Vocal Loading and Environmental Humidity Effects in Older Adults

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Objective: The goal of this study was to investigate the effects of a vocal loading challenge that combined prolonged speaking, in child-directed voice within a noisy environment, in older adults. An additional goal was to determine whether increased environmental humidity would attenuate the negative effects of this vocal loading challenge.

Method. Thirteen healthy subjects (five males and eight females; >65 years) completed a vocal loading challenge. The challenge involved 45 minutes of child-directed speech in the presence of 65 dB multitalker babble background noise. Subjects completed this challenge in both low humidity and moderate humidity in counterbalanced order. Vocal function was assessed before and after the challenge using phonation threshold pressure (PTP), cepstral peak prominence (CPP), low/high spectral ratio (LHR), perceived phonatory effort (PPE), and perceived vocal tiredness.

Results. Negative changes were observed in the aging larynx following the 45-minute vocal loading challenge. Measures of PTP, PPE, and perceived vocal tiredness demonstrated statistically significant loading effects. Increased ambient humidity significantly alleviated the negative changes observed in PPE and perceived vocal tiredness. Increased humidity significantly improved CPP measures both before and after the vocal loading challenge.

Conclusions. This study furthers our understanding of how older adults respond to a vocal loading challenge of prolonged nonhabitual speech in a noisy environment. Our data suggest that the aging voice is negatively affected by prolonged loud speaking and that humidification may be beneficial in reducing some of these negative effects.

Key Words: Vocal loading challenge–Aging voice–Child-directed speech–Humidity–Phonation threshold pressure.

INTRODUCTION

Advancing age is a significant risk factor for voice problems.[1–5] The United States had approximately 46 million older adults in 2014 (>65 years old)[6] and the elderly population is projected to almost double by the year 2050.[7] To better treat voice problems associated with aging, it is important to understand the factors that increase vulnerability to voice disorders in this population. Both intrinsic (eg, genetic, anatomic, and voicing characteristics) and extrinsic or environmental (eg, ambient hydration level background noise) factors are thought to exacerbate the negative effects of prolonged voice use and increase susceptibility to voice problems. One approach to investigate the effects of these factors is in the context of a vocal loading challenge.[8] Although there is considerable literature reporting on the effects of vocal loading challenges in young speakers,[9–14] the effects of vocal loading challenges in older adults remain unexplored.

Vocal loading challenges refer to voice tasks that stress the larynx and compromise optimal laryngeal function.[8] Prolonged loud reading has typically been utilized in vocal loading challenges[9,11,13,15] These traditional vocal loading challenges have effectively induced negative voice changes; however, their duration (oftentimes over 90 minutes) renders them impractical for use with an elderly population or for use with patients. As such, producing a vocal loading challenge of shorter duration is a clinically relevant goal. Emerging evidence would suggest that altering vocal quality or suprasegmental speech features may load the larynx more efficiently than habitual speech.[16] Nonhabitual vibratory modes may induce detrimental voice changes more quickly than habitual speech.[16] The suprasegmental features of child-directed speech differ from that of typical adult speech. These differences include elevated pitch and atypical intonation patterns.[17–19] In addition, the effects of child-directed speech in older adults have ecological validity as it may be used by these individuals in conversation with young members of the family. To the best of our knowledge, the laryngeal effects of child-directed speech have not been investigated; however, vocal loading challenges utilizing similar voicing patterns of elevated volume and altered vocal quality have been shown to produce negative laryngeal changes in the healthy, young larynx.[16]

Extrinsic variables are often manipulated to exacerbate the detrimental effects of prolonged voice use. Airway dehydration, for example, can negatively impact voice production.[20–24] Increasing systemic hydration may partially attenuate the negative effects of vocal loading challenges; however, results have been mixed and have not been examined in older adults.[25,26] An alternate method to increase airway hydration is to target surface mechanisms. Increasing airway surface hydration by increasing environmental humidity during a vocal loading challenge has only been studied with young subjects.[16,27] Investigating these effects across the life span is an important endeavor, as it is currently unknown how older speakers may respond to increased environmental humidity.

