

Formant-Estimated Vocal Tract Length and Extrinsic Laryngeal Muscle Activation during Modulation of Vocal Effort in Healthy Speakers

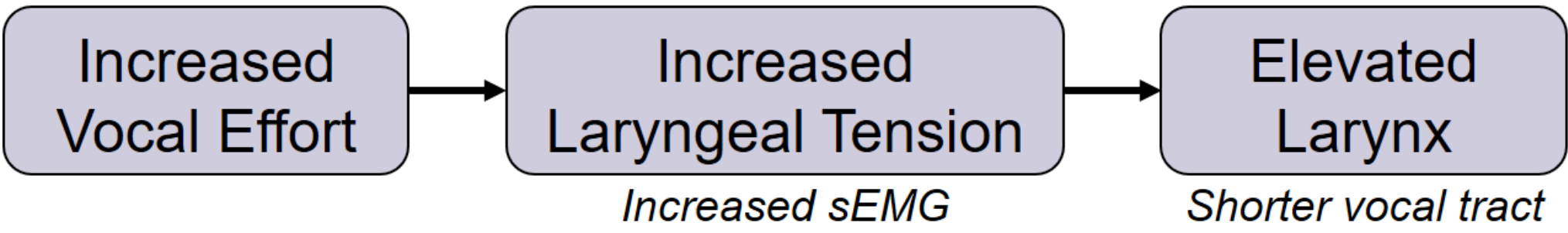
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\*Groll M. D., McKenna V. S., Hablani S., & Stepp C. E. (2020) Formant-Estimated Vocal Tract Length and Extrinsic Laryngeal Muscle Activation during Modulation of Vocal Effort in Healthy Speakers. *Journal of Speech, Language, and Hearing Research*, 63(5), 1395-1403.

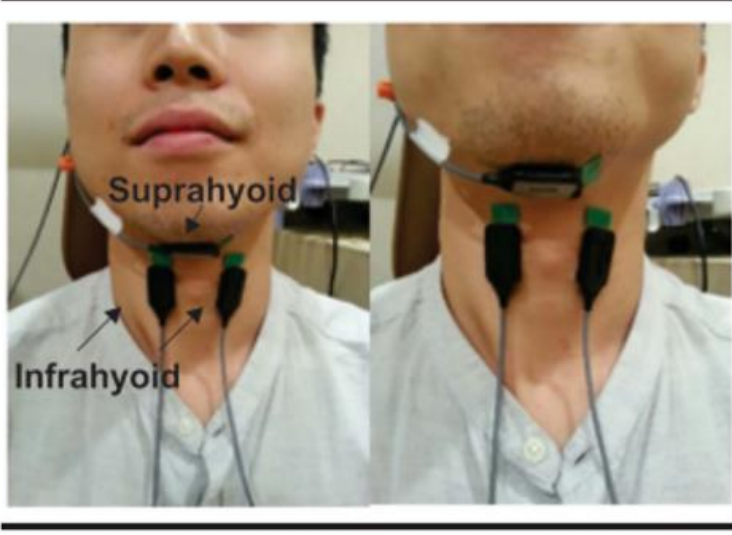
Vocal Effort and Laryngeal Tension

- Increases in neck surface electromyography (sEMG) associated with increases in vocal effort in speakers with typical voices<sup>[1]</sup>
- Laryngeal elevation in speakers with vocal hyperfunction<sup>[2,3]</sup>
- Is sEMG activity a mediating factor in laryngeal elevation during effortful speech?



