Relating ambulatory voice measures with self-ratings of vocal fatigue in individuals with phonotraumatic vocal hyperfunction

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**Motivation**
Advancements in mobile and wearable technologies continue to enhance ambulatory voice monitoring for the improved assessment and treatment of behavioral-based voice disorders. Phonotraumatic vocal hyperfunction is one common behavior-based voice disorder associated with faulty patterns of chronic vocal behavior that result in vocal fold tissue trauma, such as nodules or polyps. As a result, individuals often exhibit dysphonia and elevated levels of vocal fatigue.

**Study Design**
This study investigated the relationships between self-ratings of vocal fatigue and ambulatory voice measures in adult patients with vocal fold nodules or polyps. Using a smartphone-based ambulatory voice monitor, self-ratings were provided on a visual analog scale at five-hour intervals during the day, and data were continuously recorded from a subglottal neck-surface accelerometer.

Three vocal status prompts on visual analog scales from 0–100: Difficulty producing soft, high-pitched phonation (D-SHP); Discomfort; and Fatigue:

<table>
<thead>
<tr>
<th>D-SHP</th>
<th>Discomfort</th>
<th>Fatigue</th>
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<tbody>
<tr>
<td>≤15</td>
<td>≤70</td>
<td>≤70</td>
</tr>
<tr>
<td>&gt;15</td>
<td>≤80</td>
<td>≤80</td>
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</tbody>
</table>

Voice dosimetry metrics and summary statistics of ambulatory voice measures were computed from voiced phrases preceding the self-rating prompts, often including the standardized Rainbow Passage:

- Phonation time (% of voiced frames)
- Cycle dose (cycles)
- Distance dose (m)
- Low-to-high spectral ratio (dB)
- Fundamental frequency (%) of first non-zero spectral peak
- Cepstral peak prominence (dB SPL)
- Sound pressure level (dB SPL)
- Harmonic spectral tilt (dB/oct)
- Subharmonic peak prominence (0–1)
- Autocorrelation peak prominence (0–1)

**Results: Example Daily Voice Use Profile**

**Results: Significant Changes in Self-Ratings of Vocal Fatigue**
Given the variance inherent in perceptual judgments, the analysis focused on comparisons between time periods that exhibited clinically significant differences in self-ratings (>19.7 points on a 100-point scale), approximately one standard deviation in patients:

<table>
<thead>
<tr>
<th>Vocal status question</th>
<th>Patients with nodules or polyps</th>
<th>Matched-control subjects with typical voices</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-SHP</td>
<td>43.2 (20.6)</td>
<td>5.8 (7.5)</td>
</tr>
<tr>
<td>Discomfort</td>
<td>36.9 (20.0)</td>
<td>5.0 (6.6)</td>
</tr>
<tr>
<td>Fatigue</td>
<td>42.5 (20.3)</td>
<td>6.4 (8.1)</td>
</tr>
</tbody>
</table>

**Conclusion**
An initial look at relationships among self-ratings of vocal fatigue and objective, ambulatory voice measures was undertaken. Further study is needed to investigate subject-specific relationships and treatment-related effects due to laryngeal surgery and/or voice therapy. Ambulatory measures of glottal airflow are hypothesized to yield clinically salient measures of the voice source that relate strongly to self-ratings of vocal status.

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