

Formant-estimated vocal tract length and extrinsic laryngeal muscle activation during
modulation of vocal effort in healthy speakers

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Introduction: Vocal hyperfunction is a common symptom of voice disorders, defined as “abuse and/or misuse of the vocal mechanisms due to excessive and/or ‘imbalanced’ muscular forces” (Hillman, Holmberg, Perkell, Walsh, & Vaughan, 1989). It has been suggested that vocal hyperfunction and the accompanying increase in vocal effort and laryngeal tension result in laryngeal elevation and reduced hyolaryngeal space (Aronson & Bless, 2009; Roy & Ferguson, 2001). The goal of this study was to explore the relationships among vocal effort, extrinsic laryngeal muscle activity, and vocal tract length (VTL) within healthy speakers. We hypothesized that increased vocal effort would result in increased suprahyoid muscle activation and decreased VTL, similar to individuals with vocal hyperfunction (Roy & Ferguson, 2001).

Method: Twenty-eight healthy speakers of American English produced vowel-consonant-vowel utterances under varying levels of vocal effort. VTL was estimated from vowel formants with Equation 1, where n is the formant number, f_n is the formant frequency, and c is the speed of sound.

$$f_n = \frac{(2n - 1) \times c}{4 \times VTL} \quad (1)$$

Higher formant frequencies in a given vocal tract shape tend to be regularly spaced and do not greatly deviate from higher formant frequencies of a uniform tube with the same length, therefore maintaining the relationship in Equation 1 (Wakita, 1977). Surface electromyography (sEMG) sensors measured the activation of suprahyoid and infrahyoid muscles. A general linear model was

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used to investigate the effects of vocal effort and sEMG on VTL. Two additional general linear models were used to investigate the effects of vocal effort on suprahyoid and infrahyoid muscle activity.

Results: Neither vocal effort nor extrinsic muscle activity showed significant effects on VTL; however, the degree of extrinsic muscle activity of both suprahyoid and infrahyoid muscle groups increased with increases in vocal effort (Figure 1).

Conclusions: Increasing vocal effort resulted in increased activation of both suprahyoid and infrahyoid muscles in healthy adults, with no change to VTL. These findings are seemingly in contrast with the laryngeal heightening previously observed in individuals with vocal hyperfunction.

Acknowledgements: This work was supported by grant RO1DC015570, T32DC013017, and T32DC000030 from the National Institute on Deafness and Other Communication Disorders, and the Sargent College Dudley Allen Research Grant from Boston University.

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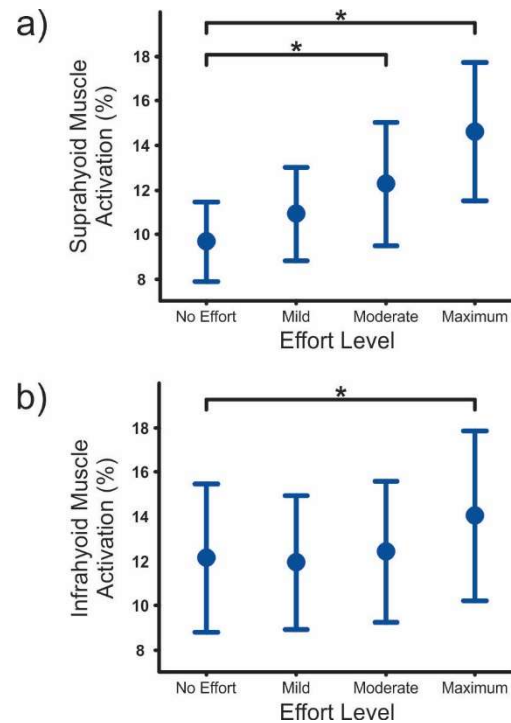


Figure 1: Mean and 95% confidence intervals of the level of muscle activation across each effort level for a) suprahyoid and b) infrahyoid muscles. Black bars indicate significant differences ($p_{adj} < .05$.)