

Introduction

- High resolution cervical auscultation (HRCA) is a non-invasive sensor-based technology that uses acoustic and vibratory signals, advanced signal processing, and machine learning to quantify swallowing.
- HRCA has accurately detected swallowing safety (PAS), swallow kinematic events, and MBSImP scores; and differentiated between swallows from healthy people and swallows from patients.
- Hypotheses:** HRCA will classify non-effortful and effortful swallows with a high degree of accuracy and there will be differences in MBSImP component scores (#9,#11,#14) between swallows.

Methods

- 36 healthy adults (65.53±7.67 years); 247 thin liquid swallows (71 effortful).
- Standardized VFSSs with 3mL thin liquid command swallows by spoon.
- Temporal kinematic reliability: 100% intra-rater and ICCs of 1.00 for inter-rater.
- MBSImP reliability: 100% intra-rater and 79% for inter-rater.
- We used multiple machine learning classifiers and a linear mixed model to analyze the data.

9 HRCA signal features classified between *non-effortful* and *effortful* swallows (76% accuracy, 76% sensitivity, 77% specificity).

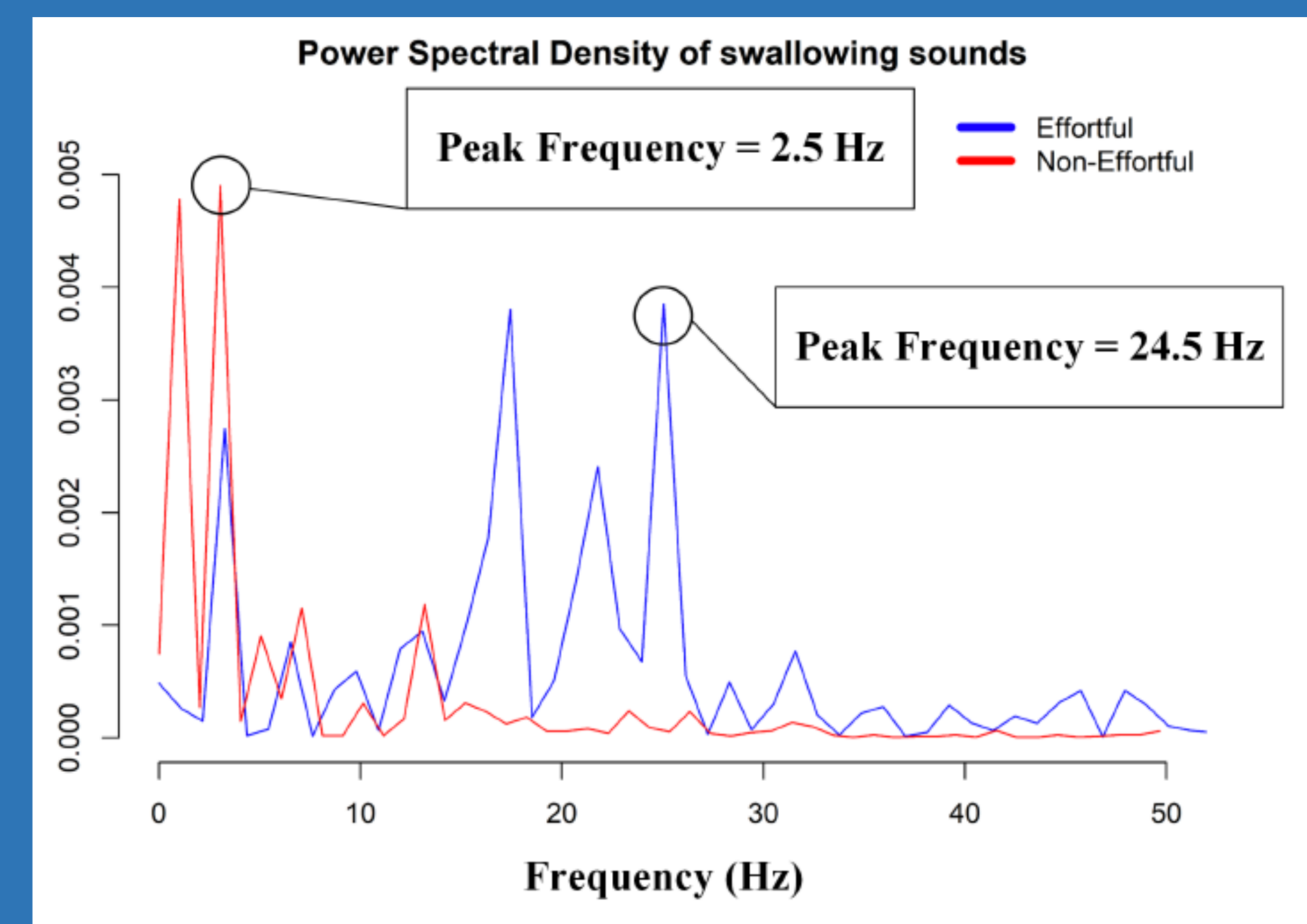


Figure 1: Power spectral density plot from the HRCA microphone signals showing the difference in peak frequency between the non-effortful and effortful swallows.

HRCA has high potential as a biofeedback method for *dysphagia treatment*.

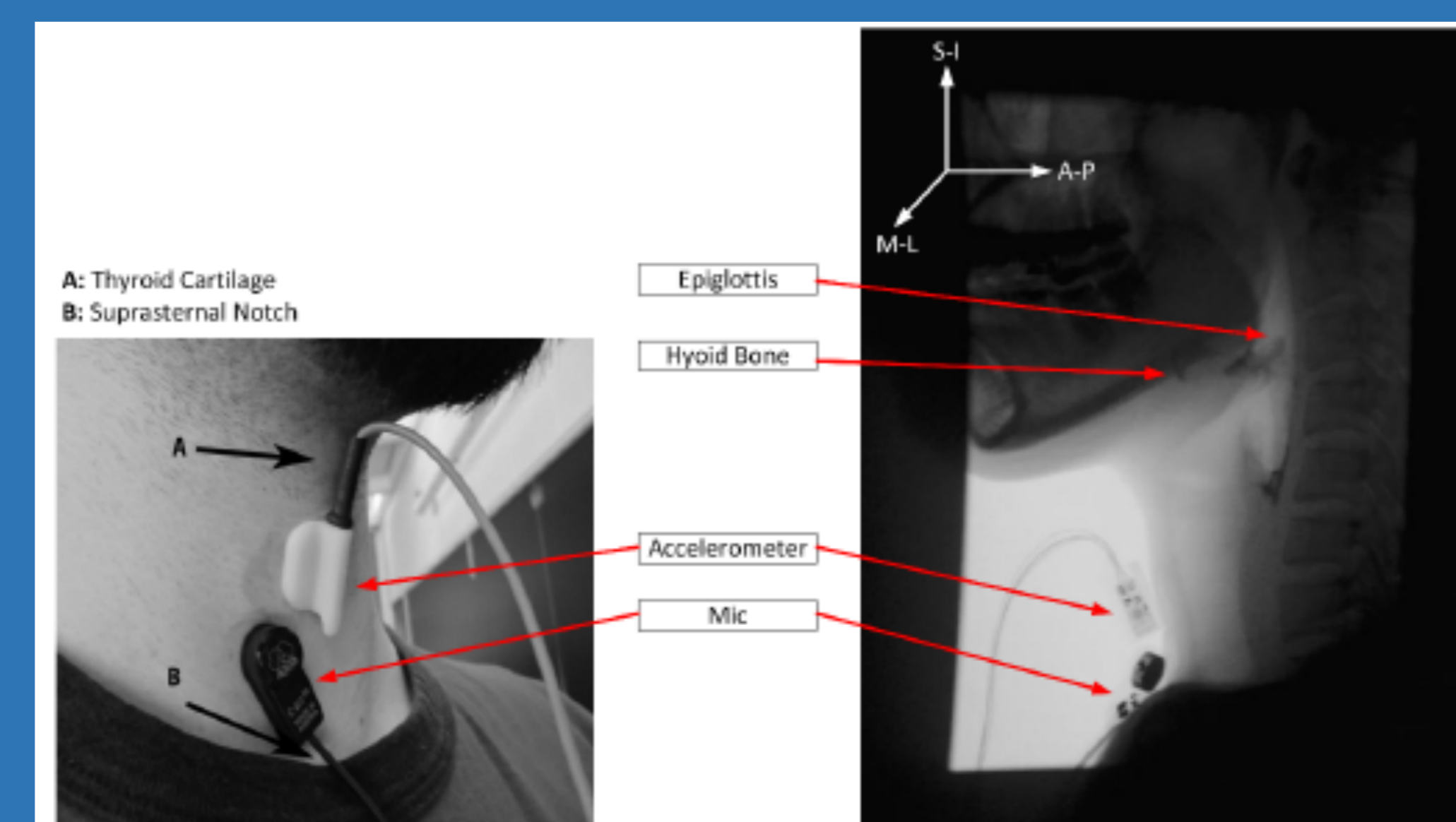


Figure 2: Placement of HRCA sensors during data collection.

