

Are all swallows equal in continuous cup drinking? An analysis of hyoid kinematics using Ultrasound Evaluation of Swallowing (USES)



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INTRODUCTION

- Continuous swallow is a common method of liquid consumption, and yet most of our knowledge of swallowing is based on discrete swallow
- Our current knowledge on continuous swallow:
 - Different patterns of hyolaryngeal complex were observed: complete opening, partial opening and mixed
 - First and final swallows in the sequence are generally regarded as different from the medial swallows
 - Medial swallows were analysed as separate tokens, with limited exploration of variation within the swallow sequence
- Clinically, continuous swallows are regularly used in swallow screening to detect aspiration. Therefore, it is imperative for us to extend our understanding of the physiology of continuous swallows

METHOD

- Ultrasound evaluation of swallowing (USES)
- pocket-sized Micro ultrasound system operating standard B-mode
 - 60mm convex probe fitted on UltraFit headset

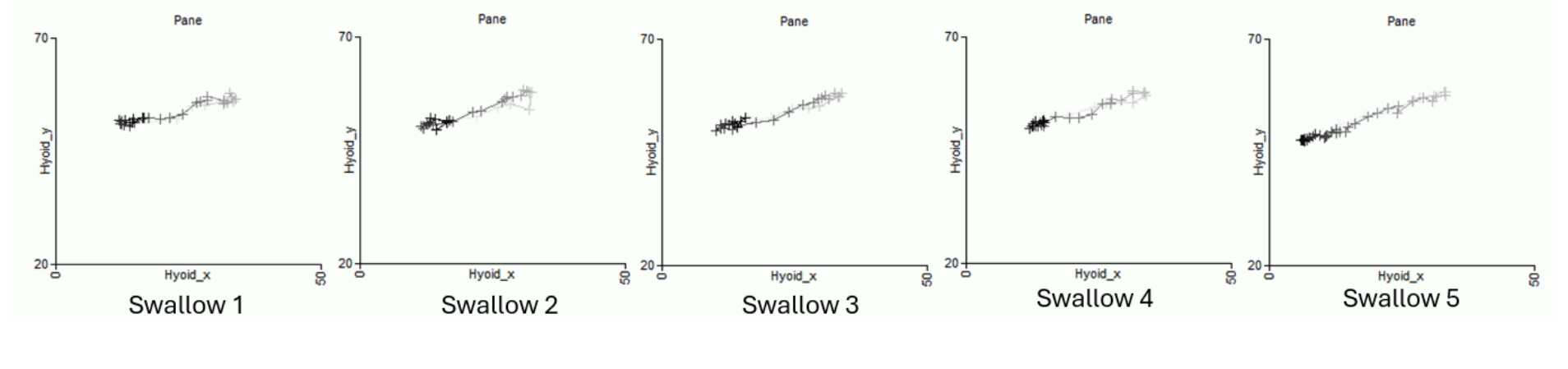
- Participants & Swallow Tokens:
- 41 healthy individuals (age)
 - no reported history of dysphagia; EAT-10 < 3
 - Part of a larger dataset; current tokens included 100ml continuous swallows & 10ml cup drinking



