Respiratory Muscle Strength Training (RMST): Practical Strategies for Immediate Clinical Translation

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Disclosures

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• Salaried employee of Weill Cornell Medical College and Weill Cornell Medicine/NewYork-Presbyterian
• No other relevant financial or non-financial disclosures or conflicts of interest
• I have no financial relationships or conflicts of interested associated with any of the devices or pieces of equipment shared in this presentation

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Avery Dakin:

• No relevant financial or non-financial disclosures or conflicts of interest
1. 1. Background
2. 2. Assessment
3. 3. Practical Strategies
4. 4. Case Study
5. 5. Question & Answer Session
Multiple Systems Impact Airway Protection

Anatomic Images
Adapted from Hixon et al. 2018
Airway Protection: Continuum of Behaviors

Swallowing
Glottal Stop / LAR
Expiratory Reflex
Expiratory Effort
Throat Clear
Cough

Prevention  Ejection
Shared Neural Substrates: Swallow, Cough & Breathing
Mechanisms of Disruption: Swallow, Cough & Breathing
Individuals with Dysphagia Present with Both Swallow & Cough Impairments

- **Swallowing**
- Glottal Stop / LAR
- Expiratory Reflex
- Expiratory Effort
- Throat Clear
- **Cough**

**Prevention**

**Ejection**
Importance of Physiologic Reserves

Graph showing the impact of typical aging and disease states on physiologic reserves over time, with a section marked "Dysphagia & Dystussia."
How do we increase functional physiologic reserves to maintain breathing, swallowing and cough?
Patient *expires* forcefully into a one-way spring loaded & calibrated trainer.

Patient *inspires* rapidly into a one-way spring loaded & calibrated trainer.

**Intervention: Respiratory Muscle Strength Training**

**EMST**

**IMST**
Intervention: Respiratory Muscle Strength Training

Resistance training against set pressure threshold to **overload** expiratory and inspiratory muscles.

Intensity, uses **increased resistance over time** and principles of sports medicine to promote adaptation in muscle strength (% relative to maximum).

Adequate **repetition**, typically 5 / 5 / 5 rule.

Sufficient **duration** or total time spent exercising.

Sufficient **frequency** of exercise.

Adequate breaks, **time between repetitions**.
Intervention: Respiratory Muscle Strength Training

**EMST**
- Internal intercostals
- External & internal abdominal oblique
- Transversus abdominis
- Rectus abdominis

**IMST**
- External intercostals
- Parasternal intercostals
- Diaphragm
- Scalenes
- Sternocleidomastoid
Airway Protection: Continuum of Behaviors

**Prevention**
- Velopharyngeal port closure
- Submental activation
- Hyoid elevation
- UES opening
- Laryngeal framework lift
- Aytenoid-epiglottic approximation
- Pharyngeal shortening

**Ejection**
- Increased sub-glottic air pressure generation
- Increased Peak Cough Flow
- Increased Cough Volume Acceleration
- Decreased Compression Phase Duration

Hutchinson, 2017; Wheeler, 2007 & 2008; Tabor, 2017; Plowman, 2016; Pitts, 2008 & 2010

Baker, 2005; Chiari, 2006; Sapienza, 2002; Weiner, 2003; Pitts, 2010; Troche 2010
Mechanisms Underpinning RST in Healthy Adults

Wheeler et al. 2007; Kendall 2014; Plowman et. al. 2021
Mechanisms Underpinning RST in Healthy Adults

Normal Swallow

Mendelsohn Maneuver

EMST Task (75% of MEP)

Effortful Swallow

Amplitude (0 – 200mV)

