Quantifying the Relationship Between Stroke and Labial Strength

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Overview

• Labial Weakness
• Cranial Nerves
• Muscles of the Facial Nerve
• Deglutition and Dysphagia
• Speech Production and Dysarthria
• Purpose of the Study
• Materials and Methods
• Results
• Discussion
• Questions
Labial Weakness

• Common deficit after stroke
• Labial weakness may result in:
  • No deficits
  • Dysarthria
  • Dysarthria and Oral Dysphagia
• *Despite variability in impact, degree of impairment required for a specific deficits is unknown*
Cranial Nerves

- CN V, VII, IX, X, XI, and XII are important for speech production and deglutition
- Nerve fibers may be:
  - Somatic Sensory: convey sensations of pain, temperature, mechanical stimuli in skin, muscles, joints
  - Visceral Sensory: relay info from visceral structures such as digestive tract, walls of blood vessels
  - Special Sensory: maintain hearing and equilibrium
  - Somatic Motor: motor supply for skeletal muscles
  - Visceral Motor: preganglionic autonomic axons
  - Branchial Motor: innervate striated muscles
Facial Nerve

- Mixed motor and sensory nerve
- Of all peripheral nerves, CN VII is the most frequently paralyzed (Wilson-Pauwels et al., 2002)
- Contains branchial motor fibers, visceral motor fibers, general sensory fibers, special sensory fibers
- Special sensory fibers: taste sensation for anterior ⅔ of tongue and hard and soft palates
Facial Nerve

Facial Nerve

• Branchial motor fibers: muscles of facial expression and stapedius muscle
• Visceral motor fibers: stimulate lacrimal, submandibular, and sublingual glands as well as mucous membranes of nose and palate
• General sensory fibers: skin of the concha and a portion of the pinna
Muscles of Facial Expression

- Muscles of facial expression: 5 Branches of CN VII
  - Temporal
    - Frontalis, occipitalis, orbicularis oculi, corrugator supercilli, and procerus muscles
  - Zygomatic
    - Orbicularis oculi muscle
Muscles of Facial Expression

• Buccal
  • Buccinator, orbicularis oris, nasalis, levator labii superioris, levator labii superioris alaeque nasi, zygomaticus major and minor, and the levator anguli oris muscles

• Mandibular
  • Mentalis, depressor anguli oris, depressor labii inferioris, and risorius muscles

• Cervical
  • Platysma muscle
Muscles of Facial Expression

• **Orbicularis Oris:**
  • Closes and compresses lips (Patel, 2011)
  • Works with superior pharyngeal constrictor and buccinator to create positive pressure in oral cavity for oral preparatory stage of swallow (Wijting and Freed, 2007)
  • Maintains labial seal to prevent anterior loss
  • Helps produce /f, v/ phonemes (Peña-Brooks & Hedge, 2000)
  • Creates lip compression to produce phonemes /p, b, m/
  • Rounds the lips to produce /w/
  • Works with levator labii superioris, mentalis, and levator labii superiorus to round and protrude lips
Muscles of Facial Expression

- **Buccinator:**
  - Pulls corner of mouth backward and compresses cheek (Patel, 2011)
  - Helps create an area of positive pressure in the oral cavity (Wijting and Freed, 2007)
  - Aids in producing /f, v/ phonemes

- **Risorious**
  - Aids in smiling (Patel, 2011)
  - Aids in producing /f, v/ phonemes
Facial Nerve in Deglutition

- Chambers and Valves System
- Orbicularis oris and buccinator work with superior pharyngeal constrictor to create positive pressure in oral cavity
- Orbicularis oris prevents anterior loss
Facial Nerve in Articulation

• Articulation:
  • Mobile articulators
  • Immobile articulators

• Lips
  • Orbicularis oris muscle (/p, b, m, w/)
  • Buccinator, orbicularis oris, risorius muscles (/f, v/)
Facial Nerve in Dysphagia & Dysarthria

- Facial nerve deficits may cause:
  - Oral dysphagia characterized by anterior loss
  - Dysarthria characterized by imprecise phoneme production
Stroke

- Stroke: most common source of disability in developed countries
- 3rd most common source of death in U.S.
- 2nd most common cause of death globally
- Complications following stroke
  - Dysarthria
  - Dysphagia
Stroke

