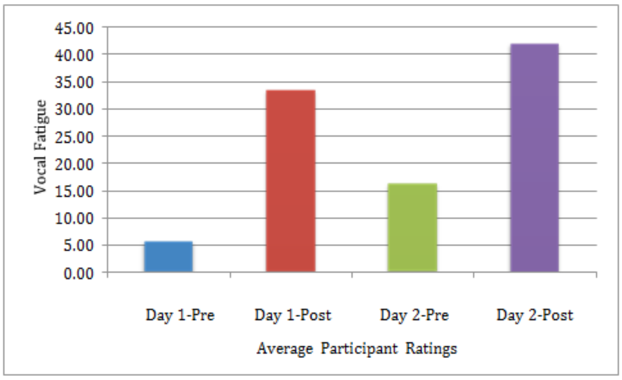


**Figure 1:** Mean ratings of vocal fatigue pre-vocal loading and post-vocal loading in accordance with thickened liquid intake.

## Discussion

The objective of the current study was to determine if the use of thickened liquid affected vocal function. The results revealed an increase in RLL-V post-vocal loading, a change that is consistent with prior reports [23-25]. The increase in loudness following a vocal loading task represents greater vocal fold adduction as a compensatory response to the demands of the vocal loading task and is considered to be a normal adaptive response [23,24,26].

There was a significant increase in perceived vocal fatigue and muscular soreness post-vocal loading. The increase in fatigue may be expected, given the demands of the vocal loading task. The increase in muscular soreness is associated with a novel form of exercise [27] and has been previously reported in studies involving simulated vocal loading using neuromuscular electrical stimulation [28-30] of interest are the comments provided by the participants upon completion of the study. Five of the seven participants reported having one or more of the following symptoms: dry throat, sore throat, headache, increased difficulty when swallowing, slow/sluggish voice, scratchy voice, raspy voice, painful talking, dry lips, and reduced talking. These symptoms may be attributed to a reduction in fluid intake, as four of the participants reported drinking less fluid during the thickened liquid period. These findings coincide with prior reports of a decrease in fluid intake among dysphagic patients placed on a thickened liquid diet [8-10].

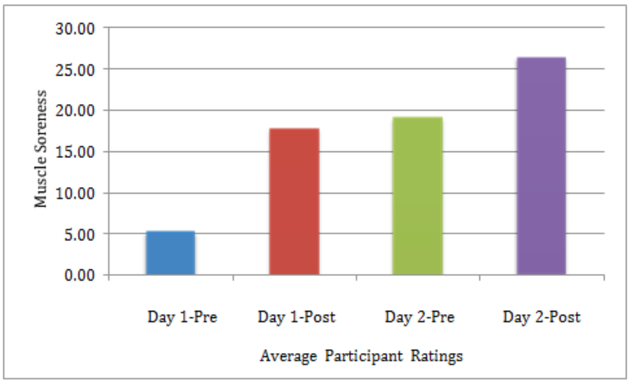


**Figure 2:** Mean ratings of muscle soreness pre-vocal loading and post-vocal loading in accordance with thickened liquid intake.

As previously noted, urine density analyses revealed that six out of seven participants had increased urine density after the thickened liquid protocol (see Table 1). The higher the urine density, the more dehydrated the individual. A USG of less than 1.010 g/ml is well hydrated, a urine density of 1.011.020 g/ml is minimally dehydrated and a urine density of 1.021-1.030 g/ml is significant dehydration [20]. Of the seven participants, only one participant was well hydrated following a 24-hour consumption of thickened liquids, four participants had mild dehydration, and two participants had significant dehydration. According to Leibovitz and colleagues [31], individuals with dysphagia are at an elevated risk for dehydration. Given the participants in this study were healthy individuals and displayed signs of dehydration after only 24 hours, it is suggested that individuals with dysphagia on a thickened liquid diet for more than 24 hours are at a significant risk for dehydration. Dehydration can lead to many negative health conditions including deterioration of cognitive status, changes in drug effects, poor wound healing, pressure sores, urinary tract infections, altered cardiac function, lethargy, weakness, constipation, and acute renal failure [31-33].

