Respiratory Muscle Strength Training: EMST vs. IMST
What is Respiration?

THE EXCHANGE OF OXYGEN FROM THE ENVIRONMENT FOR CARBON DIOXIDE FROM THE BODY’S CELLS.
Respiratory Tract
Muscles of Inhalation

Muscles of Inspiration

- Sternocleidomastoid muscle
- Scalene muscles
- Pectoralis minor muscle (cut)
- Transversus thoracis muscle
- Serratus anterior muscle
- Diaphragm

External intercostal muscles
Internal intercostal muscles

Fundamentals of Anatomy & Physiology, 10th
Edition, by Frederic H. Martini, Ph.D.
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Muscles of Exhalation

- Internal intercostals
- Abdominal muscles
- Rectus abdominis
- External obliques
- Internal obliques
- Transversus abdominis
Atmospheric Pressure always = 0.
Alveolar Pressure (air within alveoli).
Al. pressure < At. pressure = inhalation.
Al. pressure > At. pressure = exhalation.
Alveolar pressure can be changed by two forces: Passive and Active Respiratory Movement

- **Passive Respiratory Force**
  - Elastic Properties of Respiratory System
  - Expiration may be active or passive

- **Active Respiratory Force**
  - Contraction of respiratory muscles
  - INSPIRATION IS ALWAYS ACTIVE
  - Insp: Diaphragm, external intercostals increase lung volume.
  - Active Exp: any muscle that actively pulls chest wall down that adds to passive recoil—abdominal muscles, internal intercostals.
Respiratory Muscle Weakness in our patients.

- We have two obligations to our dyspneic patients:
  - The importance of their understanding of known disease on upper or lower respiratory function.
  - Make sure causative factors - i.e. heart disease, lung disease - have been ruled out.

- Low muscle tone (i.e. spinal cord injury and neuromuscular degenerative diseases) may result in disability to generate enough muscular force to create subglottic pressure (i.e: active expiratory pressure) to create volume or vary frequency in the voice.
Upper vs. Lower Respiratory Function

- **Upper Respiratory:**
  - VCD/EILO
  - AdSD
  - MTD
  - Static laryngeal conditions (bilateral ad. paralysis, web, arytenoid dislocation)

- **Lower Respiratory:**
  - Asthma, COPD, RAD
  - Must be under the care of Pulmonology, etc.
What’s the goal of RMST?

Goal:
- Increase the force generating capacity of the inspiratory or expiratory muscles.
- Improve the function of respiratory muscles through specific, though not task specific, exercise.
How does this work?

- **Muscle Overload**
- **High frequency, High resistance.**
  - 70-75% of either Maximum Expiratory Pressure (MEP) or Maximum Inspiratory Pressure (MIP)
  - 25 x daily
  - Typically, sustained for 1-2 seconds each trial.
  - Overall, typically less intrathoracic, intracranial pressure than produced during bowel movement.
What changed?

- **NEURAL CHANGES**
  - Peripheral – level of the motor unit
  - Central – level of spinal cord or brainstem (sensory nerves)
  - Cortical – cortical map area (synapses, etc.)

- **MYOGENIC CHANGES**
  - Muscular hypertrophy
  - Fiber type changes
Neural changes occur earlier than muscular changes.

Endurance training results in increased blood flow and angiogenesis with the motor cortex.

Increased muscle activation

Cortical mapping adaptations in sensory nerves, cortical thickness, and angiogenesis.
Myogenic changes

- Increase in oxidative capacity in trained muscles
  - (Oxidative capacity refers to the muscle’s maximal capacity to use oxygen in microliters of O2 per gram per hour.)
- Skeletal muscles (all respiratory muscles) are made of both slow twitch or fast twitch muscle fibers.
  - Slow: slow to contract but very resistant to fatigue. (i.e. posture)
  - Fast: fast to contract with great force, but prone to fatigue (i.e. cough).
  - All muscles have a combination, depending on function.
- RMST stimulates fast twitch resulting in muscular enlargement or “hypertrophy”.
Increases as a result of RMST

- **Expiratory:**
  - Increases in MEP “significantly” within 2 weeks of training.
  - MEP increases of up to 50% or more at 4 weeks of training.

