Respiratory Muscle Strength Training

Prepared for TAASLP by
Carrie Mills, Ph.D., CCC-SLP
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Announcements

But first, a little about you…

Experience with RMST?

Experience with Voice? Swallowing?

Experience with the principles of exercise?

Principle Resource

Title:
Respiratory Muscle Strength Training

Author:
Christine Sapienza and Bari Hoffman

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Objectives

By participating in this presentation, participants will:

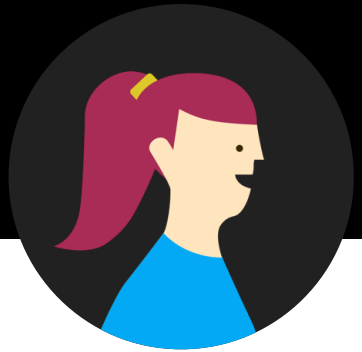
1. Be able to list 3 diagnoses for which RMST may be beneficial.
2. Be able to use current terminology associated with RMST.
3. Be able to apply the principles of exercise physiology to RMST.

Brief Review: Anatomy and Physiology of Respiration

What is respiration?

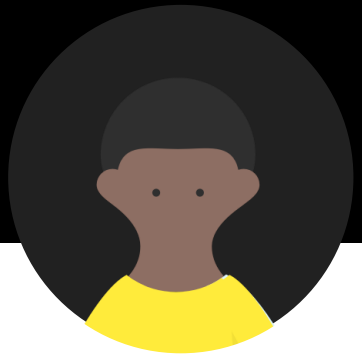
Exchange of oxygen from the environment for carbon dioxide through an inspiratory and an expiratory cycle of respiratory breath

Principle Characters



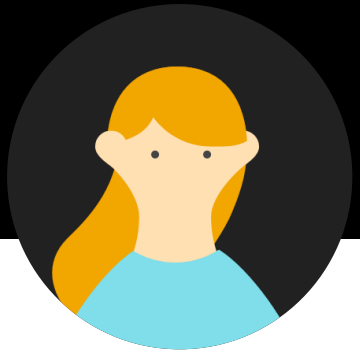
The Lungs

Elastic tissue that inflate and deflate. There are 3 lobes on the right, 2 lobes on the left (smaller on the left due to the heart.



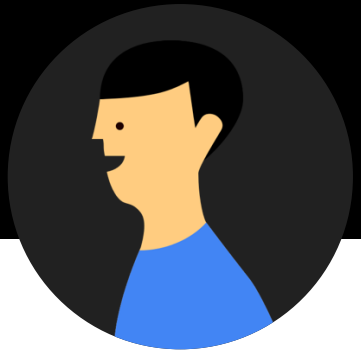
The Trachea

Cartilaginous structure consisting of 16 rings, spanning the top of the neck to the chest cavity.



The Bronchi

There are 2 main branches, connecting each lung. Smaller branches divide further to the secondary bronchi, which lead to the alveoli where gases exchange



The Thorax and Ribs

The chest cavity that surrounds and protects the lungs, inferiorly defined by the diaphragm. There are 12 pairs of ribs: 1-7 are true ribs, 8-10 are false ribs, and 11-12 are floaters

The Diaphragm

Separates the chest from the abdomen

Major muscle of INSPIRATION

Contracts to move downward and flatten, enlarging the chest cavity, moving ribs outward

It’s all about pressure, really

Quiet breathing: diaphragm is active, creates a partial vacuum- air rushes in to expand the lungs. The diaphragm then relaxes and lung space reduces.

If upper spinal cord is damaged, the diaphragm is paralyzed.

Role of the Abdominal Wall

Comprised of central and lateral muscles that arise from the ribs and pelvic girdle

Central player during passive expiration (we will talk about the intercostal muscles too)

During effortful tasks (coughing, sneezing, specific voicing tasks)- these muscles contract to compress the abdominal contents, creating pressure

Also important during defecation and childbirth

Role of the Sternum

Includes 3 processes that attach to respiratory muscles including the diaphragm and the intercostal muscles

First 7 ribs attach to the sternum

Three parts to the sternum:

1. Manubrium: attaches to ribs 1 & 2
2. Body: corpus attaches to ribs 2-7
3. Xiphoid process: smallest of all and attaches to many muscles

Role of the Clavicle

AKA: The collarbone

Extends from the manubrium

Attaches to respiratory muscles including the trapezius, pectoralis major, and the sternocleidomastoid

But what about the pressure?

Must have a driving force to move air!

