TITLE: “LINKED BY PRESSURE: Breathing and Posture”

 SPEAKER: Mary Massery, PT, SPT, DSc

 DATE: Saturday, April 6th, 2019

 CONTACT HRS: Keynote address: 3.0 contact hours. Breakout session: 4.0 contact hours.

 LOCATION: Millennium Maxwell House Hotel
Nashville, TN

 SPONSOR: TPTA Chapter

 COURSE DESCRIPTION:
Generation and modulation and intra-thoracic and intra-abdominal pressures link breathing mechanics to posture. Using her novel research and the “Soda-Pop Can” postural control model, Dr. Massery will push this connection further, demonstrating the link between glottal control, breathing, upright postural stability, spinal alignment, limb force production, gastrointestinal function, circulation, and pelvic health. Amazing connections, and they all relate to the diaphragm! Mary is a pediatric therapist, but she will apply these concepts across the lifespan and across pathologies. Everybody breathes!

 COURSE OBJECTIVES: At the conclusion of the course, participants should be able to:

1. Discuss the model of postural control (Soda Pop Can Model) linking breathing and postural control via 3 horizontal valves: glottis, diaphragm, and pelvic floor.
2. Describe the multiple, simultaneous roles of the diaphragm as related to breathing, talking, postural control, limb force productions, gastroesophageal reflux, constipation and venous return.
3. In lab, identify the variations of “normal” breathing patterns and discuss the efficiencies/inefficiencies for individual patient conditions (differential diagnosis).
4. Evaluate need for, and demonstrate, appropriate neuromotor retraining techniques for patients with ineffective breathing/postural control strategies.
**SPEAKER'S BIOGRAPHY:** Mary Massery, PT, DPT, DSc

Dr. Massery received her BS in Physical Therapy from Northwestern University in 1977, her DPT from the University of the Pacific in 2004 and her DSc from Rocky Mountain University in 2011. Her publications and interests focus on linking motor behaviors to breathing and/or postural mechanics in both pediatric and adult patient populations.

Dr. Massery has been invited to give over 900 professional presentations in all 50 US states and in 16 countries worldwide, including more than 100 presentations for the American Physical Therapy Association. Mary has delivered keynote and major addresses on topics such as cystic fibrosis and posture, pectus excavatum (chest deformities), and connections between posture & breathing.

Mary has received national awards from the APTA, including its highest clinical award, The Florence Kendall Practice Award, honoring “one’s outstanding and enduring contributions to the practice of physical therapy.” She has been honored as Outstanding Alumnus of the Year by each of her 3 universities. She was also awarded Northwestern University’s Alumnae Research Achievement Award. Mary continues to maintain a private practice in Chicago, specializing in breathing and postural dysfunction.

**COURSE SCHEDULE**

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<tr>
<th>TIME</th>
<th>PRESENTATION TYPE</th>
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<tr>
<td>8:00 – 9:30</td>
<td>Keynote Lecture</td>
<td>LINKED BY PRESSURE: Breathing and Posture</td>
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<td>9:30 – 9:45</td>
<td>Break</td>
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<td>9:45 – 11:15</td>
<td>Keynote Lecture</td>
<td>LINKED BY PRESSURE: Breathing and Posture (continued)</td>
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<td>1:30 – 3:30</td>
<td>Lab</td>
<td>I don’t have a clue how to evaluate breathing, well now you will!</td>
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<td>3:30 – 3:45</td>
<td>Break</td>
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<tr>
<td>3:45 – 5:45</td>
<td>Lab</td>
<td>Can you change someone’s breathing pattern? YEP!</td>
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<td>5:45</td>
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</table>
LINKED BY PRESSURE: Breathing and Posture

Mary Massery, PT, DPT, DSc
Owner, Massery Physical Therapy, Glenview, IL, USA

TN-APTA Chapter Spring Meeting
April 6th, 2019
Nashville, TN
8:30 – 11:00 am

Conflict of Interest statement
☐ Mary is paid an honorarium for this presentation
☐ No other conflicts to report

Description
Pressure!