These data support the participants' ratings of increased vocal effort and soreness after the thickened liquid period both prior to and following the vocal loading task. Systemic dehydration of the body, as well as superficial dehydration of the vocal tract, such as may occur through oral breathing or conditions of low humidity, contributes to increases in perceived vocal effort [14,34,35]. This increase in perceived vocal effort is likely related to an increase in PTP [34]. As previously discussed, reduced hydration contributes to an increase in vocal fold viscosity, thus decreasing mobility and increasing the muscular effort required to phonate [13].

The results of the current study did not demonstrate any significant effect of thickened liquid use on vocal function. These findings should be interpreted with caution, given the limitations of the study. One of the primary limitations was the small sample size used in the study. The inclusion of only seven participants is not large enough to be used for generalization. In addition, the participants in this study were all normal, healthy volunteers. The extent to which the use of thickened liquids may affect vocal function in patients with dysphonia and/or patients with dysphagia is not known. Sivasankar and Fisher [34] demonstrated that superficial dehydration of the vocal tract in dysphonic speakers was associated with greater increases in phonatory threshold pressure in comparison to non-dysphonic speakers. They suggested that this pattern was due to a reduced ability of the dysphonic speakers to compensate for the negative effects of dehydration. It is likely that individuals with a compromised laryngeal system may exhibit more significant vocal reactions to reduced fluid intake associated with thickened liquid use.

A second limitation was the length of time during which the participants consumed thickened liquids. The participants were only required to drink thickened liquids for 24 hours, which is a brief time frame, particularly in reference to the use of thickened liquids in patients with dysphagia. Thickened liquids are frequently recommended for weeks, months, possibly even a number of years. The long-term effects of thickened liquid intake upon vocal function have not been determined and warrant further investigation.

## References

1. Garcia JM, Chambers E 4th, Molander M (2005) Thickened liquids: practice patterns of speech-language pathologists. Am J Speech Lang Pathol 14: 4-13.
2. Kuhlemeier KV, Palmer JB, Rosenberg D (2001) Effect of liquid bolus consistency and delivery method on aspiration and pharyngeal retention in dysphagia patients. Dysphagia 16: 119-122.
3. Robbins J, Gensler G, Hind J, Logemann JA, Lindblad AS, et al. (2008) Comparison of 2 interventions for liquid aspiration on pneumonia incidence: a randomized trial. Ann Intern Med 148: 509-518.
4. Logemann JA (1998) Evaluation and treatment of swallowing disorders (2ndedn) Pro-Ed.
5. Sura L, Madhavan A, Carnaby G, Crary MA (2012) Dysphagia in the elderly: management and nutritional considerations. Clin Interv Aging 7: 287-298.
6. Logemann JA, Gensler G, Robbins J, Lindblad AS, Brandt D, et al. (2008) A randomized study of three interventions for aspiration of thin liquids in patients with dementia or Parkinson's disease. J Speech Lang Hear Res 51: 173-183.
7. McGrail A, Kelchner LN (2012) Adequate oral fluid intake in hospitalized stroke patients: does viscosity matter? Rehabil Nurs 37: 252-257.
8. Vivanti AP, Campbell KL, Suter MS, Hannan-Jones MT, Hulcombe JA (2009) Contribution of thickened drinks, food and enteral and parenteral fluids to fluid intake in hospitalised patients with dysphagia. J Hum Nutr Diet 22: 148-155.
9. Whelan K (2001) Inadequate fluid intakes in dysphagic acute stroke. Clin Nutr 20: 423-428.
10. Garcia JM, Chambers E 4th, Clark M, Helverson J, Matta Z (2010) Quality of care issues for dysphagia: modifications involving oral fluids. J Clin Nurs 19: 1618-1624.
11. Goulding R, Bakheit AM (2000) Evaluation of the benefits of monitoring fluid thickness in the dietary management of dysphagic stroke patients. Clin Rehabil 14: 119-124.
12. Titze IR (1992) Phonation threshold pressure: a missing link in glottal aerodynamics. J Acoust Soc Am 91: 2926-2935.