In this study, older individuals (>65 years) completed a 45-minute vocal loading challenge on two consecutive days. The only difference between days was the ambient humidity that was adjusted to low or moderate levels. The literature suggests that the effects of vocal loading are best captured

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using a combination of acoustic, aerodynamic, and self-reported voice measures.[8] Emerging evidence suggests that acoustic measures such as cepstral peak prominence (CPP) and low/high spectral ratio (LHR) may be sensitive to subtle laryngeal changes induced by vocal loading challenges. These measures are particularly useful as they can be applied to continuous speech, as opposed to sustained vowels.[11,28–32] A recent study from our laboratory revealed that CPP was sensitive to the adverse effects of a 30-minute vocal loading challenge.[16] Therefore, these cepstral measures were included in the current study. In addition, the aerodynamic measure of phonation threshold pressure (PTP) was utilized to determine the effects of the vocal loading challenge and humidity. PTP has been observed to be consistently sensitive to the effects of vocal loading challenges in healthy speakers.[8,25,26] In addition, there is evidence that airway dehydration may increase PTP.[21,22,33–36] Self-perceived measures of phonatory effort and perceived vocal tiredness have also been reported to increase following vocal loading challenges[9,14,37,38] and airway dehydration.[39]

This study investigated the effects of a vocal loading challenge in older adults. The vocal loading challenge consisted of 45 minutes of loud, child-directed speech in the presence of background noise. Additionally, we quantified if increased environmental humidity would attenuate the negative effects of vocal loading. Therefore, the vocal loading challenge was completed in low humidity and moderate humidity in counterbalanced order across subjects. It was hypothesized that older adults would be adversely affected following the 45-minute vocal loading challenge and that the detrimental vocal effects would be greater in low humidity as compared to moderate humidity.

METHODS

Participants

Thirteen healthy adults (five males and eight females) participated in this investigation. Procedures were approved by the Purdue University Institutional Review Board. Participants were between 65 and 78 years of age (mean age: 72 years), reported general good health, and denied a history of laryngeal or respiratory disease.

Screening

Screening protocols included audiometry (Diagnostic Audiometer AD229e, Interacoustics A/S, Assens, Denmark), refractometry (ATAGO refractometer, Bellevue, WA), the Vocal Fatigue Index-Part I,[40] and the Reflux Symptom Index (RSI).[41] Additionally, two speech-language pathologists with 30+ years of experience rated overall vocal severity of the participants reading the rainbow passage using the CAPE-V scale.[42] All participants passed hearing screenings at 40 dB HL at 500 Hz, 1 KHz, and 2 KHz. Before each experimental session, urine hydration was measured using refractometry to establish adequate systemic hydration. Threshold hydration criterion was set at ≤1.02g/mL. If participants did not meet the criterion, they were offered water and testing was repeated. All 13 participants met criterion before participating in the rest of the study. VFI-10, RSI scores, and CAPE-V scores along with additional participant demographics are presented in Table 1.

TABLE 1.
Subject Demographic Data and Screening Results

Subject	Sex	Age (Years)	Cape-V Rating (Inches)	VFI Part 1*	RSI
1	Female	70	2.06	5	8
2	Female	72	1.19	3	3
3	Female	78	0.19	4	7
4	Female	73	0.75	0	9
5	Female	65	0.75	4	14
6	Female	66	0.13	3	7
7	Female	77	0.38	0	0
8	Female	77	0.75	1	8
9	Male	65	0.56	6	1
10	Male	70	1.63	17	0
11	Male	77	0.63	3	2
12	Male	75	0.19	10	13
13	Male	72	0.06	18	2

Abbreviations: RSI, Reflux Symptom Index; VFI, Vocal Fatigue Index.
* Scores <24 are considered within normal range.

Experimental design

Participation in this study involved two sessions scheduled on consecutive days at similar times of the day (±1 hour). Participants were asked about their voice use, food consumption, and water intake prior to each session. A log was used to confirm similar patterns of voice use and diet before both sessions. The experimental protocol was identical on both days, except for the ambient humidity in which the vocal loading challenge was conducted. The ambient humidity during each session was set to low (22%–30% relative humidity) or moderate (52%–70% relative humidity). These humidities were regulated by dehumidifiers (Model# HC 300, HoneyCombe Dehumidifier, Munters Corporation, Glendale Heights, IL) and humidifiers (Nortec Livesteam Mini SAM-e, Fuller Engineering, Carmel, IN) that were inbuilt into the room with engineering controls within the room. The order of low or moderate humidity sessions was randomized for all participants. Participants were blinded to ambient humidity level.

At the start of the experimental session, each participant's maximum frequency range (in Hz) was obtained. For this, a contact microphone was placed around the subject's neck and participants were asked to glide on a soft /i/ sound to their highest and lowest frequencies on two trials. The frequency range was converted to semitones. Next, the 10th and 20th percent pitches were calculated from this semitone range and used for voice measures. Participants then sat in the experimental room (low humidity or moderate humidity) for 20 minutes to allow for thermal equilibration.[43] We expected that humidity acclimation would also occur in this 20-minute equilibration period. Baseline voice measures were then collected and participants completed a 45-minute vocal loading challenge. Finally, voice measures were reobtained. The dehumidifiers and humidifiers used to control ambient humidity were turned off during data collection to minimize background noise.