Measuring tongue strength with the Iowa Oral Performance Instrument (IOPI): Normal Values

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IOPI measures maximum pressure in an air-filled bulb that is pressed with the tongue “as hard as you can.” This pressure is interpreted as a measure of tongue strength.
Clinical uses of the IOPI:

Deciding whether a patient’s tongue is weak.

If yes, start tongue exercise therapy.

if no, try a more useful therapy.

Documenting the basis of your decision.

Convincing the patient that exercises will be helpful.

Convincing the administration and third-party payer.

Assessing and demonstrating the effect of tongue exercise therapy.
Steps to measure tongue strength:
1. Attach connecting tube to the IOPI.
2. Open tongue bulb package and attach connecting tube to tongue bulb.
3. Turn on the IOPI.
4. Press “Peak” button, then “Reset peak” (if the display is not “0”).
5. Help the patient position the tongue bulb (see next slide).
6. Instruct the patient to press the tongue bulb against the roof of the mouth “as hard as you can.”

7. For safety, hold on to the tongue bulb tube when it is in the patient’s mouth.
Standard procedure:

Three trials separated by 10-15 second of rest.

The maximum pressure of these three trials is recorded as the tongue strength for this patient.
Tongue endurance measurement:

Time how long a patient can maintain a pressure of 50% of their maximum pressure (tongue strength) when instructed to keep the green (top) light on. Pressure to turn on the green light is set to 50% of maximum.
Lip strength measurement:

Place the IOPI tongue bulb under the cheek at the corner of the mouth and ask the patient to “grimace” as hard as they can. Use the IOPI to record the maximum pressure.
Alternative method of measuring lip strength
(used by Clark and Solomon: *Dysphagia* eprint DOI 10.1007)

Fig. 1 IOPI tongue bulb positioned between two wooden tongue blades during lip compression assessment
What are Normal Values of tongue strength?

Published studies of tongue strength using the IOPI or IOPI-like devices.
<table>
<thead>
<tr>
<th>Reference #</th>
<th>Tongue strength (kPa)</th>
<th>Tongue endurance (s)</th>
<th>Instrument</th>
<th>Young(#)</th>
<th>Old(#)</th>
<th>Old&lt;Young?</th>
<th>Female&lt;Male?</th>
</tr>
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<tr>
<td>1 Kydd</td>
<td>54</td>
<td></td>
<td>press. cell</td>
<td>30</td>
<td>0</td>
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<td>all male</td>
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<tr>
<td>2 Dworkin</td>
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<td>0</td>
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<tr>
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<td>65</td>
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<td></td>
<td>IOPI</td>
<td>10</td>
<td>14</td>
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<tr>
<td>7 Solomon</td>
<td>69</td>
<td>30</td>
<td>IOPI</td>
<td>13</td>
<td>6</td>
<td>no diff.</td>
<td>yes (small diff.)</td>
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<tr>
<td>8 Theodoros</td>
<td>73</td>
<td></td>
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<tr>
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<td>75</td>
<td>45</td>
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<td>65</td>
<td>34</td>
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<td>yes</td>
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<td>60</td>
<td>38</td>
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<td>11</td>
<td>2</td>
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<td>not reported</td>
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<tr>
<td>11 Nicosia</td>
<td>75</td>
<td></td>
<td>Kay system</td>
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<td>10</td>
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<td>not reported</td>
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<tr>
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<td>38</td>
<td></td>
<td>IOPI</td>
<td>32 (est.)</td>
<td>31(est.)</td>
<td>NA</td>
<td>yes (small diff.)</td>
</tr>
<tr>
<td>13 Lazarus</td>
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<td>20</td>
<td>IOPI</td>
<td>31</td>
<td>0</td>
<td>NA</td>
<td>not reported</td>
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<tr>
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<td>0</td>
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<tr>
<td>16 Neel</td>
<td>50</td>
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<td>IOPI</td>
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<td>0</td>
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<td>15 (est.)</td>
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<td>yes</td>
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<tr>
<td>18 Stierwalt</td>
<td>61</td>
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<td>32</td>
<td>18</td>
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<tr>
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<td>IOPI</td>
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<td>4</td>
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<td>not reported</td>
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<tr>
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<td>60</td>
<td></td>
<td>IOPI</td>
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<td></td>
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<td>yes (small diff.)</td>
</tr>
<tr>
<td>21 Solomon</td>
<td>60</td>
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<td>44</td>
<td>few</td>
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<td>not reported</td>
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<tr>
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<td>45</td>
<td></td>
<td>IOPI-like</td>
<td>652</td>
<td>201</td>
<td>males only</td>
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<tr>
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<td>70</td>
<td></td>
<td>IOPI</td>
<td>64</td>
<td>32</td>
<td>yes</td>
<td>yes (barely)</td>
</tr>
<tr>
<td>24 Clark</td>
<td>60</td>
<td></td>
<td>IOPI</td>
<td>39</td>
<td></td>
<td>not reported</td>
<td>not reported</td>
</tr>
</tbody>
</table>