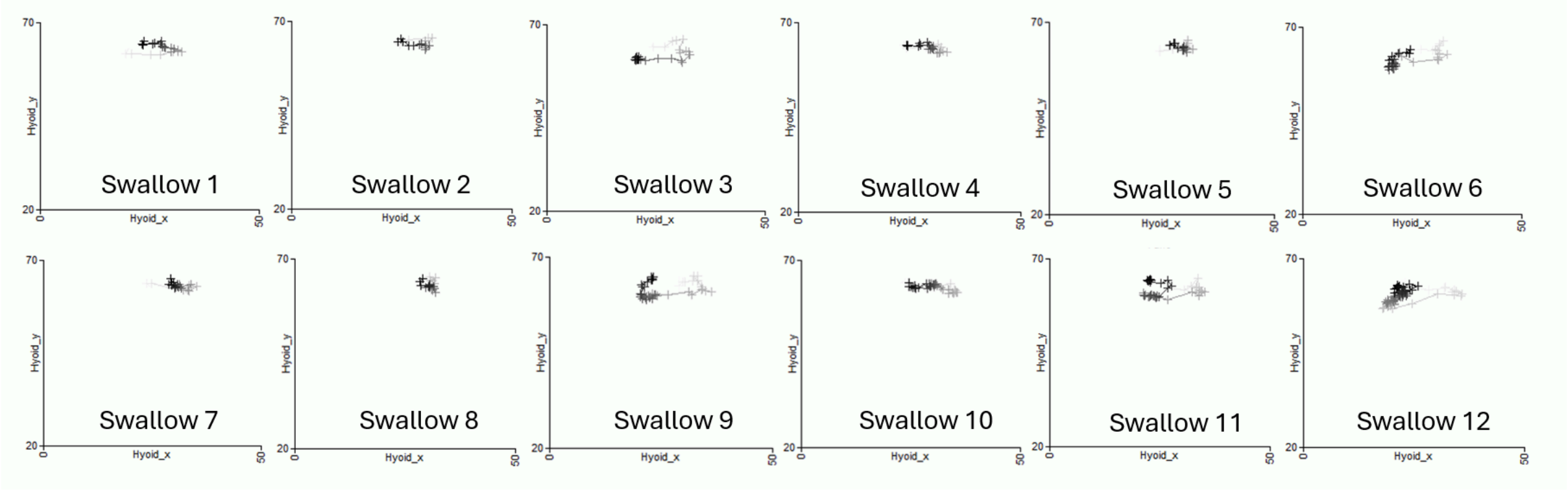
RESULTS

Hyoid Trajectories

qualitative analysis of the hyoid trajectories showed that most participants had similar hyoid movement patterns across the swallows in a swallow sequence.



A small number of participants showed intra-sequence variations in the hyoid trajectories



Hyoid Metrics (Initial, medial vs final)

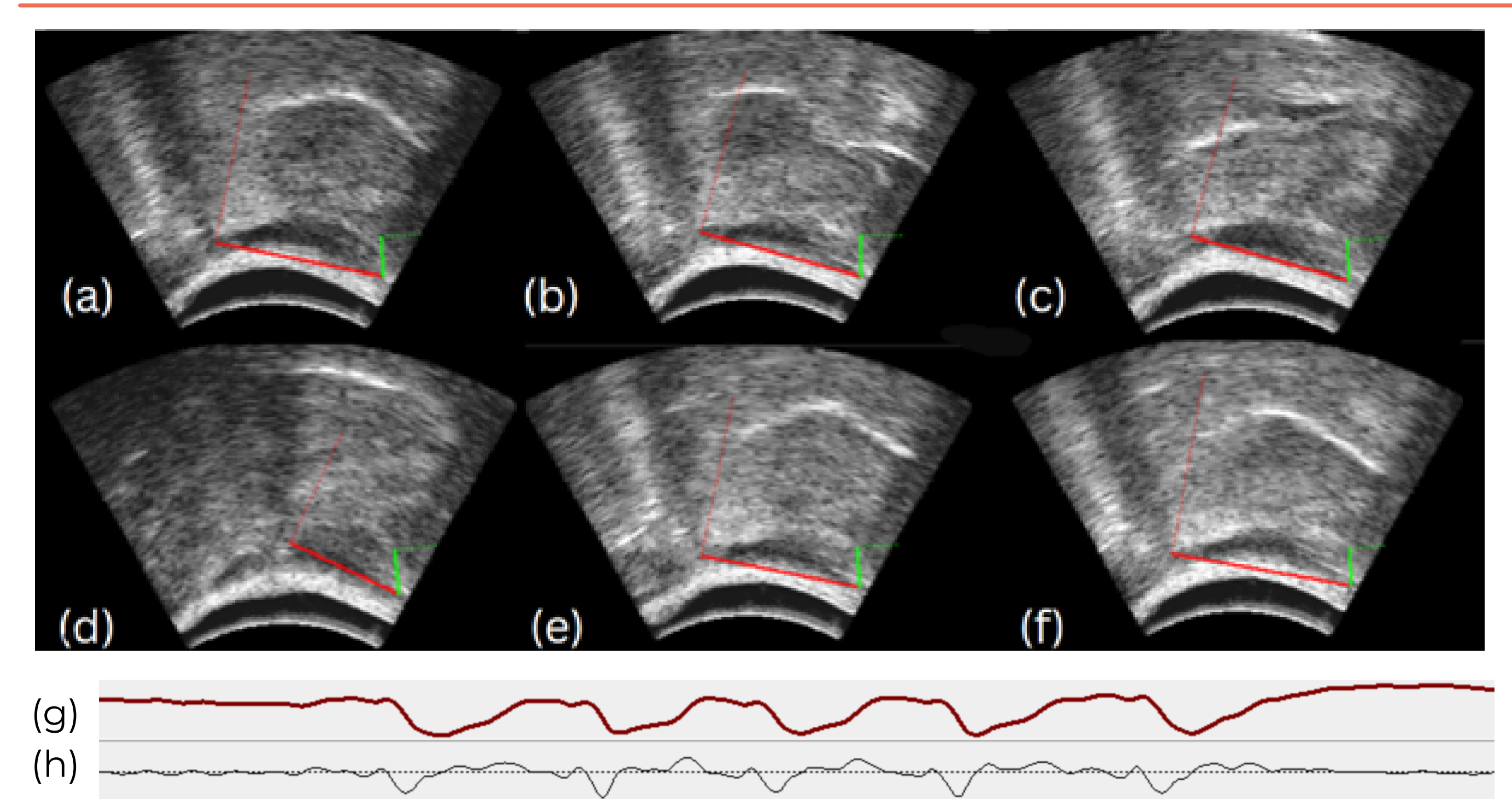
- ANOVA compared each parameter across positions in a continuous swallow sequence
- Initial swallows (cf. medial & final)
 - higher maximum displacement
 - higher forward velocity
- Medial swallows (cf. initial & final)
 - shorter total duration
- Final swallows (cf. medial)
 - longer duration for hyoid to return to rest position after swallow
 - longer time to peak backward velocity
 - higher backward velocity