Time (9 sec. windows)
Mechanisms Underpinning RST in Healthy Adults

Hutcheson et al. 2017
Mechanisms Underpinning RST in Healthy Adults

Hutcheson et al. 2017
Mechanisms Underpinning RST in Healthy Adults

Hutcheson et al. 2017
<table>
<thead>
<tr>
<th>Reference</th>
<th>Patient Population</th>
<th>Resp load (% MIP/MEP)</th>
<th>Repetitions (# / time session)</th>
<th>Frequency (days / week)</th>
<th>Duration (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weiner et al., 2003; 2006</td>
<td>COPD</td>
<td></td>
<td></td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Chiara et al., 2006</td>
<td>Multiple Sclerosis</td>
<td></td>
<td></td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Pitts et al., 2009</td>
<td>Parkinson’s Disease</td>
<td></td>
<td></td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Troche et al., 2009; 2014; 2022</td>
<td>Highinspiration tolerated</td>
<td></td>
<td></td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Martin et al., 2011</td>
<td>Ventilator Dependence</td>
<td></td>
<td></td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Reyes et al., 2015</td>
<td>Huntington’s Disease</td>
<td></td>
<td></td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Plowman et al., 2019; 2023</td>
<td>ALS</td>
<td></td>
<td></td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Hegland et al., 2016</td>
<td>Stroke</td>
<td></td>
<td></td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Hutcheson et al., 2018</td>
<td>Head and Neck Cancer</td>
<td></td>
<td></td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Donohue et al. 2023</td>
<td>Cardiac Surgery</td>
<td></td>
<td></td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>
Assessing Respiratory Muscle Strength
Why assess respiratory muscle strength?
To develop an educated hypothesis on if respiratory muscle strength is reduced and contributing to cough and swallowing impairments.
Why assess respiratory muscle strength?

To develop an educated hypothesis on if respiratory muscle strength is reduced and contributing to cough and swallowing impairments.

To develop rationale for recommending RMST.
Why assess respiratory muscle strength?

To develop an educated hypothesis on if respiratory muscle strength is reduced and contributing to cough and swallowing impairments.

To develop rationale for recommending RMST.

To personalize the delivery of an RMST protocol.
How do I assess respiratory muscle strength?
American Thoracic Society/European Respiratory Society

ATS/ERS Statement on Respiratory Muscle Testing

This Joint Statement of the American Thoracic Society (ATS), and the European Respiratory Society (ERS) was adopted by the ATS Board of Directors, March 2001 and by the ERS Executive Committee, June 2001
In clinical practice, respiratory muscle strength (RMS) is primarily assessed by measuring:

- Maximal expiratory pressure (MEP; $P_{E_{\text{max}}}$)
- Maximal inspiratory pressure (MIP; $P_{I_{\text{max}}}$)
In clinical practice, respiratory muscle strength (RMS) is primarily assessed by measuring:

- Maximal expiratory pressure (MEP; $P_{E_{\text{max}}}$)
- Maximal inspiratory pressure (MIP; $P_{I_{\text{max}}}$)

MEP involves inhaling to the top of vital capacity, then exhaling with maximal effort for at least 1.5 seconds.
In clinical practice, respiratory muscle strength (RMS) is primarily assessed by measuring:

- Maximal expiratory pressure (MEP; $P_{E_{\text{max}}}$)
- Maximal inspiratory pressure (MIP; $P_{I_{\text{max}}}$)

MEP involves inhaling to the top of vital capacity, then exhaling with maximal effort for at least 1.5 seconds.

MIP involves exhaling to the bottom of vital capacity, then inhaling with maximal effort for at least 1.5 seconds.
RMS Testing Instructions

Prevent air leakage around the lips and through the nose (use nose clips for the nose, and have an extra pair of hands to squeeze the lips around the mouthpiece)
Prevent air leakage around the lips and through the nose (use nose clips for the nose, and have an extra pair of hands to squeeze the lips around the mouthpiece)

The maximum of 3 trials that vary by ≤ 20% is then recorded
Equipment for RMS Testing
Manometer, capable of measuring positive & negative pressures
Equipment for RMS Testing

Manometer, capable of measuring positive & negative pressures

± Disposable respiratory bacterial filter
Equipment for RMS Testing

MicroRPM

Low-cost generic manometer

Pressure Threshold Devices (e.g., EMST150)
MicroRPM Respiratory Pressure Manometer (MD Spiro)
‘Industry Standard’
MicroRPM Respiratory Pressure Manometer (MD Spiro) ‘Industry Standard’

$1500 MicroRPM

$4.30 per Flanged Expiratory Filter

$4.30 per Flanged Inspiratory Filter

$1.82 per filter

(A-M Systems; 15 x 22 mm)
Low-Cost Generic Manometer

Leaton Digital Manometer (LDM) 
‘Low-Cost Alternative’
Low-Cost Generic Manometer

Leaton Digital Manometer (LDM)  
‘Low-Cost Alternative’

$40.00 LDM

$1.82 per filter  
(A-M Systems; 15 x 22 mm)

$0.41 per adaptor  
(Qosina; 6 x 22 mm)

$2.13 per foot, silicone tubing  
(Quickrun; 6 mm ID)
Pressure Threshold Training Products
Pressure Threshold Training Products

RMS training can be facilitated using two types of devices
Pressure Threshold Training Products

RMS training can be facilitated using two types of devices.