• What locations of a stroke may cause labial weakness?
  • Facial nerve nucleus
  • Unilateral or bilateral UMN lesions
  • Pons
  • Cerebellopontine angle (CP angle)
  • Middle cerebral artery
  • Anterior choroidal artery (supplies the globus pallidus, internal capsule, and choroid plexus of basal ganglia)
  • Occlusion of basilar artery causing a pontine stroke
  • Anterior cerebral artery
  • Thalamus

(Hankey, 2002; Savitz, 2007; Poolos, 2001)
Literature Review on Labial Weakness

• Clark et al. (2009): quantified labial strength in healthy adults
  • 30 +/- 10 kPa
• Clark and Solomon (2011): no age effects with regards to labial strength
  • Significant differences in tongue lateralization and protrusion and posterior tongue elevation with regards to age
• Nagy (2011): differences in right vs. left strength of smile
• Purves et al. (2008): use of left face in expressing emotion
Literature Review on Labial Weakness

- Nakatsuka et al. (2011): compared EMG to a novel lip force device
  - Also tested directional lip force
  - Because orbicularis oris is a sphincter muscle, can the right and left sides act independently?
  - 8 directions measured: upper, right-upper, right, right-lower, lower, left-lower, left, and left-upper
  - No significant differences in lip closing force using EMG or novel device for oblique or horizontal directions
  - Significant difference found for vertical direction
Purpose of the Study

1. Quantify labial strength following stroke and determine if it is significantly different from labial strength in healthy controls
2. Correlate labial strength with clinical deficits
3. Determine if a significant difference in labial strength exists in the control group, experimental group with no deficits, experimental group with dysarthria, and the experimental group with dysarthria and dysphagia.
Hypotheses

1. Mean labial strength will be less in the experimental group than in the control group;
2. Increases in labial strength will negatively correlate with regards to a participant having no deficits, dysarthria, or dysphagia, and;
3. Mean labial strength will be the least in the experimental group with dysarthria and dysphagia and will negatively correlate with clinical deficits.
Methods

• Design: comparative
• Subjects
  • Control Group
  • Experimental Group
• Oral-Motor Evaluation
• Diadochokinetic Rates
• Clinical Swallow Evaluation
• Measurement of Labial Strength
Iowa Oral Performance Instrument (IOPI)

- Provides objective measurements of lingual, labial, and hand strength
- Measures pressure in kilopascals (kPa)
  - Range: 0 to 254 kPa
  - 1 mmHg = 0.133 kPa
- Average hand strength
  - 150 kPa for males
  - 140 kPa for females
- Average labial strength
  - 30 kPa +/- 10 (Clark et al., 2009)
Definitions

• Dysarthria: imprecise consonant production during bilabial alternation motion rates (AMR)
• Oral Dysphagia: anterior loss during cup edge drinking
Control Group

• 42 participants
• 12 male; 30 female
• 32 right handed; 10 left handed
• Mean age 43.67 years
• Age range: 24 – 80 years
• Average IOPI score
  • Right: 25.88
  • Left: 25.6
• Average DDK rates: 6.21; 6.24; 6.11; 2.4
Experimental Group

- 31 participants
- 17 male; 14 female
- 30 right handed; 1 left handed
- Mean age 57.06 years
- Age Range: 25 to 82 years
- Average IOPI score
  - Affected: 13.77
  - Unaffected: 20.0
- Average NIH stroke scale score: 6.48
- Average # days till SLP consult: 1.55
- Average DDK rates: 3.87; 4.51; 4.48; 1.8
Stroke Type

- Ischemic: 28
- Hemorrhagic: 3
Stroke Location

- Left MCA: 9
- Right MCA: 5
- Left BG: 8
- Right BG: 4
- Left Thalamic: 1
- Right Thalamic: 1
- Bilateral BG: 1
- R Fronto Temp: 1
- Left ACA: 1
- Right Cerebellum: 1
Data Analysis

• Shapiro-Wilk Test of Normality
• Two Independent Sample T-test
• Correlation Analysis – Spearman’s Rho
• One Way Analysis of Variance (ANOVA)
• Multiple Comparison Tests
Shapiro-Wilk Test of Normality

• Normally Distributed Data Sets
  • IOPI Control Group- right and left sides
  • IOPI Experimental Group – affected and unaffected sides
  • Age of Experimental Group