Study Methods

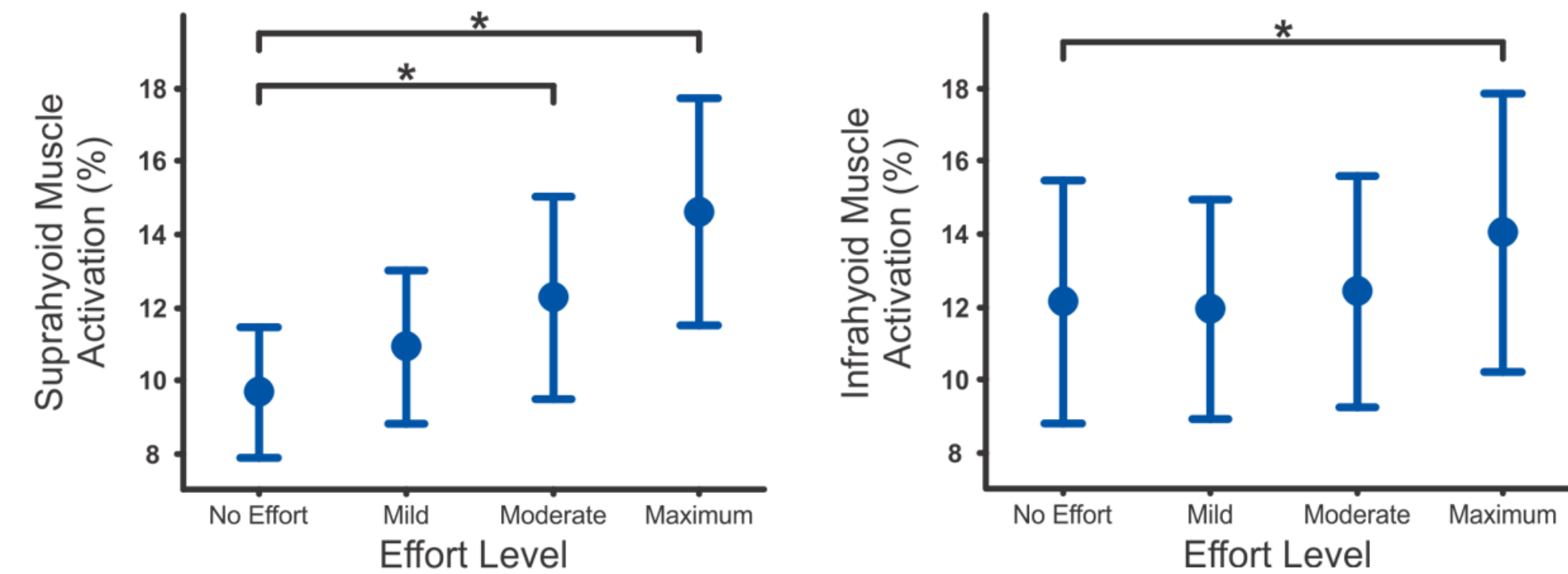
- N = 28 (12 M, 16 F) young speakers with typical voices
- Three sEMG sensors placed on suprahyoid, and L/R infrahyoid muscles
- Formants calculated from /ifi/ utterances spoken with no, mild, moderate, and max effort
- VTL estimated from 3<sup>rd</sup> and 4<sup>th</sup> formants



