

The neuromuscular development of swallowing continues into the school-age years: Evidence from a preliminary cross-sectional study

Rachel Hahn Arkenberg¹, Samantha Mitchel¹, Barb Brown¹, Lisa Goffman², & Georgia A. Malandraki¹

¹ Purdue University ² University of Texas, Dallas



Introduction

Background:

- Few studies on motor development of swallowing in childhood suggest “adult-like” control by age five (e.g. Green et al., 1997; Ruark et al., 2002).
- However, theories of motor development support protracted refinement for *all* systems (Hadders-Algra, 2018; Thelen, 2005) and emerging research on swallowing aligns (Hennessey et al., 2018).
- There is a gap in our knowledge of the typical development of the neuromuscular control of swallowing throughout childhood.

To start addressing this gap, we compared the neuromuscular control of swallowing in children at two distinct stages of neurodevelopment: 7-8 years old, when there is continuing cortical thickening, and 11-12 years old, a range that encompasses the peak of gray matter volume for children.

Aim: to compare neuromuscular activation during swallowing tasks in younger and older typically developing school-aged children.

Methods

Design: Cross-sectional design (on-going study)

Screening: intelligence, language, hearing, cranial nerve exam

Participants:

| | n | Mean Age (years;mos.) | Age Range (years;mos.) | Race & Ethnicity |
|-------|---|-----------------------|------------------------|------------------------------------|
| Young | 7 | 7;6 | 7;0-7;11 | 6 white & non-Hispanic; 1 Hispanic |
| Older | 5 | 12;2 | 11;7 – 12;9 | 5 white & non-Hispanic; |

Experiment:

- Skin preparation & sensor placement
- EMG data collection
 - Criterion reference task:
 - Submental: tongue pressure measured with Iowa Oral Performance Instrument
 - Lips: alternating “kiss smile” task
 - Swallow trials: 3 self-administered trials of: 5 mL water, 10 mL water, cup sip water, sequential cup sip water, 5 cc pudding, and bites of pretzel

Methods Cont.