Continuous flow devices – greater pressure is required to blow through open tubes with smaller diameters, assuming flow and volume of air are held constant.
RMS training can be facilitated using two types of devices:

- **Continuous flow devices** – greater pressure is required to blow through open tubes with smaller diameters, assuming flow and volume of air are held constant.

- **Pressure threshold devices** – one-way valve that only opens once an (adjustable) specified pressure level is achieved. Can be used to estimate MEP and MIP.
Pressure Threshold Training Products

EMST150, EMST75 Lite, IA150 Inspiratory Adapter
‘Industry Standard’ for RMST (not necessarily RMS testing)
Pressure Threshold Training Products

EMST150, EMST75 Lite, IA150 Inspiratory Adapter

‘Industry Standard’ for RMST (not necessarily RMS testing)

$54.99 EMST150

$54.99 EMST75 Lite

$29.99 IA 150 Inspiratory Adaptor

$1.82 per filter

(A-M Systems; 15 x 22 mm)
Calculating MEP/MIP From the EMST Devices
Calculating MEP/MIP From the EMST Devices

<table>
<thead>
<tr>
<th>EMST 150 Pressure</th>
<th>Whole Turn</th>
<th>Quarter Turn</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>0</td>
<td>0 (* Home base)</td>
</tr>
<tr>
<td>37.5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>45</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>52.5</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>1</td>
<td>0 (* Home base)</td>
</tr>
<tr>
<td>63.75</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>67.5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>71.25</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>75</td>
<td>2</td>
<td>0 (* Home base)</td>
</tr>
<tr>
<td>78.75</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>82.5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>86.25</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>90</td>
<td>3</td>
<td>0 (* Home base)</td>
</tr>
<tr>
<td>93.75</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>97.5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>101.25</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>105</td>
<td>4</td>
<td>0 (* Home base)</td>
</tr>
<tr>
<td>108.75</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>112.5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>116.25</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>120</td>
<td>5</td>
<td>0 (* Home base)</td>
</tr>
<tr>
<td>127.5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>135</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>142.5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>150</td>
<td>6</td>
<td>0 (* Home base)</td>
</tr>
</tbody>
</table>
RMS testing requires an element of coordination – so even though 'strength assessment' skill is still involved and can impact the strength measures!
RMS testing requires an element of coordination – so even though 'strength assessment' skill is still involved and can impact the strength measures!

Consider asking the examinee to rate their Rating of Perceived Exertion (RPE) to better identify if maximal effort was accurately achieved!

(learn more about RPE in the next section)
Comparing to normative data assists in estimating if the person has MEPs and MIPs that are lower than expected.