$$f_n = \frac{(2n - 1) * c}{4L}$$

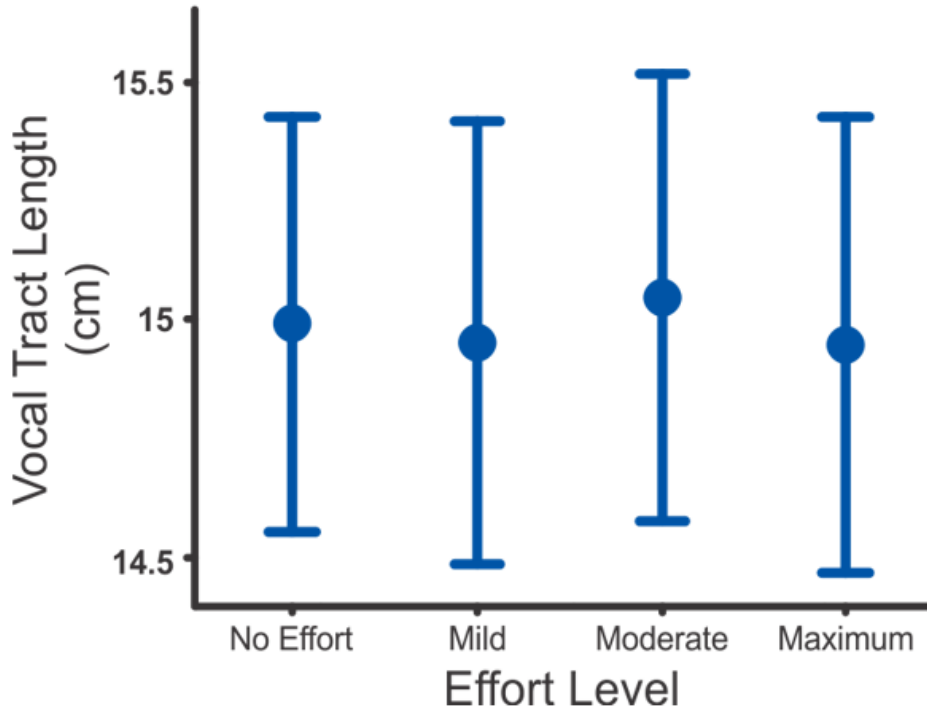
Results

Suprahyoid and infrahyoid muscle activation was greater at increased levels of vocal effort