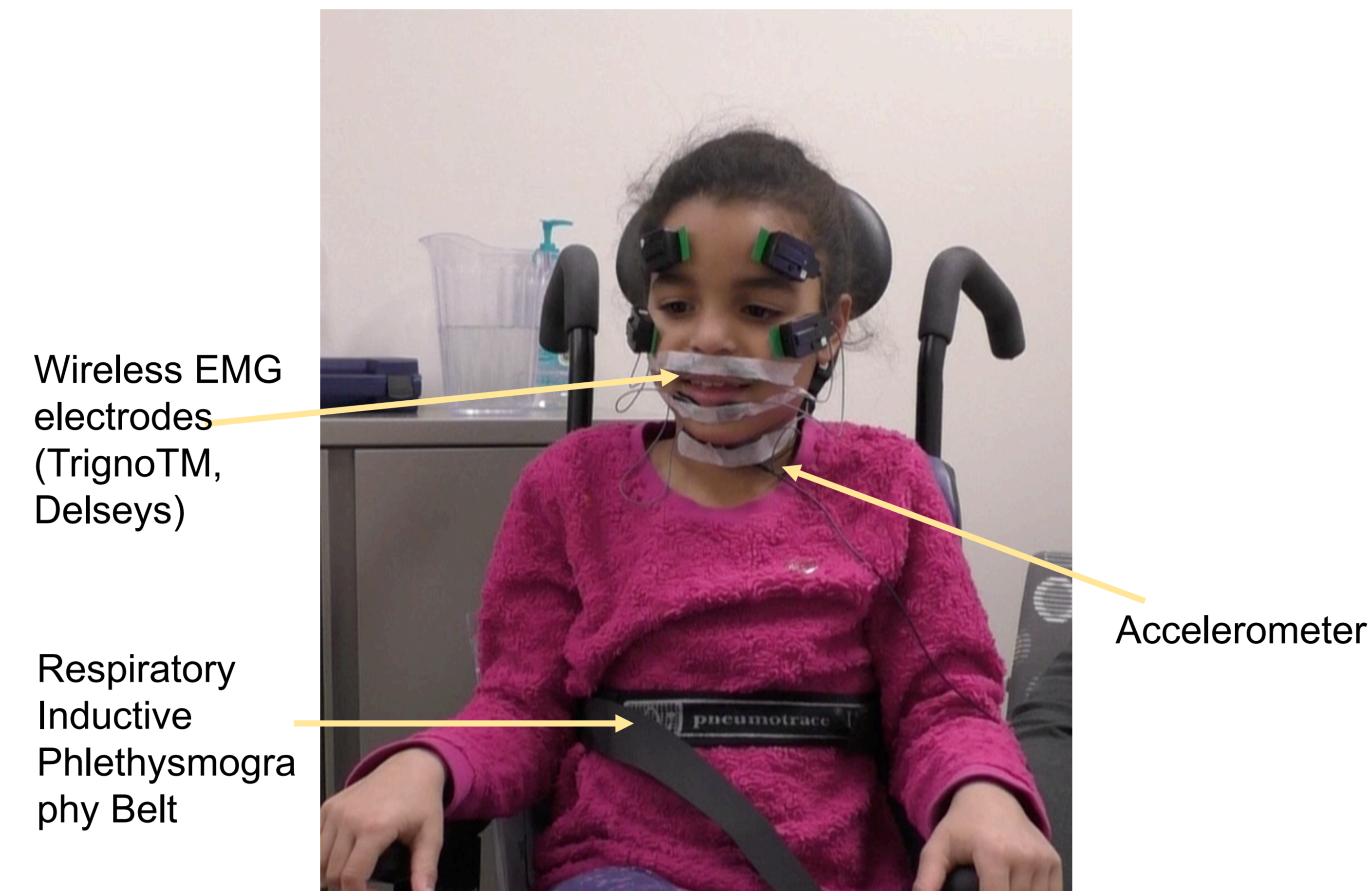


Figure 1: Materials for electromyography data collection

Surface EMG outcomes: normalized mean amplitude (area under the curve) and burst duration of the smoothed sEMG signal.

Analysis: Non-parametric analyses (Wilcoxon signed-rank test) were utilized to analyze the data at this stage.

Results

Normalized mean amplitude (Area Under the Curve): When tasks were combined, younger and older children produced significantly different activation for: lower lip right ($p < 0.001$), upper lip right ($p < 0.004$), upper lip left ($p < 0.004$), & submental left ($p < 0.044$). For significance broken down by tasks, see Figure 2.