Parameters	Initial	Medial	Final
HxD Max	11.95 (3.59)	10.74 (3.82)	11.48 (3.71)
F. peak vel	63.85 (20.66)	55.20 (20.66)	57.59 (24.46)
B. peak vel	39.18 (13.40)	38.22 (16.45)	46.60 (20.36)
Total duration	0.92 (0.29)	0.79 (0.23)	0.91 (0.26)
Start-to-max	0.38 (0.12)	0.32 (0.11)	0.42 (0.15)
At-max time	0.27 (0.32)	0.21 (0.23)	0.19 (0.22)
Max-to-end time	0.27 (0.13)	0.25 (0.13)	0.30 (0.13)
Time to f. vel	0.12 (0.05)	0.12 (0.05)	0.17 (0.11)
Time to b. vel	0.38 (0.31)	0.32 (0.11)	0.75 (0.26)

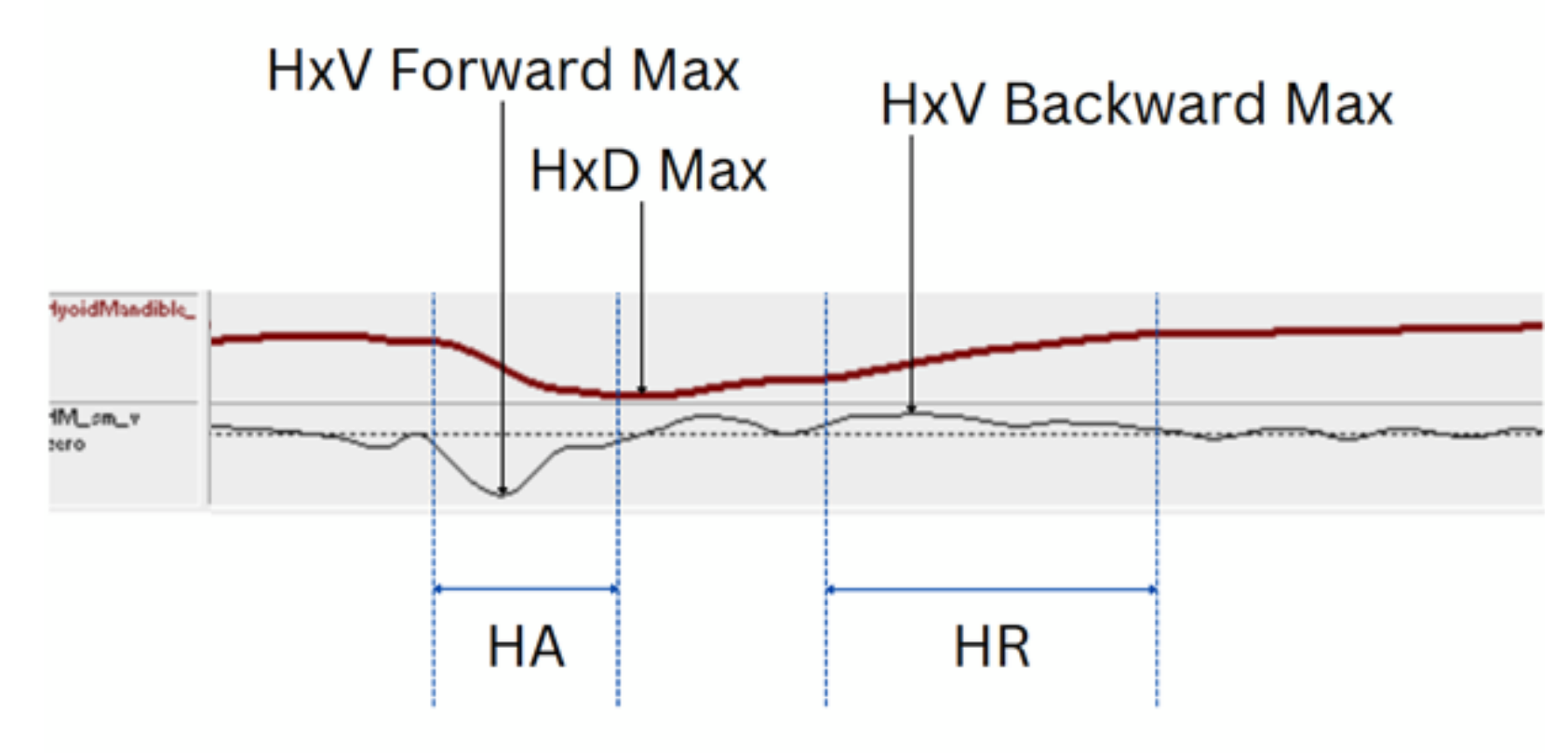
OBJECTIVES

- Explore the hyoid kinematics in continuous swallow through qualitative comparison of hyoid trajectories in the swallow sequence
- Investigate the quantitative differences of the hyoid metrics in the initial, medial and final swallows

HYOID ANALYSIS



The distance between the hyoid and the mandible was estimated during swallowing [e.g., (a) to (f)] using DeepLabCut (DLC) neural net. The hyoid-mandible distance was plotted in (g), and the velocity of movement was calculated and plotted in (h).



For each swallow in the sequence, the point with the shortest hyoid-mandible distance (HxD Max) was labelled. Period of forward (HA) and backward (HR) hyoid movement and max velocity were identified (HxV Forward Max & HxV Backward Max)

From the events labelled above, the following hyoid metrics were generated:

- Maximal displacement (mm)
- Forward peak velocity (mm/s)
- Backward peak velocity (mm/s)
- Total duration (sec)
- Start-to-max duration (sec)
- At max duration (sec)
- Max-to-end duration (sec)
- Time to forward velocity (sec)
- Time to backward velocity (sec)

DISCUSSION & CONCLUSION

- While most swallows within a sequence follow a similar pattern, there are variations between the initial, medial and final swallows within a sequence
 - **initial** swallows began with hyoid closest to the 'resting' position, with a difference in the **'hyoid advancement' phase**
 - **medial** swallows were shorter and more **cyclical**
 - **final** swallows, generally considered the 'clearing swallows', have a larger bolus volume than the other swallows, with a difference in the **'hyoid retraction' phase**
 - These variations could result from physiological adaption due to the co-occurring swallowing events
- **Habitual swallowing patterns** can also result in variations between the swallowing physiology within the sequence
- Not all swallows in a continuous cup drinking are the same.
- Understanding the demand for motor adaptation in a swallow sequence will help us to further explore the effect of dysphagia on continuous drinking

RELATED LITERATURE
 Chi-Fishman, & Sonies (2000). doi:10.1044/jslhr.4306.148
 Daniels et al (2004). doi:10.1044/1092-4388(2004)004
 Daniels & Foondas (2001). doi:10.1007/s00455-001-0061-0
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