A SCOPING LITERATURE REVIEW OF RELATIVE FUNDAMENTAL FREQUENCY IN INDIVIDUALS WITH AND WITHOUT VOICE DISORDERS

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BACKGROUND

What is relative fundamental frequency (RFF)?

- Acoustic metric of **cycle-by-cycle changes in voice fundamental frequency (f_0)** during voicing transitions
- Instantaneous f_0 of **10 voicing cycles** around voiceless consonant
- Allows for within- and across-subject comparisons due to f_0 normalization (semitones; ST)

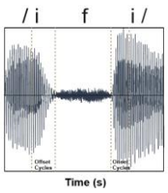


Fig. 1. Acoustic waveform of the utterance "ifi." Voicing offset and onset cycles used to calculate RFF are marked surrounding the voiceless fricative, /f/.

Why is RFF clinically useful?

Offset cycle 10 and **onset cycle 1** (cycles closest to the voiceless consonant) are **clinical indicators of vocal effort and laryngeal tension**

PURPOSE

Despite the clinical utility of RFF, a **critical review of the literature has not been completed**.

This review aims to:

i. describe methods frequently employed to calculate RFF
ii. provide a summary of findings across specific patient populations
iii. identify next steps for implementing and interpreting RFF measures in clinical practice

METHODS

- Systematic literature search completed across 5 databases in Feb-2020 (updated Apr-2021) [1]
- **Eligibility criteria:**
  - ✓ Inclusion:
    - Human subjects
    - English language
    - Measured RFF (ST)
  - × Exclusion:
    - Conference abstracts
    - Case study, single subject design, meta-analysis or review
    - Non-normalized f_0 (Hz)
- Two authors extracted study data, including: population, methods for obtaining RFF (speech stimuli, signal processing), and voicing cycle values (offset 10, onset 1)

RESULTS

Fig 2. Proportion of studies reporting different methods and outcomes.

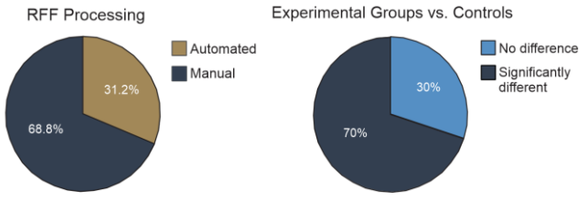
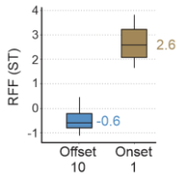


Fig 3. Range of RFF values reported for vocally healthy adults



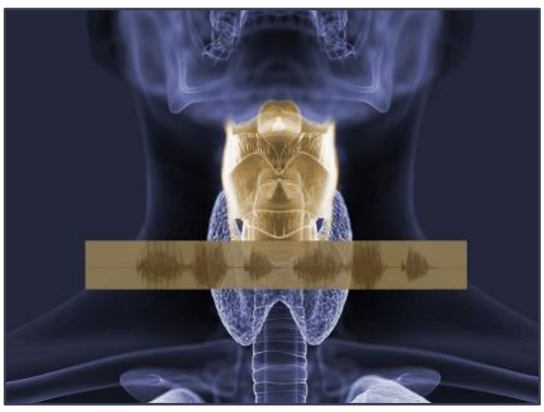
- Only **37 of 5693** articles for review met our inclusion criteria (spanning 1998–2021)
- **Speech stimuli:**
  - Vowel-consonant-vowel utterances (n=17)
  - Running speech (n=18)
  - Both stimuli (n=2)
- **Study populations:**
  - Vocally healthy adults (n=29)
  - Muscle tension dysphonia (n=17)
  - Phonotraumatic lesions (n=11)
  - Parkinson's disease (n=8)
  - Spasmodic dysphonia (n=6)
  - Older adults (n=9)
  - Children (n=3)
- Only **4 of 37** studies tracked therapeutic progress, involving those with muscle tension dysphonia, phonotraumatic lesions, and vocal fatigue
- **Inconsistent relationships between RFF and auditory-perceptual metrics**
  - Moderate relationships between measures of vocal strain/effort and RFF, with stronger relationships when examined within-subject [2]
  - Whether RFF relates to overall dysphonia severity is still in need of investigation

DISCUSSION & CLINICAL IMPLICATIONS

- **Open-source algorithms** allow for fast, reliable RFF computation
- Measures of RFF from microphones and accelerometers allow for both **in-office voice evaluations** and **ambulatory monitoring** initiatives
- As current clinical assessments rely on subjective measures, objective estimates of **RFF could reduce clinician interpretation discrepancies**

Clinical Implications

- More large-scale treatment studies needed
- Automated RFF extraction needed in widely available software for clinical implementation
- Studies needed to determine viability of algorithmic extraction methods for running speech



CONCLUSIONS

Rapid advances in algorithmic RFF extraction is making it a more viable clinical option. More work is needed to understand within-subject clinical tracking for patient applications.

REFERENCES & ACKNOWLEDGEMENTS

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[2] Lien, Y., Michener, C., Eadie, T., & Stepp, C. (2015). Individual monitoring of vocal effort with relative fundamental frequency: Relationships with aerodynamics and listener perception. *Journal of Speech, Language, and Hearing Research*, *58*, 566-575.

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Voice & Swallow Mechanics Lab