Utility of Spirometry as a Measurement Tool to Evaluate Breathing and Swallowing Coordination (BSC)

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Utility of Spirometry as a Measurement Tool to Evaluate Breathing and Swallowing Coordination (BSC)

Aamna Malik, Jessica Thurman, Dr. Deanna Britton
Additional collaborators: Andrew Palmer, Donna Graville
Introduction

Current methods include:

<table>
<thead>
<tr>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal Thermistry</td>
</tr>
<tr>
<td>Respiratory Inductance Plethysmography</td>
</tr>
<tr>
<td>Electromyography (EMG) of diaphragm and abdominal muscles</td>
</tr>
</tbody>
</table>

Limitations: These methods do not capture the volume of inspired and expired air. They are limited to detection of the presence and direction of airflow.
What is spirometry?

- A measurement tool that allows researchers to track flow and volume of air inspired and expired. It can be used to measure the respiratory phase pattern and swallow apnea duration.

Figure 1: Measures of Breathing Swallowing Coordination (BSC):
Swallow apnea duration and respiratory phase pattern

- Swallow apnea duration (SAD)- circled
- Respiratory phase pattern – squared
  (Associated volume/flow will be reported as well.)
- Swallow Duration:
  (bordered by vertical bars)
Is it feasible to measure BSC via spirometry?
Method

- Recruitment of healthy adults
  - SPHR Undergraduate and Post-Bacc Students
  - Faculty and community members

- Exclusion criteria:
  - Neurological condition
  - Difficulty with breathing and or swallowing
Method

Nasal mask (Phillips Wisk) set-up on participant.
Method

The nasal mask was then connected to pneumotachograph (Hans Rudolph 3813) and spirometer/Powerlab (ADInstruments, Inc.)

Participants were instructed to keep their lips sealed unless they were taking bites and sips of food.
## Method

<table>
<thead>
<tr>
<th>DRINK</th>
<th>FOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Three 10-ml sips of water via medicine cups</td>
<td>1. Three teaspoons of applesauce</td>
</tr>
<tr>
<td>2. One 30-ml sequential sip</td>
<td>2. One bite of cracker</td>
</tr>
</tbody>
</table>
Method

Sips of liquids were administered in a cup with a straw.
Method

Participants were given apple sauce by the researcher
Method

- LabChart 8 (ADInstruments):
  - Swallow apnea duration (SAD)
  - Respiratory Phase Pattern (RPP)
    - Volume of pre- and post- apnea respirations
    - Average of peak flow (RMS)

- The RPP data was also compared to the same measures derived from inspiratory and expiratory phases of tidal breathing.
Results - Feasibility

Eleven subjects were recruited. One was later excluded from analysis due to possible history of neurological injury.

Measurement of BSC was quick and easily tolerated by participants.
* On average collection of all data took less than 10 minutes.
Results – Single Sips (N=10)

• Average swallow apnea duration (SAD) was 0.91s (SD=0.63)

• RPP:
  o Expiratory/ Expiratory - 83% of swallows
  o Expiratory / Inspiratory – 10% of swallows (one subject)
  o Inspiratory / Expiratory – 7% of swallows (2 subjects – 1 of 3 swallows)
Example of tidal breathing

Inspiration above

Expiration below
# RPP – volume and flow during single sips of water

N = 10

<table>
<thead>
<tr>
<th></th>
<th>Volume (L)*</th>
<th>Flow RMS (L/s)*</th>
<th>Volume - % of Average TV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Swallow apnea RPP</td>
<td>0.16 (0.14)</td>
<td>0.16 (0.06)</td>
<td>0.20 (0.16)</td>
</tr>
<tr>
<td>Post-Swallow apnea RPP</td>
<td>0.32 (0.29)</td>
<td>0.21 (0.10)</td>
<td>0.43 (0.36)</td>
</tr>
</tbody>
</table>

*Mean (SD)

Acronyms: Respiratory phase pattern (RPP); Liters (L); Root mean square (RMS); Liters/second (L/s); Tidal volume (TV)
## Results: Average SAD with Sequential Sips

<table>
<thead>
<tr>
<th>Sequential Sips</th>
<th># SADs</th>
<th>SAD (s) - Mean</th>
<th>SAD (s) - SD</th>
<th>Average SAD per swallow</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=3</td>
<td>1</td>
<td>3.26</td>
<td>0.21</td>
<td>1.09</td>
</tr>
<tr>
<td>N=1</td>
<td>2</td>
<td>1.53</td>
<td>1.19</td>
<td>1.02</td>
</tr>
<tr>
<td>N=6</td>
<td>3</td>
<td>0.65</td>
<td>0.21</td>
<td>0.65</td>
</tr>
</tbody>
</table>
## Results – RPP with Sequential Sips (N=10)

<table>
<thead>
<tr>
<th>RPP</th>
<th># SADs</th>
<th>EX-EX</th>
<th>IN-EX</th>
<th>EX-IN</th>
<th>IN-IN</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=3</td>
<td>1</td>
<td>.66 (2 of 3)</td>
<td>0</td>
<td>.33 (1 of 3)</td>
<td>0</td>
</tr>
<tr>
<td>N=1</td>
<td>2</td>
<td>1 (1 of 1)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>N=6 (of 18 samples)</td>
<td>3</td>
<td>0.72</td>
<td>0.17</td>
<td>0.11</td>
<td>0</td>
</tr>
</tbody>
</table>
## Results – Sequential Sips (N= 10)

### RPP volume and airflow

<table>
<thead>
<tr>
<th></th>
<th>Volume (L)*</th>
<th>Flow RMS (L/s)*</th>
<th>Volume - % of Average TV*</th>
</tr>
</thead>
<tbody>
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<td><strong>Pre-Swallow apnea RPP</strong></td>
<td>0.19 (0.16)</td>
<td>0.16 (0.06)</td>
<td>0.21</td>
</tr>
<tr>
<td><strong>Post-Swallow apnea RPP</strong></td>
<td>0.31 (0.28)</td>
<td>0.23 (0.11)</td>
<td>0.35</td>
</tr>
</tbody>
</table>

*Mean (SD)*

Acronyms: Respiratory phase pattern (RPP); Liters (L); Root mean square (RMS); Liters/second (L/s); Tidal volume (TV)
Preliminary differences with sequential sips

- Variability in swallows
  - Number of SADs (duration varied with the number)
  - RPP – More instances of inspiration before and after

- However, the volume and flow during RPPs were similar to single sips.
Variations in sequential sips

One long swallow apnea

Three separate sips
Breath holding & disruptions in tidal breathing

Breath hold before swallowing a sip of water

A “sniff” during tidal breathing followed by a saliva swallow
Informal Observation: “Schluckathmung”/ʃʊk.at.mɛn/ 

- An “inspiratory effort” at the beginning or end of the swallow
Discussion

Possible significance of findings:
- Evaluation of BSC via spirometry is feasible and yields additional airflow measures which may further aid assessment of BSC in individuals with neuromuscular and respiratory impairments.

Future directions:
Spirometry may potentially be useful as a form of biofeedback for BSC.
Limits and future studies

- Small pilot study.
  - Larger sample size needed

- Measuring disordered swallows

- Test run with a bite of food/liquid to ensure participant understands instructions

- Future study with ALS patients
  - Spirometry with simultaneous Videofluoroscopic Swallow Study (VFSS)
Questions?