Results

Effort level and muscle activity had no significant effect on vocal tract length

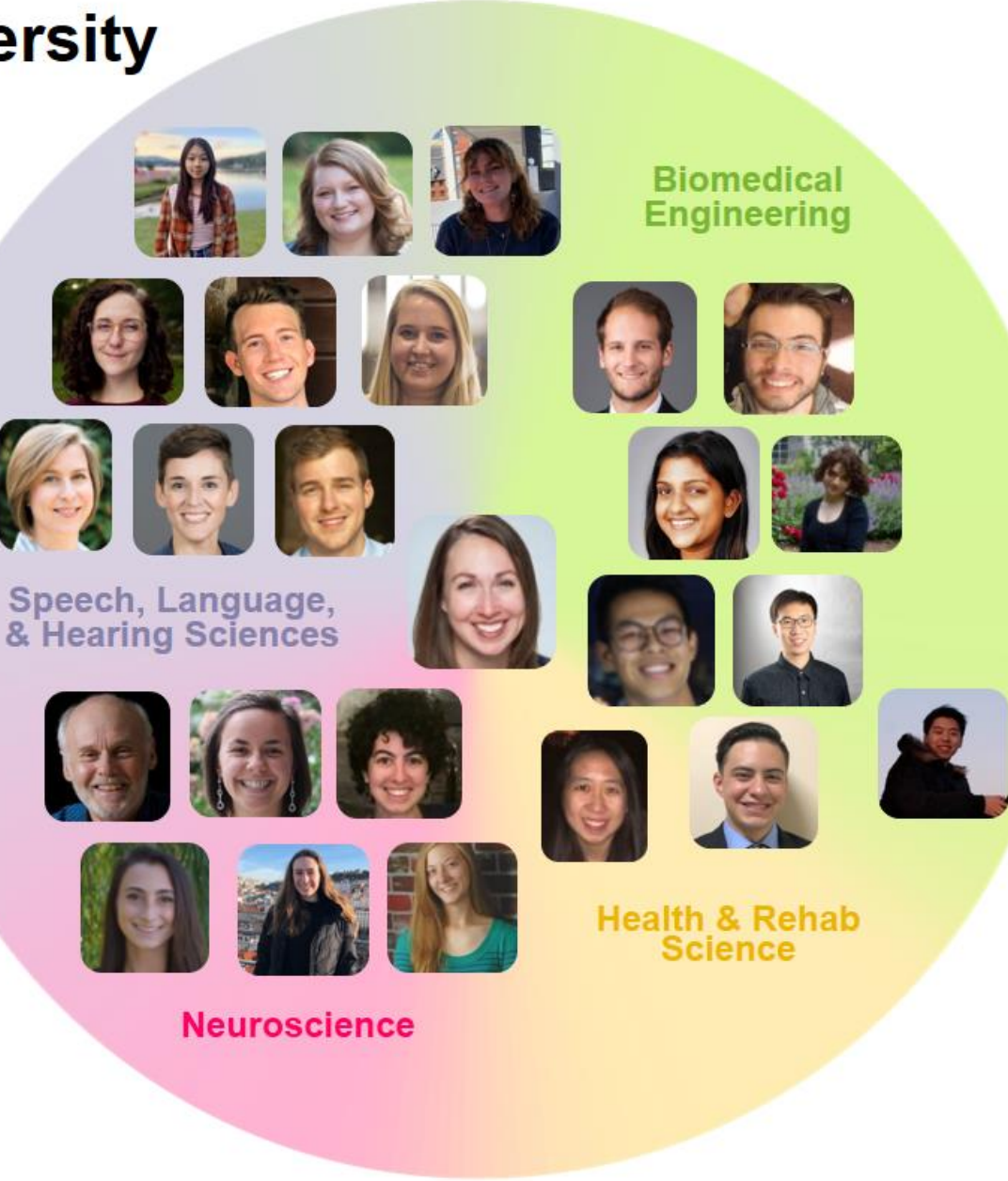


Discussion

- Increased muscle activation, with no change in VTL, may indicate a co-contraction of opposing muscles resulting in an overall increase in laryngeal tension
- Current results contrast to laryngeal elevation in individuals with VH, suggesting differences in vocal effort mechanisms
  - Laryngeal elevation may be a compensatory mechanism to chronic vocal effort
  - Increases in extrinsic laryngeal muscle activity may be a response to acute increases in vocal effort

Acknowledgements

Boston University Stepp Lab:

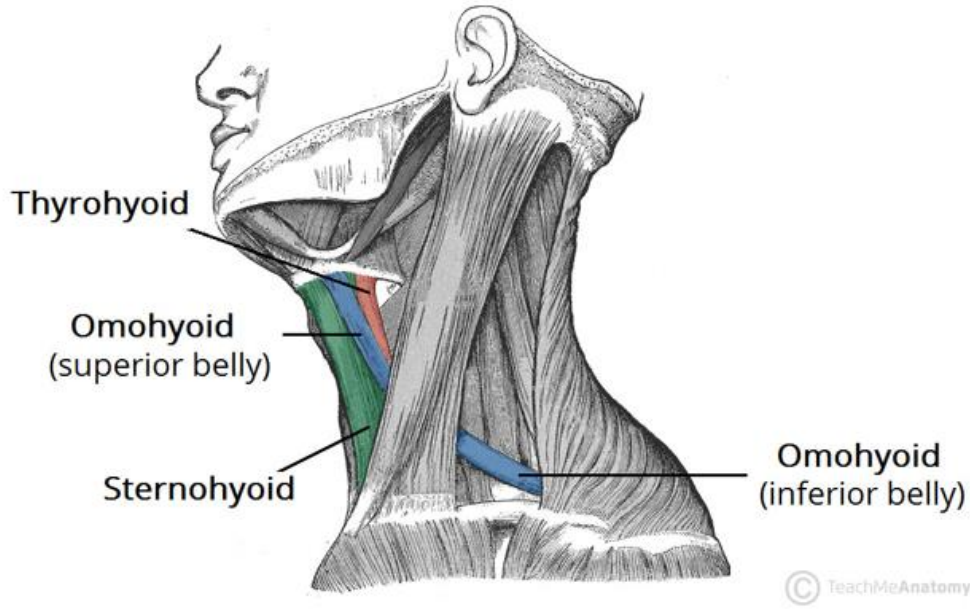
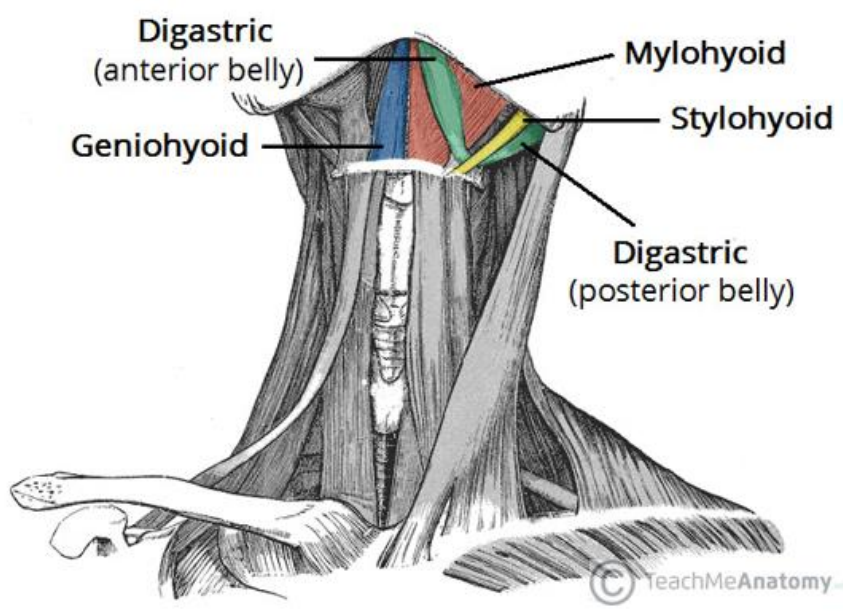