### Table 2
Maximal Respiratory Pressures in Females and Males by Age Groups.

<table>
<thead>
<tr>
<th>Sex/Age Groups, Years</th>
<th>n</th>
<th>Pmax, cmH(_2)O</th>
<th>PEmax, cmH(_2)O</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Females</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–29</td>
<td>314</td>
<td>98.74 (24.1)</td>
<td>141.7 (30.9)</td>
</tr>
<tr>
<td>30–39</td>
<td>58</td>
<td>103.9 (23.3)</td>
<td>139.5 (29.3)</td>
</tr>
<tr>
<td>40–49</td>
<td>50</td>
<td>106.9 (20.1)</td>
<td>152.1 (30.3)</td>
</tr>
<tr>
<td>50–59</td>
<td>57</td>
<td>102.4 (26.1)</td>
<td>142.7 (28.2)</td>
</tr>
<tr>
<td>60–69</td>
<td>52</td>
<td>101.3 (18)</td>
<td>150.3 (27.3)</td>
</tr>
<tr>
<td>70–80</td>
<td>55</td>
<td>90.6 (27.8)</td>
<td>136.3 (34.5)</td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>84.4 (19.8)</td>
<td>127.4 (31)</td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–29</td>
<td>296</td>
<td>126.7 (27.8)</td>
<td>194.6 (45.6)</td>
</tr>
<tr>
<td>30–39</td>
<td>52</td>
<td>136.2 (25.1)</td>
<td>184 (39.5)</td>
</tr>
<tr>
<td>40–49</td>
<td>54</td>
<td>129.9 (32.2)</td>
<td>200.7 (48.9)</td>
</tr>
<tr>
<td>50–59</td>
<td>55</td>
<td>133.3 (21.8)</td>
<td>202.8 (40.9)</td>
</tr>
<tr>
<td>60–69</td>
<td>48</td>
<td>130.9 (28.1)</td>
<td>205.3 (53)</td>
</tr>
<tr>
<td>70–80</td>
<td>48</td>
<td>122 (20.8)</td>
<td>199.2 (37.2)</td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>100.6 (22.6)</td>
<td>170 (45.5)</td>
</tr>
</tbody>
</table>

Data are reported as mean (standard deviation) unless otherwise stated. cmH\(_2\)O: centimetres of water; PEmax: maximal expiratory pressure; PImax: maximal inspiratory pressure.
Compare to Normative Data

Comparing to normative data assists in estimating if the person has MEPs and MIPs that are lower than expected.

If MEP and MIP are reduced, and if you think this reduction in RMS is contributing to cough and/or swallowing decline, then consider the potential role for RMST.
www.jamescurtisphd.me
(Tutorials > Cough > Respiratory Muscle Strength Testing)
Practical EMST Strategies

Exercise principles for rehabilitation
EMST in-person
EMST via telehealth
Exercise principles for rehabilitation
Resources for exercise/rehabilitation prescription:

Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise

Garber, 2011; ACSM 2021
## Resources for exercise/rehabilitation prescription:

<table>
<thead>
<tr>
<th>Resistance exercise</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>Each major muscle group should be trained on 2–3 d wk$^{-1}$.</td>
</tr>
<tr>
<td><strong>Intensity</strong></td>
<td>60%–70% of the 1RM (moderate to hard intensity) for novice to intermediate exercisers to improve strength.</td>
</tr>
<tr>
<td></td>
<td>≥80% of the 1RM (hard to very hard intensity) for experienced strength trainers to improve strength.</td>
</tr>
<tr>
<td></td>
<td>40%–50% of the 1RM (very light to light intensity) for older persons beginning exercise to improve strength.</td>
</tr>
<tr>
<td></td>
<td>40%–50% of the 1RM (very light to light intensity) may be beneficial for improving strength in sedentary persons beginning a resistance training program.</td>
</tr>
<tr>
<td></td>
<td>&lt;50% of the 1RM (light to moderate intensity) to improve muscular endurance.</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>No specific duration of training has been identified for effectiveness.</td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Resistance exercises involving each major muscle group are recommended.</td>
</tr>
<tr>
<td></td>
<td>A variety of exercise equipment and/or body weight can be used to perform these exercises.</td>
</tr>
<tr>
<td><strong>Repetitions</strong></td>
<td>8–12 repetitions is recommended to improve strength and power in most adults.</td>
</tr>
<tr>
<td></td>
<td>10–15 repetitions is effective in improving strength in middle aged and older persons starting exercise.</td>
</tr>
<tr>
<td></td>
<td>15–20 repetitions are recommended to improve muscular endurance.</td>
</tr>
<tr>
<td><strong>Sets</strong></td>
<td>Two to four sets are the recommended for most adults to improve strength and power.</td>
</tr>
<tr>
<td></td>
<td>A single set of resistance exercise can be effective especially among older and novice exercisers.</td>
</tr>
<tr>
<td></td>
<td>≤2 sets are effective in improving muscular endurance.</td>
</tr>
<tr>
<td><strong>Pattern</strong></td>
<td>Rest intervals of 2–3 min between each set of repetitions are effective.</td>
</tr>
<tr>
<td></td>
<td>A rest of ≥48 h between sessions for any single muscle group is recommended.</td>
</tr>
<tr>
<td><strong>Progression</strong></td>
<td>A gradual progression of greater resistance, and/or more repetitions per set, and/or increasing frequency is recommended.</td>
</tr>
</tbody>
</table>

*1RM = 1 repetition maximum = MEP

Garber, 2011
Additional Considerations...