• Data Sets that were Not Normally Distributed
  • Age of Control Group
  • NIHSS scores
Two-Independent Sample T-test

- Control and Experimental IOPI scores
  - Affected – significantly different
  - Unaffected – significantly different
Correlation Analysis

- **Control Group:** Age and labial strength
  - No significant correlation - right and left side
Correlation Analysis

- Control Group: Gender and Labial Strength
  - No significant correlation
Correlation Analysis

• Control Group: Handedness and Labial Strength
  • No significant correlation
Correlation Analysis

- Experimental Group: NIHSS score and labial strength
  - No significant correlation—affected or unaffected sides
Correlation Analysis

- Experimental Group: NIHSS score and deficits
  - No significant correlation
Correlation Analysis

- **Experimental Group: Labial Strength and Deficits**
  - Significant correlation between participant’s deficits and labial strength
  - \( r = -0.748 \) (affected) and \( r = -0.733 \) (unaffected)
One-way Analysis of Variance

- 4 Groups
  - Control
  - Experimental, no deficits
  - Experimental, dysarthria
  - Experimental, dysarthria and dysphagia

- At least 2 means were significantly different for each side
## Multiple Comparison Tests-Affected Side

<table>
<thead>
<tr>
<th>Participants</th>
<th>Mean</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>25.88 +/- 0.52</td>
<td>a (n = 42)</td>
</tr>
<tr>
<td>Exper., No Deficits</td>
<td>18.31 +/- 1.07</td>
<td>b (n = 13)</td>
</tr>
<tr>
<td>Exper., Dysarthria</td>
<td>12.8 +/- 1.75</td>
<td>c (n = 10)</td>
</tr>
<tr>
<td>Exper. Dys. &amp; Dysphagia</td>
<td>7.63 +/- 1.12</td>
<td>d (n = 8)</td>
</tr>
</tbody>
</table>

Means followed by same letter grouping are not significantly different according to multiple comparison tests.
### Multiple Comparison Tests – Unaffected Side

<table>
<thead>
<tr>
<th>Participants</th>
<th>Mean</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>25.6 +/- 0.61</td>
<td>a (n = 42)</td>
</tr>
<tr>
<td>Exper., No Deficits</td>
<td>24.54 +/- 0.79</td>
<td>a (n = 13)</td>
</tr>
<tr>
<td>Exper., Dysarthria</td>
<td>18.1 +/- 1.74</td>
<td>b (n = 10)</td>
</tr>
<tr>
<td>Exper. Dys. &amp; Dysphagia</td>
<td>14.88 +/- 1.62</td>
<td>b (n = 8)</td>
</tr>
</tbody>
</table>

Means followed by same letter grouping are not significantly different according to Mann Whitney U tests.
Multiple Comparison Tests

• Control Group and Experimental Group, no deficits
  • Significant difference between the two groups on the affected side
  • No significant difference between the two groups on the unaffected side
Multiple Comparison Tests

- Experimental Group, no deficits & Experimental Group, dysarthria
- Significant difference between the two groups for each side

![Graph showing labial strength comparison between no deficits and dysarthria across affected and unaffected conditions.](image)
Multiple Comparison Tests

• Experimental Group, dysarthria & Experimental Group, dysarthria & dysphagia:
  • Significant difference for affected side
  • No significant difference for unaffected side
Discussion

- Control
- Exper. No Deficits
- Exper., Dysarthria
- Exper., Dysar. & Dysph.
Discussion

• Use of the IOPI as part of a screening tool for patients following a stroke
  • Significant correlation between labial strength and deficits

• Ranges
  • Over 18 kPa- no further evaluation of labial strength warranted
  • 10-18 kPa- expect dysarthria
  • Under 10 kPa- expect dysarthria & dysphagia

• Increases understanding of normal physiology for speech production and deglutition
Limitations

• Exclusion of participants with higher NIHSS scores secondary to inability to follow commands
• Time from onset of symptoms until patient was admitted to the hospital
• Time from patient being admitted to hospital until SLP consult
• Subjective measures for evaluation of dysarthria
Future Research

• Quantifying labial strength in other populations – myasthenia gravis, traumatic brain injury
• Use of the IOPI and the ranges from current study as goals for therapy
Questions?

• Thanks!

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References

References