The force is the difference between the alveolar pressure and the atmospheric pressures

Atmospheric pressure is always set to zero

When alveolar pressure is above atmospheric pressure, it is positive.

When alveolar pressure is below atmospheric pressure, it is negative.

For lungs to inflate must have negative pressure- that causes air to flow into the lungs (i.e., inspiration). For lungs to deflate, must have positive pressure.

How do we create pressure?

Two forces at play:

1. Passive force: elastic properties of the respiratory system
2. Active force: contraction of the respiratory muscles (strength AND coordination)

The act of respiration is always active- muscle contraction must take place to maintain.

How do we create pressure?

Muscles of inspiration: DIAPHRAGM IS MAIN SQUEEZE (innervated by the phrenic nerves). Also the external intercostal muscles (between the ribs). Plus about 17 accessory muscles (not active during quiet inspiration, not targeted during IMST)

Muscles of expiration: internal intercostal muscles and abdominal muscles (targeted during EMST) and 4 secondary muscles

Force of active expiratory cycle is like squeezing a balloon from the outside= recoil

How do we measure these pressures?

Maximum Inspiratory Pressure (MIP or PImax): Healthy adults, values of 60cmH20

Maximal Expiratory Pressure (MEP or PEmax): Healthy adults, values of 80cmH20

Values are higher for males than females, and decline with age.

These measurements are used to detect, diagnose, and treat respiratory weakness. Norms are based on age, sex, and height

Measured with a digital manometer, calibrated in cmH2O

Used to gauge baseline, measure progress or decline

A MEP lower than 30cm H2O can lead to an ineffective cough

Devices: Fluke (www.fluke.com), MicroDirect (mdspiro.com/microrpm)- may be present in your hospital

A brief history of RMST

Therapeutic technique with 70 years of applied programs:

- Populations: voice disorders, chronic lung disease, PD, spinal cord injury, MS

    Also used for patients to improve ventilatory capacity

- Just as exercise can improve muscle contractile activity, prolonged periods of inactivity (mechanical ventilation) can atrophy muscles and decrease contractions necessary for adequate respiration.
- Also used in healthy adults!

Therapeutic Considerations for EMST

Conditions that impact alveolar pressure:

COPD: narrows upper airway, leads to dyspnea (uncomfortable breathing), reduced vocal loudness, hoarseness

Low muscle tone (spinal cord injury)

Neuromuscular degenerative diseases

Multiple sclerosis

Adductor spasmodic dysphonia

Muscle tension dysphonia

Laryngeal webbing, subglottic stenosis, bilateral abductor vocal fold paralysis, arytenoid joint dislocation

Hypofunctional voice disorders: adductor vocal fold paralysis, bowing or scarring, even paradoxical vocal fold dysfunction

Parkinson’s Disease and CVA: Phonation and Swallowing

RMST effective at improving phonation in patients with PD: IMST versus EMST

- Different effects:

  IMST: increases maximum phonation time

  EMST: increases subglottic pressure, which correlates with increased vocal loudness.

EMST also improves cough capacity, reduces aspiration (improved hyoid elevation), improves strength of muscles of the soft palate, buccal musculature, pharyngeal constrictors.

Additional benefits of IMST

Reported as an effective treatment for upper airway obstruction

- Bilateral laryngeal paralysis
- Scarring associated with treatment for laryngeal papilloma
- Exercise induced PVFM

Improves maximal minute ventilation and decreases dyspnea

*Alternative to surgery for upper airway obstruction

Pulmonary Function Testing

Standard pulmonary function testing to determine the origin of dyspnea

Forced Vital capacity (FVC)

Forced Expiratory Volume in 1 second (FEV1)

Maximum voluntary ventilation (MVV)

Maximum inspiratory and expiratory flow loop (can diagnose airway obstruction)

These are completed with a spirometer

Using the correct terminology...uh-oh

Support: use “pressure” instead of breath support re: voicing

Diaphragmatic breathing: do not discuss re: expiratory breathing, instead use “abdominal force”. Diaphragm is an inspiratory muscle.

Clavicular breathing: overused, inaccurate description of “poor breath support”

Force: power exerted over an object.

Strength: amount of force a muscle can produce

Endurance: amount of sustained effort over time

Respiratory Muscle Characteristics

The human body has 3 types of muscle tissue:

1. Cardiac- in the heart
2. Smooth: lines the walls of most internal structures (blood vessels, airways, and viscera)
3. Skeletal: muscles that move the skeleton (diaphragm, intercostals, abdominal muscles)
    a. The skeletal muscles can operate under both voluntary and involuntary conditions
    b. Either fast twitch or slow twitch (depending on how rapidly a fiber uses energy)
        i. Slow oxidative (SO)* endurance
        ii. Fast Oxidative Glycolytic (FOG)* strength
        iii. Fast Glycolytic (FG)* strength

How does this apply to RMST?