● **Weeks 1-8** → NEURAL adaptation to training
  ● Improvements in coordination
  ● May see rapid strength gains

● **Weeks 8+** → changes in muscle structure and size
  ● May see slower strength gains

● If you aren’t seeing improvements continue EMST for at least 12 weeks

Gabriel, 2006
Application to EMST

- In sedentary patients $\rightarrow$ start with lower resistive load
- In active patients $\rightarrow$ consistency and performance
- In neurodegenerative patients $\rightarrow$ PATHOPHYSIOLOGY!
  - Parkinson’s $\rightarrow$ moderate – high resistive loads*
  - ALS $\rightarrow$ low – moderate resistive loads*

*patient-specific! Consider current health status and previous physical activity
Exercise/rehabilitation prescription:

You can download older versions online (for free)
Rating of perceived exertion/effort (RPE) scale

- Used by coaches, trainers, physical therapists, etc. to measure exercise effort
- Monitor (and adjust) exercise intensity
- Engages your client!
- Data tracking

1Borg, 1982
EMST Prescription - What’s the evidence?

- 5x5x5 at 75% of MEP
- Few studies have focused on how modifying EMST exercise parameters impact outcomes
  - Resistive load, number of repetitions, training frequency, duration, etc.
  - RPE?
How do individuals rate their effort in a high intensity EMST session?

Dakin & Troche, *in preparation*
Effort and Physiologic Response to EMST

- 20 healthy adult participants
  - Performed 10 sets of 10 repetitions (100 repetitions)
  - 75% of MEP
  - Reported their RPE after each repetition
  - Monitored heart rate and oxygen saturation
  - Repetition pacing to avoid lightheadedness/dizziness

- Research questions:
  - Did RPE change in the session?
  - Did physiologic measures change in the session?
Effort and Physiologic Response to EMST

- Results: RPE increased by .04 with each set
  - A tiny change!
  - Median rating remained at a 7

- Heart rate at the end of each set increased by .08
  - Tiny change again!

- Oxygen saturation did not change
Effort and Physiologic Response to EMST

- Results continued...
- 3/20 participants reported cheek soreness 24 hours post-session
- 2 participants did not complete protocol due to lightheadedness/dizziness
Effort and Physiologic Response to EMST

- Clinical implications?
  - The respiratory system is designed to be efficient and is not easily fatigable!

- Caveat:
  - Single visit!
  - Participants were healthy adults—more research is needed in clinical populations
EMST in-person
Practical Strategies for EMST - In Person

● STEP 1. Assess MEP

● Introduce the RPE scale
  ■ Give them high and low anchors

■ We want your BEST PERFORMANCE!

How effortful is the activity?

0  Nothing at all
0.5 Just noticeable
1  Very light
2  Light
3  Moderate
4  Somewhat heavy
5  Heavy
6
7  Very heavy
8
9
10 Very, very heavy
** Maximal

Laboratory for the Study of Upper Airway Dysfunction, Teachers College, Columbia University, 2023
Practical Strategies for EMST - In Person

● STEP 2. Provide your rationale

● Cough strength vs swallowing safety
Practical Strategies for RMST - In Person

● STEP 3. Device overview

● “The EMST device has a one-way pressure valve. You will blow into the device and when you reach the target pressure the valve will open and you will hear a hiss of air flowing through the device. The goal is to produce a strong and crisp hiss.”