Note #2: Protrusive force on 12mm diameter load cell (force transducer)
Note #12: All subjects referred for swallowing problems; also, possible methodological difference
Note #15: Subject age range: 70-89
Note #19: All subjects had suffered a CVA (stroke)
Note #21: Estimate from scatter of measures from asymptomatic patients judge "normal"
Note #22: Used tongue bulb larger and softer than IOPI tongue bulb
References for Normal Values

Selected set of 10 published studies that report means and standard deviations of tongue elevation strength in normal adults, or in normal controls used in studies of swallowing or speech abnormalities.
References


<table>
<thead>
<tr>
<th>Group</th>
<th>Age range (years)</th>
<th>Number of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young</td>
<td>20-39</td>
<td>226</td>
</tr>
<tr>
<td>Middle</td>
<td>40-60</td>
<td>159</td>
</tr>
<tr>
<td>Old</td>
<td>&gt;60</td>
<td>155</td>
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</table>
Fig. 2 Tongue and facial strength (maximum pressure in kPa) averaged across group for men and women. Error bars = ±1 SD.
Fig. 3 Tongue and facial strength (maximum pressure in kPa) averaged for the three age groups. Error bars = ±1 SD
A clinician would be correct 95% of the time if they concluded that the following people have abnormally low tongue strength:

- A young person whose maximum tongue pressure is less than 44 kPa.
- A middle-aged person whose maximum tongue pressure is less than 43 kPa.
- An old person whose maximum tongue pressure is less than 37 kPa.
Studies of tongue exercise
Speculation:

1. Most normal-functioning people have a tongue that is pretty “physically fit”.
   - Mastication
   - Swallowing
   - Speaking

2. If that is the case, then lack of mastication and/or swallowing may cause, by disuse atrophy, tongue weakness.
<table>
<thead>
<tr>
<th>Time</th>
<th>Current Mean (Range), kPa</th>
<th>Change from Baseline Mean, kPa</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>41 (36–46)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>44 (39–49)</td>
<td>3</td>
<td>.14</td>
</tr>
<tr>
<td>Week 4</td>
<td>47 (43–51)</td>
<td>6</td>
<td>.002*</td>
</tr>
<tr>
<td>Week 6</td>
<td>49 (45–53)</td>
<td>7</td>
<td>.001*</td>
</tr>
</tbody>
</table>

* Statistically significant.
Table 5: Change in Maximum Isometric Pressures (measured with the IOPI)

<table>
<thead>
<tr>
<th>Location</th>
<th>Baseline Mean Pressure (kPa)</th>
<th>95% Cl</th>
<th>Week 4 Mean Pressure (kPa)</th>
<th>95% Cl</th>
<th>P</th>
<th>Week 8 Mean Pressure (kPa)</th>
<th>95% Cl</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior tongue</td>
<td>35.6</td>
<td>21.9–38.4</td>
<td>45.3</td>
<td>37.1–53.5</td>
<td>&lt;.001*</td>
<td>51.8</td>
<td>43.6–60.0</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Posterior tongue</td>
<td>30.2</td>
<td>26.8–44.5</td>
<td>47.1</td>
<td>38.2–56.0</td>
<td>.01*</td>
<td>54.6</td>
<td>45.7–63.5</td>
<td>&lt;.001*</td>
</tr>
</tbody>
</table>

Abbreviation: Cl, confidence interval.
*Statistically significant.
Robbins et al.: stroke patient/tongue exercise

Fig 3. Change in mean score on the Penetration-Aspiration Scale for the 10mL liquid bolus condition. Legend: ●, mean score for 10mL liquid bolus condition. *Statistically significant.
Summary Conclusions

Tongue exercise can increase strength, but the increase will probably be small unless the patient’s tongue is relatively weak to start with. At least 8 weeks of exercise is necessary to produce optimal effects.
Summary: Exercise help?
Some evidence shows that increases in strength resulting from tongue exercise are associated with improved swallowing. More research to document the efficacy of tongue exercise is needed, however.
HOW does exercise increase strength??
- Increases the strength of muscle cells. Right?
- Eventually, but short-term strength increases because:
  - We can drive our motor neurons better:
  - We’re exercising our NEURONS too!!
Motor Units

CNS

Motor Neurons plus Muscle Units

**Maximum Effort Synaptic Input**
- Many big muscle cells
- High force output
- Fast contracting
- Fatigable
- Anaerobic metabolism

**Moderate Effort Synaptic Input**
- Medium # muscle cells
- Medium/ low force output
- Reasonably fast
- Fatigue resistant
- Mixed anaerobic and aerobic

**Low Effort Synaptic Input**
- Small # muscle cells
- Low force output
- Slow contracting
- Non-fatigable
- Aerobic metabolism
What muscles are exercised during tongue elevation?

- Hooked wire EMG electrodes in intrinsic and submental muscles during tongue elevation task with IOPI.
  - Intrinsic tongue
  - Geniohyoid (GH)
  - Mylohyoid (MH)
  - Medial pterygoid (MP)
  - Anterior belly of digastric (ABD)
Figure 3. Scatter plots for each muscle comparing normalized EMG as a function of percent of maximal pressure. 

- GH 
- Medial Pterygoid 
- MH 
- ABD 
- Velum 
- Intrinsic Tongue
For References:

- www.IOPImedical.com
- Published References (menu)
- erich@IOPImedical.com