Results

Table 1: Explanation of features extracted from the HRCA signals.

Domain	Signal Feature	Significance
Time	Standard deviation	Reflects the signal variance around its mean value.
	Skewness	Describes the asymmetry of amplitude distribution around mean.
	Kurtosis	Describes the peakness of the distribution relative to normal distribution.
Information-Theoretic	Lempel-Ziv Complexity	Describes the randomness of the signal.
	Entropy rate	Evaluates the degree of regularity of the signal distribution.
Frequency	Peak Frequency (Hz)	Describes the frequency of maximum power.
	Spectral Centroid (Hz)	Evaluates the median of the spectrum of the signal.
	Bandwidth (Hz)	Describes the range of frequencies of the signal.
Time-Frequency	Wavelet Entropy	Evaluates disorderly behavior for non-stationary signal.

Table 2: Statistically significant HRCA signal features for classifying effortful and non-effortful swallows.

	Standard Deviation	Skewness	Kurtosis	Lempel-Ziv complexity	Entropy Rate	Peak Frequency	Spectral Centroid	Bandwidth	Wavelet entropy
Microphone	0.0177*	0.4246	0.0936	0.1989	0.4892	0.0330*	0.0004*	0.0014*	0.0161*
Anterior-posterior	0.0056*	0.6068	0.6068	0.3430	0.4603	0.5481	0.7029	0.5582	0.1718
Superior-inferior	0.0043*	0.0942	0.3582	0.9820	0.2410	0.1750	0.2033	0.1233	0.0443*
Medial-lateral	0.0238*	0.3065	0.2134	0.5180	0.2958	0.9400	0.5739	0.5182	0.1152

There were no significant differences in MBSImP scores #9, #11, and #14 between non-effortful and effortful swallows.

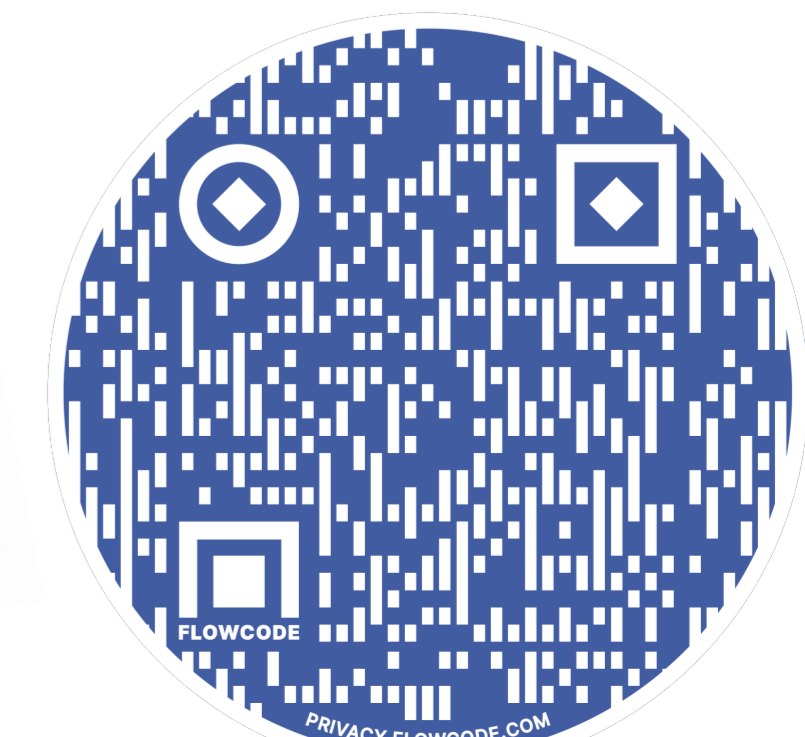
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Acknowledgments

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