● Provide a model if you have an EMST device
Practical Strategies for RMST - In Person

- STEP 4. Familiarization
- At least 3 opportunities at a low setting
- Hand in cheeks***
- Minimize instructions!
  - “Breathe in, device in, blow hard”
Practical Strategies for RMST - In Person

● STEP 5. Set the device to the training target
   ○ e.g., 75% of MEP

● Perform repetitions
   ○ e.g., 25 repetitions
   ○ Modify the protocol as needed/preferred

● Ask for RPE
EMST via Telehealth
Practical Strategies for RMST - Telehealth

Research Article

Rehabilitation of Airway Protection in Individuals With Movement Disorders: A Telehealth Feasibility Study

Jordanna S. Sevitz, James C. Borders, Avery E. Dakin, Brianna R. Kiefer, Roy N. Aicalay, Sheng-Han Kuo, and Michelle S. Troche

Laboratory for the Study of Upper Airway Dysfunction, Department of Biobehavioral Sciences, Teachers College, Columbia University, New York, NY. Department of Speech, Language, and Hearing Sciences, Purdue University, West Lafayette, IN. Department of Neurology, Columbia University Irving Medical Center, New York, NY. Department of Neurology, Tel Aviv Sourasky Medical Center, Israel
Practical Strategies for RMST - Telehealth

- **Aims:** Determine the practical feasibility and preliminary treatment effect of EMST and cough skill training (CST) via telehealth

- **Methods:**
  - 20 participants with movement disorders
  - 4 weeks of EMST and 2 weeks of CST via telehealth
    - 2x per week with a clinician
    - 3x independent practice (+ caregiver as needed)
Practical Strategies for RMST - Telehealth

- Results
  - Practical feasibility
    - 18 min to get pMEP and perform EMST; 18 min for CST
    - Caregivers:
      - Increased device resistance, read peak flow values, helped with data tracking, provided verbal cues/encouragement, adjusted participant posture, helped with lip seal
  - Mean pMEP increased (66 → 87 cmH₂O)
  - Mean PEFR increased (293 → 350 L/min)
Practical Strategies for RMST - Telehealth

- Conclusions: The delivery of EMST and CST is feasible via telehealth and yielded improvements in pMEP and PEFR.

- Caveat: pMEP was lower than what we have seen in similar groups with in-person assessment.
  - In-person baseline and post-assessment is preferred.
Takeaways

- There is no one-size-fits-all approach to rehabilitation
- Adapt your protocol based on therapy modality, your client’s health status, rehabilitation goals, and preferences
- Include RPE in your sessions!
Clinical Case:

68 year-old male with Spinal Onset ALS.

~6 months from time of diagnosis.

8 lb. weight loss over past 3 months.

Referred to clinical SLP for swallow and motor-speech evaluation.
**Eating Assessment Tool-10**

<table>
<thead>
<tr>
<th>EAT-10 Item</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. My swallowing problem has caused me to lose weight.</td>
<td>3</td>
</tr>
<tr>
<td>2. My swallowing problem interferes with my ability to go out for meals.</td>
<td>2</td>
</tr>
<tr>
<td>3. Swallowing liquids takes extra effort.</td>
<td>2</td>
</tr>
<tr>
<td>4. Swallowing solids takes extra effort.</td>
<td>2</td>
</tr>
<tr>
<td>5. Swallowing pills takes extra effort.</td>
<td>2</td>
</tr>
<tr>
<td>6. Swallowing is painful.</td>
<td>0</td>
</tr>
<tr>
<td>7. The pleasure of eating is affected by my swallowing.</td>
<td>2</td>
</tr>
<tr>
<td>8. The pleasure of eating is affected by my swallowing.</td>
<td>1</td>
</tr>
<tr>
<td>9. I cough when I eat.</td>
<td>2</td>
</tr>
<tr>
<td>10. Swallowing is stressful</td>
<td>2</td>
</tr>
</tbody>
</table>