RMST is not an endurance exercise program

- Emphasizes max effort for short periods of time
- May stimulate an increase in the size/strength of FG fibers

Hypertrophy: enlargement of tissue from the increase in size of cells

There are differences in the fibers of muscles for corticospinal muscles (limb muscles) versus corticobulbar muscles (muscles associated with speech, swallow, and cough).

- These fibers respond differently to various factors, such as aging

How does muscle training differ for respiratory muscles?

Similar to skeletal muscles, changes to the muscle can be peripheral (motor unit), central (spinal cord, brainstem) or cortical (synapses, cortical map area).

As you exercise, see myogenic changes: Fiber changes, hypertrophy can occur

Neural changes first, then myogenic

For RMST: reports of a 29.6% increase in muscle strength after 2 months, 40.5% after 3 months (Kubo et al, 2010).

EMST: significant increases in MEP in as little as 2 weeks, 50%+ after 4 weeks, 158% after 20 weeks!!!

Yes, but does it last?

Atrophy- typically, skeletal muscles return to pre-training levels approximately 1 month after stopping exercise.

BUT: muscles involved with forced expiration (abdominal and expiratory intercostals) maintain the significant gains achieved compared to pretraining levels as long as 8 weeks post therapy ends

Considerations for Exercise

Load- amount of weight lifted, or load applied. Based on individual's strength, which is reported in 2 different ways:

- expressed as % of max load a person can lift x 1 (1-RM)*
- Max load a person can lift for a given repetition number

*most RMST programs use this method

Considerations for Exercise

Volume: total number of repetitions, calculated as the total number of repetitions of exercise multiplied by the lift load.

Rest Period: amount of time taken between sets of exercise

Velocity: speed of exercise production (for lower loads, can move slower; for higher loads, move faster)

Frequency: The amount of times the exercise is performed

Important considerations when designing your program

Training overload principle: exercise must be heavier than normal loads and become more challenging during the training program to improve strength/endurance

Can be achieved by increasing resistance (referred to as “strength training”) or duration of exercise (referred to as “endurance training”).

Training Progression: to improve strength/endurance, the training load must gradually increase over time

Use calibrated device to mark baseline and progression

Must personally tailor training to meet individual needs- but general principle is to increase load by 10% each week

Important considerations (continued)

Training specificity: the training effect is specific only to the muscles and energy systems engaged in exercise. Know when to target IMST versus EMST, as benefits will be limited to the muscle systems engaged.

Training Reversibility: recovery periods are important, but a lapse of weeks to months between exercise results in detraining (loss of strength and endurance). With regards to respiration, detraining is more impacting for endurance than strength (after 8 weeks, no significant loss of strength, but 12% decrease in endurance)

Types of training programs

Strength versus endurance

Strength: goal is to increase maximal force of the muscle: subject specific muscles to a maximal overload during a brief training session

Example: 1-6 sets of exercise per session, targeting 6-12 contractions of a load that is 30-75% of maximum generating force capacity. Includes a 1-5 minute recovery period

Endurance: goal is to increase muscular endurance: subject specific musculature to repeated contractions at a low load. Target is below 50% of maximum force generating capacity, starts at 10 minutes and increases.

Types of Respiratory Muscle Strength Training Programs

Whole body exercise

Targeted RMST approaches:

- Isocapnic hyperpnea training
- Incentive spirometer devices
- Resistive trainers
- Pressure threshold trainers
- Computer controlled with biofeedback

Types of training devices: EMST versus IMST

Common features: handheld with either

- Spring loaded valve that releases with resistance
- Resistive device alone

Types of training devices: EMST versus IMST

1) Isocapnic hyperpnea: recently available for home use, requires monitoring of mixed gas concentrations, highly dependent on users airflow rate (can impact training effect)
2) Incentive spirometer: to open airways following surgery. Used for IMST (volume or flow) with or without feedback- but no load bearing, influenced by airflow rate, not appropriate for RMST.
3) Resistive Trainers: small holes to breath through, or diminished number of holes as the rate progresses. With or without feedback: impacted by user airflow (Expand-A-Lung Breathing Fitness Exerciser, The Breather- both IMST and EMST, both available on Amazon).