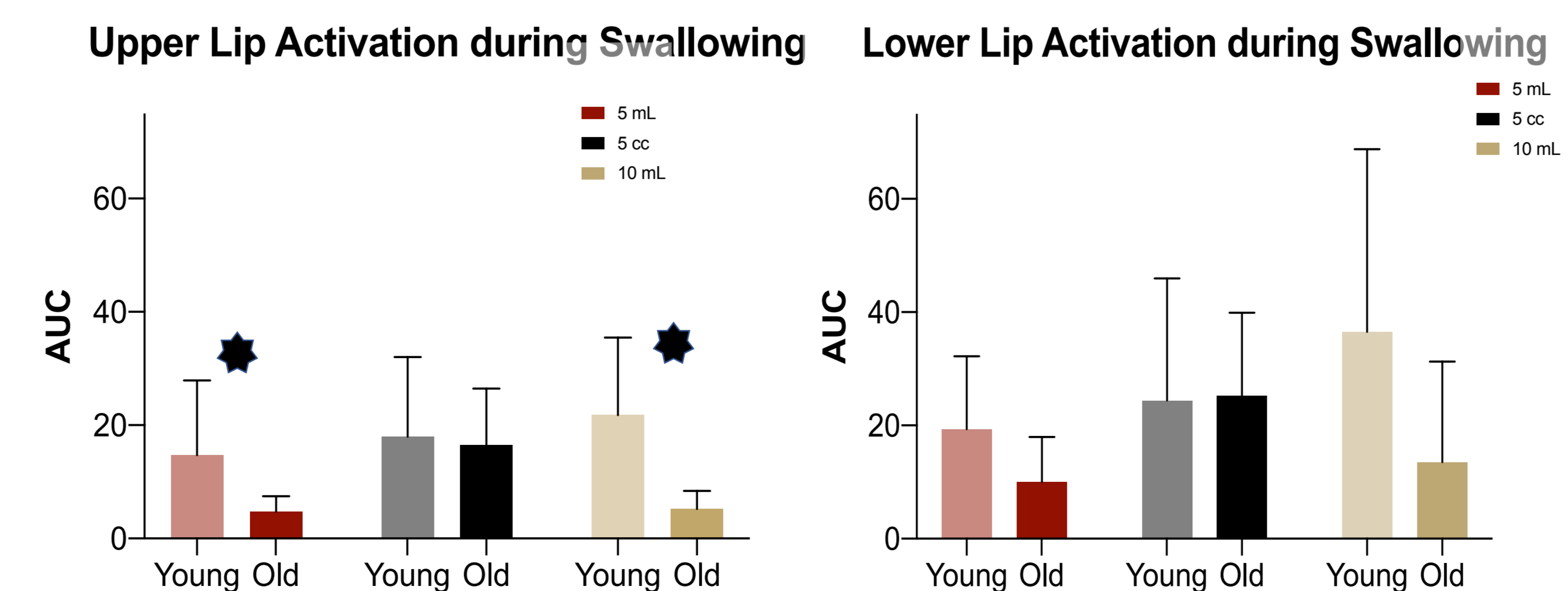


Figure 2: Normalized mean amplitude during swallowing tasks * $p < 0.05$

Results Cont.

Burst Duration: statistically significant difference in bites of 5 cc pudding ($p < 0.012$; see Figure 2)