**Total Score:** 18 indicating moderate self-perceived swallowing impairments.
## Motor-Speech Assessment

<table>
<thead>
<tr>
<th>Speech Subsystem:</th>
<th>Metric:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory:</td>
<td>Maximum Phonation Duration: 23 seconds (normal &gt;15 seconds)</td>
</tr>
<tr>
<td></td>
<td>Maximum Loudness: Impaired</td>
</tr>
<tr>
<td></td>
<td>Loudness in Conversation: Reduced</td>
</tr>
<tr>
<td>Laryngeal:</td>
<td>Vocal Quality: Breathy</td>
</tr>
<tr>
<td></td>
<td>Pitch Range: reduced</td>
</tr>
<tr>
<td>Velopharyngeal:</td>
<td>Resonance: Hypernasal</td>
</tr>
<tr>
<td></td>
<td>Nasal Emission: Not observed</td>
</tr>
<tr>
<td>Articulatory:</td>
<td>Precision in Conversation: Imprecise</td>
</tr>
<tr>
<td></td>
<td>Precision in Reading: Imprecise</td>
</tr>
<tr>
<td></td>
<td>During DDK: Increased articulatory breakdown</td>
</tr>
<tr>
<td>Prosody:</td>
<td>Prosody: Restricted</td>
</tr>
<tr>
<td>Intelligibility:</td>
<td>Informal Clinician Rating during Conversation: ~70% with maximal effort</td>
</tr>
</tbody>
</table>

**Bamboo Passage:**

Speaking Rate 82.4 WPM or severely reduced compared to norms (160-180 WPM)
# Pulmonary Function Tests

<table>
<thead>
<tr>
<th>Respiratory Testing:</th>
<th>Obtained Value:</th>
<th>Expected Value:</th>
<th>% Predicted:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forced Vital Capacity</td>
<td>3.84 L</td>
<td>4.86 L</td>
<td>79%</td>
</tr>
<tr>
<td>Maximal Expiratory Pressure</td>
<td>136 cmH(_2)O</td>
<td>111.2 cmH(_2)O</td>
<td>122%</td>
</tr>
<tr>
<td>Maximal Inspiratory Pressure</td>
<td>105 cmH(_2)O</td>
<td>100 cmH(_2)O</td>
<td>105%</td>
</tr>
</tbody>
</table>
Cough Testing

<table>
<thead>
<tr>
<th>Cough Testing:</th>
<th>Obtained Value:</th>
<th>Expected Value:</th>
<th>% Predicted:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Cough Flow Meter</td>
<td>5.23 L/s</td>
<td>5.88 L/s</td>
<td>89%</td>
</tr>
</tbody>
</table>

What if it was 2 L/s?

<3.97 L/s is associated with increased risk for airway invasion in ALS populations.

≥3.23 L/s represents a clinically meaningful cutoff for effective airway clearance.

≥2.70 L/s is recommended threshold to initiate non-invasive ventilation in ALS according to American Academy of Neurology standards.
## Treatment Plan

<table>
<thead>
<tr>
<th>Pre-Treatment Metric:</th>
<th>Obtained Value:</th>
<th>Expected Value:</th>
<th>% Predicted:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximal Expiratory Pressure</td>
<td>136 cmH₂O</td>
<td>111.2 cmH₂O</td>
<td>122%</td>
</tr>
</tbody>
</table>

### 8-week RST program at 50% load.

<table>
<thead>
<tr>
<th>Pre-Treatment Metric:</th>
<th>Obtained Value:</th>
<th>Expected Value:</th>
<th>% Predicted:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximal Expiratory Pressure</td>
<td>176 cmH₂O</td>
<td>111.2 cmH₂O</td>
<td>158%</td>
</tr>
</tbody>
</table>

Plowman et al. 2019; Plowman et al. 2023; Robison et al. 2018
Circling Back!

**Prevention**
- Velopharyngeal port closure
- Submental activation
- Hyoid elevation
- UES opening
- Laryngeal framework lift
- Aytenoid-epiglottic approximation
- Pharyngeal shortening

**Ejection**
- Increased sub-glottic air pressure generation
- Increased Peak Cough Flow
- Increased Cough Volume Acceleration
- Decreased Compression Phase Duration

Hutchinson, 2017; Wheeler, 2007 & 2008; Tabor, 2017; Plowman, 2016; Pitts, 2008 & 2010
Baker, 2005; Chiari, 2006; Sapienza, 2002; Weiner, 2003; Pitts, 2010; Troche 2010
Conclusions

RMST is an evidence-based intervention for swallow and cough dysfunction.

RMST is a viable and affordable treatment option for multiple patient populations with dysphagia and dystussia.

Next Steps? Improve accessibility and uptake of approaches (NIH NINDS R01) to Dr. Michelle Troche. Stay tuned!
Questions?