Influence of Obligatory Mouth Breathing, During Realistic Activities, on Voice Measures

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Summary: Objective. Low humidity environments and mouth breathing may contribute to superficial vocal fold dehydration. The purpose of this study was to investigate the effects of obligatory mouth breathing, during daily activities in low- and high-humidity environments, on voice measures. The activities included 15 minutes of obligatory mouth breathing alone, during loud reading and during exercise. The effects of mouth breathing and humidity were compared in subjects who either reported or did not report vocal worsening after heavy voice use.

Study Design. Prospective, between-group, repeated-measures design.

Methods. Sixty-three healthy adults with normal respiratory function and perceptually normal voice participated in this study. Thirty-one subjects reported symptoms of voice worsening with heavy voice use. Thirty-two subjects who did not report these symptoms participated as controls. Phonation threshold pressure and perceived phonatory effort were measured at baseline and after each obligatory mouth breathing challenge. Ambient humidity was set to either low or high humidity.

Results. Obligatory mouth breathing in loud reading and exercise significantly increased phonation threshold pressure when compared with mouth breathing alone. This increase in phonation threshold pressure was observed at low and high humidity, in both subject groups. There were no significant effects for perceived phonatory effort.

Conclusions. Obligatory mouth breathing during loud reading and exercise negatively impact phonation threshold pressure. Future investigations that include longer challenge durations, and subjects with voice disorders, are needed to elucidate the underlying mechanisms for increases in phonation threshold pressure.

Key Words: Phonation threshold pressure–Vocal loading–Exercise–Mouth breathing.

INTRODUCTION

Several behavioral and environmental factors are implicated in causing superficial vocal fold dryness.[1–7] Mouth breathing, inhaled medication, pollution, exercise, and low humidity environments may dehydrate the vocal fold surface.[4,8–10] Superficial vocal fold dryness is of clinical concern because it increases the effort for voice production.[6] This study investigated the detrimental phonatory effects arising from the interaction of two factors that are presumed to induce superficial vocal fold dehydration. Mouth breathing and low humidity were selected as the factors deserving further study because they often co-occur. Mouth breathing is common during loud reading, exercising, and sleeping. In the present study, to simulate mouth breathing during everyday activities, participants completed 15 minutes of obligatory mouth breathing alone (15M), in loud reading (15R), and in exercise (15E). Each challenge was completed in either low humidity or high humidity, by two groups of participants (experimental group and control group). The experimental group included participants who reported a worsening of voice with heavy voice use. Individuals reporting symptoms of vocal fatigue and throat dryness, and those presenting with benign vocal pathology, are considered more vulnerable to the ill effects of superficial vocal fold dehydration as compared with speakers who do not report voice problems.[9,11] Subjects in the control group did not report voice decrement after heavy voice use. Phonation threshold pressure (PTP) and perceived phonatory effort (PPE) were selected as voice measures. PTP is the minimum lung pressure required to initiate and sustain vocal fold vibration.[6] PTP has been used extensively as a noninvasive means to investigate voice deterioration resulting from dehydration.[4,7,9,12,13] PPE reflects the ease of voice production as perceived by speakers themselves, and may also change as a function of dehydration challenge.[14]

METHODS

Subjects

All procedures used here were approved by the Purdue University Institutional Review Board. Sixty-three adults with perceptually normal speech and voice and normal respiratory function (≥80% vital capacity and forced vital capacity on spirometry) participated in this investigation. All subjects reported general good health with no preexisting medical conditions and were taking no medication except oral contraceptives during participation. Thirty-two subjects were assigned to a control group (16 males and 16 females, age range = 18–29 years, mean age = 21 years). Subjects in the control group did not report voice deterioration after heavy voice use. Thirty-one participants were assigned to the experimental group (16 males and 15 females, age range = 18–38 years, mean age = 22 years). Subjects in the experimental group reported a worsening of voice with heavy voice use that was accompanied by both throat discomfort and dryness (12 subjects); accompanied by only throat dryness (nine subjects); or accompanied by only throat discomfort (six subjects). In the experimental group,

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22 subjects reported that their voice worsened one to three times per month, whereas nine subjects reported a higher frequency of voice worsening (one to four times per week). All subjects were asymptomatic at the time of testing.

Challenges

Each subject completed three mouth breathing challenges in either low humidity ($\leq$30%) or high humidity ($\geq$53%). Ambient humidity was verified using a Traceable Memory Hygrometer (VWR, Radnor, PA). Each subject followed the protocol depicted in Figure 1.