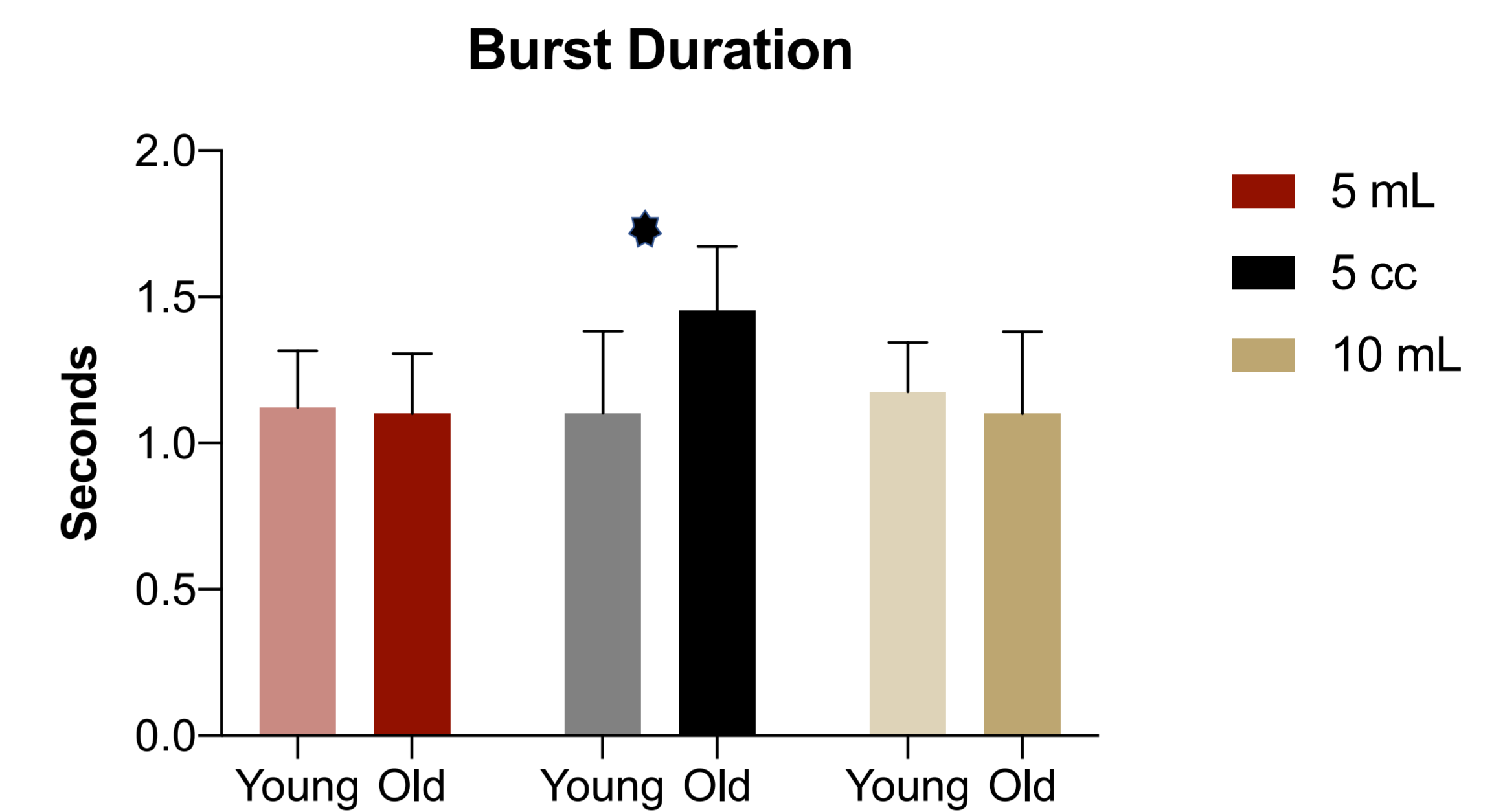


Figure 3: Burst duration during three swallowing tasks * $p < 0.05$

Discussion

This preliminary study provides support that typically developing children continue to demonstrate refinement of neuromuscular control of swallowing between 7-8 and 11-12 years of age, consistent with theories of motor development (Hadders-Algra, 2018; Thelen, 2005). To our knowledge it is the first to document protracted neuromuscular development of swallowing in older children.

Limitations: small sample size, non-naturalistic setting, limited diversity in the sample.

Mapping the development of swallowing during later childhood may have significant implications for diagnosis and treatment of clinical populations in the future.

References

- Green, J. R., Moore, C. A., Ruark, J. L., Rodda, P. R., Morvée, W. T., & Vanwittenburg, M. J. (1997). Development of Chewing in Children From 12 to 48 Months: Longitudinal Study of EMG Patterns. *Journal of Neurophysiology*, 77(5), 2704–2716. <https://doi.org/10.1152/jn.1997.77.5.2704>
- Hadders-Algra, M. (2018). Early human motor development: From variation to the ability to vary and adapt. *Neuroscience & Biobehavioral Reviews*, 90, 411–427. <https://doi.org/10.1016/j.neubiorev.2018.05.009>
- Hennessey, N. W., Fisher, G., & Ciccone, N. (2018). Developmental changes in pharyngeal swallowing acoustics: A comparison of adults and children. *Logopedics Phoniatrics Vocology*, 43(2), 63–72. <https://doi.org/10.1080/14015439.2017.1326526>
- Ruark, J. L., McCullough, G. H., Peters, R. L., & Moore, C. A. (2002). Bolus Consistency and Swallowing in Children and Adults. *Dysphagia*, 17(1), 24–33. <https://doi.org/10.1007/s00455-001-0098-0>
- Thelen, E. (2005). Dynamic Systems Theory and the Complexity of Change. *Psychoanalytic Dialogues*, 15(2), 255–283. <https://doi.org/10.1080/10481881509348831>

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Contact us:
hahn@purdue.edu
Or scan QR code
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