Types of training devices: EMST versus IMST

4) Pressure threshold load (not susceptible to variations in user airflow rate)***

Valve opening pressure dependent on stiffness of spring and compression/shortening of spring against valve.

Allows for: variable loading

Examples of devices:

The Respironics *Threshold® IMT*

PowerBreathe® www.powerbreathe.com

- Recently highlighted on NPR: Daniel Craighead at Univ of Bolder found that by completing 30 breaths per day for six weeks lowers systolic BP by 9mm mercury. Check out the You Tube Video!

EMST150 or EMST75 (Lite): Aspire Products at EMST150.com or Amazon.

The only EMST device on the market, and it has an inspiratory adaptor

Contraindications for RMST

- Not recommended for the following:
  - Recent acute stroke
  - Untreated HTN
  - Untreated GERD/LPR
  - Reactive airway disease (e.g., asthma)
  - Women who are pregnant

- Important to note that intrathoracic pressures (150cmH20 max) are not as high as those pressures generated during a bowel movement or strong cough

Demonstration of the devices

EMST150

The Breather

Respiratory Training for Special Populations

What does the research show?

Improvements in:

Breathing: improvements in MIP and MEP as well as reduced perception of dyspnea

Cough: impacts inspiratory and expiratory musculature necessary for strong cough production

Swallow: increased submental force (HLE improvements)

Speech: weak phonation and disturbances of the respiratory cycle are 2 of 5 major characteristics of speech impairments associated with weakened expiratory/laryngeal musculature

Case Studies

Case #1: Parkinson’s Disease

Patient: 65yo male arrives for speech and swallowing exam. He denies impairment, but his wife reports:

Low volume- must repeat himself to be understood

Prolonged eating times

Coughing during meals

Evaluation reveals: hypokinetic dysarthria with reduced loudness in conversations, adequate with increased cueing. VFSS: penetration to VF with thin liquids with inconsistent cough. Cough function assessment shows reduced peak expiratory flow and increased compression during phase duration. No cognitive impairment noted.

What would you do?

Your ideas?

Recommended Plan of Care for Case #1

EMST- recent study found improved swallowing and cough response with patients with PD following 4 weeks of treatment

25 repetitions, 5 days per week: showed reductions in penetration and aspiration, increased hyoid displacement and increased cough acceleration (cough effectiveness)

Not as great results with speech function- what would you do instead?

Case Studies

Case #2: Progressive Supranuclear Palsy (PSP)

Patient: 70yo male, initially diagnosed with PD, now with PSP. He has difficulty communicating his impairments. Caregiver reports progressively impaired speech and swallowing (meal times are scary). Food becomes stuck as he is swallowing and he cannot cough to expel it.

Evaluation revelas: Severe spastic dysarthria with decreased speech precision and rate, which impacts the natural quality of speech production and intelligibility.

VFSS: moderate sensorimotor oropharyngeal dysphagia with consistent penetration of thin, 1 silent aspiration (sequential cup sips). Vallecular retention with thicker consistencies. Absent cough on command. Cannot blow out a candle, but has an involuntary cough. Can follow general commands.

What would you do?

Your ideas?

Recommended Plan of Care for Case #2

Start first practicing blowing in-out on a no-load device, slowly introduce EMST

Traditional speech and swallowing exercises

Case Studies

Case #3: Chronic Obstructive Pulmonary Disease (COPD)

Patient: 45yo male with % breathlessness all of the time. Minimal benefit from his bronchodilators in improving his dyspnea.

Evaluation shows no speech/swallowing impairment, but harsh vocal quality during conversation and obvious effort during breathing.

What would you do?

Your ideas?

Recommended Plan of Care for Case #3

Inspiratory Muscle Strength Training program

Other Cases Reviewed in the book:

Patients with Bilateral Abductor Vocal Fold Paralysis (IMST) MS (EMST), Sedentary Elderly (EMST), Spinal Cord Injury (IMST), Professional Voice User (EMST)

Chapters highlighting these cases:

Grade 1 Subglottic Stenosis: IMST

Exercise Induced Laryngeal Obstruction: IMST (highlighted at Fall Voice Conference years ago!!!)

Velopharyngeal Insufficiency: EMST

Vocal Fold Paresis: IMST

Dysphagia in Complex Patient- Acute Care Setting (EMST)

Chronic Refractory Cough and Presbyphonia (EMST)

Tracheostomy and Ventilator-Dependent Patients (both)

Head and Neck Cancer (base of tongue): EMST

Review

Would you recommend this technique?

Your thoughts? Questions? Concerns?