To ensure obligatory mouth breathing, the subject's nostrils were occluded with nose clips during each challenge. For the 15M challenge, subjects sat in silence. In the 15R challenge, subjects were instructed to read aloud at 70 dB. The investigator monitored intensity on a sound level meter (RadioShack, Fort Worth, TX) and cued subjects to adjust their intensity as necessary. In the 15E challenge, subjects jogged in place. The order of 15M and 15R challenges were counterbalanced across subjects. The 15E challenge was always the last challenge that subjects completed to reduce any carryover effects of respiratory change during exercise to other nonexercise tasks.[15] Thirty-two subjects (16 control subjects, 16 experimental subjects) completed the mouth breathing challenges in low humidity and 31 (16 control subjects, 15 experimental subjects) subjects completed the challenges in high humidity.

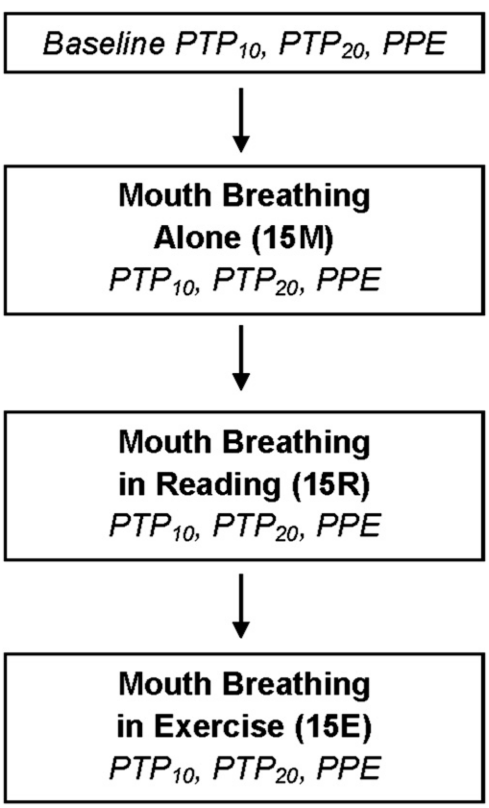

FIGURE 1. Schematic of experimental protocol. The order of 15M and 15R challenges were counterbalanced across subjects. The ambient humidity was set to either low or high humidity.

Voice measures

The instrumentation for PTP included a circumferentially vented pneumotachograph face mask with PTL-1 and PTW-1 pressure transducers coupled to an aerodynamic measurement system (MSIF-2; Glottal Enterprises, Syracuse, NY) for the measurement of oral flows and oral pressures, per validated procedures.[8,9,16] On the day of participation, subjects were trained on the PTP task. First, the investigator modeled five to seven /pi/ syllable repetitions on a single breath at a rate of 1.5 syllables/s at conversational pitch, in a voice just above a whisper. Each subject then practiced this task at a conversational pitch with visual feedback on the computer monitor. Subjects were considered trained when they met the following criteria: production of at least three consecutive /p/ peaks of even height, oral flows approximating 0 mL/s, and consistent, quiet voicing. After training, each subject's maximum pitch range was determined. The 10th and 20th percent pitches were noted. PTP is frequently produced at these pitches.[2,9,17] The 10th percent pitch was specifically selected because it is on the lower extreme end of the pitch range and may be sensitive to the hydration state of the vocal folds.[10] The 20th percent pitch was selected because it is characteristic of conversational speech.[18] Subjects practiced the PTP task at the 10th percent pitch (PTP_{10}) and 20th percent pitch (PTP_{20}) till criteria described above for accurate PTP productions were met. Once subjects were deemed trained, the investigator collected at least five strings of five to seven /pi/ syllable repetitions each at the 10th and 20th percent pitches. PTP_{10} and PTP_{20} were obtained at baseline and after each challenge (Figure 1). For data analysis at each pitch, the peak pressures for /p/ from three middle /pi/ syllables in each string were obtained. These values were averaged across syllable strings for estimating PTP. For interrater reliability, 10% of the existing samples were randomly selected for remeasurement by another investigator. The first and second measurements showed strong correlations ($r = 0.86$).

PPE ratings were obtained using a 10-in visual analog scale.[8] Each subject produced a string of /pi/ syllables at the 80th percent pitch. Subjects then rated their effort to produce the /pi/ syllables by marking a vertical line on the visual analog scale. The marking was measured using a standard ruler to estimate PPE. PPE markings were measured at baseline and after each challenge (Figure 1).

Statistical analysis

Raw PTP_{10}, PTP_{20}, and PPE data were adjusted to baseline because we were interested in comparing the extent of deterioration in voice measures after obligatory mouth breathing. Data for PTP_{10} and PTP_{20} were not normally distributed, therefore, data were square root transformed to obtain a normal distribution. A mixed General Linear Model was applied to the PTP data using *SPSS* 18.0 software (IBM, Chicago, IL). In this statistical model, the between levels were groups (experimental and control) and humidities (low and high). The within levels were mouth breathing challenges (15M, 15R, and 15E) and pitches (PTP_{10} and PTP_{20}). *t* Tests were used for post hoc analysis. PPE data were not normally distributed, which precluded