13. Verdolini K, Titze IR, Fennell A (1994) Dependence of phonatory effort on hydration level. J Speech Hear Res 37: 1001-1007.
14. Fisher KV, Ligon J, Sobecks JL, Roxe DM (2001) Phonatory effects of body fluid removal. J Speech Lang Hear Res 44: 354-367.
15. Verdolini K, Min Y, Titze IR, Lemke J, Brown K, et al. (2002) Biological mechanisms underlying voice changes due to dehydration. J Speech Lang Hear Res 45: 268-281.
16. Solomon NP, Glaze LE, Arnold RR, van Mersbergen M (2003) Effects of a vocally fatiguing task and systemic hydration on men's voices. J Voice 17: 31-46.
17. Verdolini-Marston K, Sandage M, Titze IR (1994) Effect of hydration treatments on laryngeal nodules and polyps and related voice measures. J Voice 8: 30-47.
18. Gorham-Rowan M, Coston J (2015) Analysis of speech-language pathology graduate students' experience with thickened liquids. Internet J Allied Health Sci Prac 13: article 12.
19. Silva RP, Mündel T, Altoé JL, Saldanha MR, Ferreira FG, et al. (2010) Preexercise urine specific gravity and fluid intake during one-hour running in a thermoneutral environment-A randomized cross-over study. J Sports Sci Med 9: 464-471.
20. Casa DJ, Stearns RL, Lopez RM, Ganio MS, McDermott BP, et al. (2010) Influence of hydration on physiological function and performance during trail running in the heat. J Athl Train 45: 147-156.
21. Gorham-Rowan M, Waggener G, Morris R, Fowler L (2011) Blood lactate levels associated with neuromuscular electrical stimulation to the laryngeal area. Paper presented at the 40th Annual Voice Symposium: Care of the Professional Voice.
22. Lagorio LA, Carnaby-Mann GD, Crary MA (2010) Treatment of vocal fold bowing using neuromuscular electrical stimulation. Arch Otolaryngol Head Neck Surg 136: 398-403.
23. Laukkanen AM, Järvinen M, Artkosi T, Waaramaa-Mäki-Kulmala T, Kankare E, et al. (2004) Changes in voice and subjective sensations during a 45 minute vocal loading test in female subjects with vocal training. Folia Phon Logop 56: 335-346.
24. Laukkanen AM, Ilomäki I, Leppänen K, Vilkman E (2008) Acoustic measures and self-reports of vocal fatigue by female teachers. J Voice 22: 283-289.
25. Laukkanen AM, Kankare E (2006) Vocal loading-related changes in male teachers' voices investigated before and after a working day. Folia Phoniatr Logop 58: 229-239.
26. Jónsdottir V, Laukkanen AM, Vilkman E (2002) Changes in teachers' speech during a working day with and without electric sound amplification. Folia Phoniatr Logop 54: 282-287.
27. Armstrong RB (1984) Mechanisms of exercise-induced delayed onset muscular soreness: a brief review. Med Sci Sports Exerc 16: 529-538.
28. Fowler LP, Awan SN, Gorham-Rowan M, Morris R (2011) Investigation of fatigue, delayed-onset muscle soreness, and spectral-based cepstral measurements in healthy speakers after neuromuscular electrical stimulation. Ann Otol Rhinol Laryngol 120: 641-650.
29. Fowler L, Gorham-Rowan M, Hapner ER (2011) An exploratory study of voice change associated with healthy speakers following transcutaneous electrical stimulation to laryngeal muscles. J Voice 25: 54-61.
30. Gorham-Rowan M, Fowler L, Hapner E (2010) Acoustic analysis of voice change in normal speakers following transcutaneous electrical stimulation to the laryngeal area. The Open Rehab J 3: 67-74.
31. Leibovitz A, Baumoehl Y, Lubart E, Yaina A, Platinovitz N, et al. (2007) Dehydration among long-term care elderly patients with oropharyngeal dysphagia. Gerontology 53: 179-183.
32. Copeman J (2000) Promoting nutrition in older people in nursing and residential homes. Br J Community Nurs 5: 277-278, 280-284.
33. Sivasankar M, Fisher KV (2002) Oral breathing increases Pth and vocal effort by superficial drying of vocal fold mucosa. J Voice 16: 172-181.
34. Vinturri J, Alku P, Sala E, Sihvo M, Vilkman E (2003) Loading-related subjective symptoms during a vocal loading test with special reference to gender and some ergonomic factors. Folia Phonoiatr Logop 55: 55-69.