- **Inspiratory:**
  - MIP also increased, similarly to MEP.
  - Also, synergy noted between training inspiratory muscle strength and PCA.
  - Results: very small changes in glottic opening, but BIG changes in the sensation of SOB/obstruction.
Detraining:

Skeletal muscle size will return to pre-training levels within 1 month of exercise cessation.

HOWEVER, respiratory muscle gains remain significantly higher than pre-training levels up to 8 weeks after training cessation.
Candidates for RMST
Research into populations that benefit

<table>
<thead>
<tr>
<th>Healthy Athletes</th>
<th>Professional Voice Users</th>
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<tbody>
<tr>
<td>COPD</td>
<td>Asthma</td>
</tr>
<tr>
<td>Aging</td>
<td>Arthritis</td>
</tr>
<tr>
<td>Cardio Pulmonary Disease</td>
<td>CHF</td>
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<tr>
<td>Diaphragmatic Paralysis</td>
<td>MS</td>
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<tr>
<td>Post polio syndrome</td>
<td>Spinal cord injury</td>
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<tr>
<td>Ventilator dependent</td>
<td>Dysphagia</td>
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<tr>
<td>Presbyphonia</td>
<td>Parkinson’s Disease</td>
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<tr>
<td>Bilateral VF Paralysis</td>
<td>VCD/ELIO</td>
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<tr>
<td>Obesity</td>
<td>Myasthenia Gravis</td>
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<tr>
<td>ALS</td>
<td>Cystic Fibrosis</td>
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<tr>
<td>Duchenne Muscular Dystrophy</td>
<td>Myotonic Dystrophy</td>
</tr>
<tr>
<td>Instrumentalists</td>
<td>Singers</td>
</tr>
</tbody>
</table>
Breathing

RMST has shown

- significant and progressive improvements in MIP and MEP
- reduction in the perception of dyspnea.
Cough

- Weakness in forced inhalatory or forced expiratory muscles reduce ability to build up necessary air pressures and velocity.
- Increased MIP increases lung volume.
- Increased MEP increases high velocity of expiratory flow.
Swallow

- Improved cough to reduce aspirated materials
- Improved pharyngeal swallow
- Increased submental muscle force generation, so therefore, increased hyolaryngeal complex movement (airway protection, UES opening)
Speech

- Increases subglottic pressure
- Increases synergy between diaphragm and PCA
- “THINK LOUD, THINK SHOUT” – Loud voicing stimulates improved articulation, and other muscles controlling speech in some neurogenic populations.
## RMST by diagnostics

<table>
<thead>
<tr>
<th>IMST</th>
<th>EMST</th>
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<tbody>
<tr>
<td>General Exercise</td>
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</tr>
<tr>
<td>COPD</td>
<td>Singers</td>
</tr>
<tr>
<td>Diaphragmatic Paralysis</td>
<td>Navy Divers</td>
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<tr>
<td>Obesity</td>
<td>Young and healthy</td>
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<tr>
<td>Upper Airway Limitation (PVFM/VCD/EILO)</td>
<td>Sedentary Elderly</td>
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<tr>
<td>ALS</td>
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<td>Cardiopulmonary Disease</td>
<td>COPD</td>
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<td>Pompe Syndrome</td>
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<td>Spinal Cord Injury</td>
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<td>Asthma</td>
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</table>
Evaluation

MicroRPM Respiratory Level Meter
Norms: Inspiratory Strength

<table>
<thead>
<tr>
<th>Group</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Men</td>
<td>106 cm H20</td>
</tr>
<tr>
<td>Women</td>
<td>73 cm H20</td>
</tr>
<tr>
<td>Boys</td>
<td>75 cm H20</td>
</tr>
<tr>
<td>Girls</td>
<td>63 cm H20</td>
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</tbody>
</table>

## Norms: Expiratory Strength

<table>
<thead>
<tr>
<th>Gender</th>
<th>Expiratory Strength (cm H20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>148</td>
</tr>
<tr>
<td>Women</td>
<td>93</td>
</tr>
<tr>
<td>Boys</td>
<td>96</td>
</tr>
<tr>
<td>Girls</td>
<td>80</td>
</tr>
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Respiratory Trainers

IMST
Respironics (for deconditioned patients)