Citations

- [1] McKenna, V. S., Diaz-Cadiz, M. E., Shembel, A. C., Enos, N. M., & Stepp, C. E. (2019). The relationship between physiological mechanisms and the self-perception of vocal effort. *Journal of Speech, Language, and Hearing Research*, 62(4), 815–834.
- [2] Roy, N., & Ferguson, N. A. (2001). Formant frequency changes following manual circumlaryngeal therapy for functional dysphonia: Evidence of laryngeal lowering. *Journal of Medical Speech-Language Pathology*, 9(3), 169–176.
- [3] Lowell, S. Y., Kelley, R. T., Colton, R. H., Smith, P. B., & Portnoy, J. E. (2012). Position of the hyoid and larynx in people with muscle tension dysphonia. *The Laryngoscope*, 122(2), 370–377.

Suprahyoid & Infrahyoid muscles

- Targeted suprahyoid muscles – mylohyoid, geniohyoid, and digastric
- Targeted infrahyoid muscles – thyrohyoid, sternohyoid, and omohyoid



<https://teachmeanatomy.info/neck/muscles/>

Participants

- N = 28 (12 male, 16 female) young speakers with typical voices
- Aged 18 – 29 years (M = 20.8 yrs, SD = 2.76 yrs)

Data Analysis

- sEMG activity calculated as percent (%) activation from maximal voluntary contraction tasks
- (1) General linear model (GLM) with VTL as outcome; participant and effort as factors, % activations as covariates
- (2) Two GLMs with % activations as outcome; participant and effort as factors

Participant	Effort	VTL	Suprahyoid % Activation	Infrahyoid % Activation
P1	No	XX cm	XX %	XX %
	Mild	XX cm	XX %	XX %
	Moderate	XX cm	XX %	XX %
	Maximum	XX cm	XX %	XX %

Results

Effort level and muscle activity had no significant effect on vocal tract length

Effect	df	F-value	p-value	Effect Size ( $\eta_p^2$ )	Qualitative Effect Size
Participant	27	64.29	< .001	0.96	Large
Effort Level	3	0.15	0.93	--	--
Suprahyoid Muscle Activation	1	0.02	0.88	--	--
Infrahyoid Muscle Activation	1	2.41	0.13	--	--

Results

Suprahyoid and infrahyoid muscle activation was greater at increased levels of vocal effort

Suprahyoid Muscle Activation					
Effect	df	F-value	p-value	Effect Size ( $\eta_p^2$ )	Qualitative Effect Size
Participant	27	13.37	< .001	0.82	Large
Effort Level	3	11.21	< .001	0.30	Large
Infrahyoid Muscle Activation					
Effect	df	F-value	p-value	Effect Size ( $\eta_p^2$ )	Qualitative Effect Size
Participant	27	31.87	< .001	0.92	Large
Effort Level	3	3.23	0.027	0.11	Medium