- Successful coordination of postural stability and respiratory mechanics depends on how well the patient with motor impairments:
  - **Generates** trunk pressure
  - **Regulates** trunk pressure
  - **Maintains** trunk pressure
  - **And** successfully manages those pressures in both the thoracic and abdominal cavities.

---

Trunk Pressure / No Pressure

---

Trunk Pressure / No Pressure

---
What Supports the Skeleton?
Pressure!

The “Soda-Pop Can” Model of Postural Support

Kendall 1993, p 11

A Postural Control Model Using a Soda-Pop Can

- Closed System
- Positive pressure from internal can is greater than atmospheric pressure
- Pressure creates functional strength to an otherwise weak external structure

A Postural Control Model Using a Soda-Pop Can

- Vocal folds and glottal structures
- Diaphragm
- Abdominal cavity
- Thoracic cavity
- Pelvic floor
New definition of “Core”

- Core stability extends from the vocal folds on top to the pelvic floor on the bottom and includes every muscle in between!

Normal Pressures: IAP

- Normal intra-abdominal pressures (IAP)
  - Always positive!
  - Higher during inhalation than exhalation
  - Supine at rest: Healthy weight adults: 5 - 7 cm H₂O
  - Upright postures at rest: 16-20 cm H₂O (higher in standing than sitting)
  - IAP requirements increases with higher postural activities or higher respiratory activities: sports, cough, etc.


Normal Pressures: ITP

- Normal intra-thoracic pressures (ITP)
  - Low pressure system compared to abdomen
  - Negative pressure during inhalation
  - Positive pressure during exhalation
  - Quiet breathing: very small changes +/- 3 cm H₂O
  - ITP increases during glottal restriction (i.e. yell, cough) or closure (i.e. breath hold)
Positive Pressure Compromised

External Pressure > Internal Pressure

Potential Results:
Collapsed Skeletal and Internal Organ Alignment and Structure

Jacob Matthew

Mary Massery: mmassery@aol.com
www.MasseryPT.com
Practical Session

- Are YOUR vocal folds really related to postural demand?

STAND UP AND SEE FOR YOURSELF!

Clinical Implications

Take Home Messages:

- Breathing, postural control, and the trunk pressures needed for optimal motor function, cannot be assessed or treated separately!

- All the trunk muscles work together to support postural stability as well as to provide simultaneous support for their primary functions such as respiration, limb force production, balance, and continence.

TOP OF THE CAN
The vocal folds and glottal structures

Vocal Folds & Glottal Structures:
“Gate-Keepers” for Trunk Pressures

Massery Dissertation
DSc RMU doctoral committee: Hodges, Moerchen, Hagins
Research conducted at UQ, supervised by Hodges

- Question: Which glottal conditions, if any, caused greater balance disturbances?
- 12 subjects
- Gentle perturbations similar to being bumped in a crowd (2%-3% body weight)
- 7 glottal conditions

Massery 2013
Take-Aways

- Engaging the glottis was necessary to optimize thoracic stability and upright balance responses.
  - Breath holding may be effective for thoracic stability tasks (force production) such as pushing a heavy door.
- A mandatory open glottis was less stable than any other glottal condition for both thoracic stability and overall balance.
  - Voicing or natural breathing may be a better alternative to breath hold for effective trunk control (balance) such as while carry groceries in both hands to the car.

CLINICAL PROBLEM: Kevin, 13 y/o
10 y/o: Brainstem tumor. 12 y/o: Anoxic L-CVA with profound weakness of right diaphragm

- Without Passy Muir Valve (PMV), Kevin’s knees buckled easily.
- Clinical tip: I made Kevin count (engaging vocal folds for proximal control).
  - Sneaky . . . 😊
- Kevin needed PMV for postural stability.
Tayashiki 2016 & 2018

Investigated: 12 healthy adults
- Is IAP dependent on breathing conditions (lung volumes)?
- Do higher IAPs (proximal pressures) increase hip extension torque (power)?
  - Kevin’s transfers?

Results:
- Greatest hip extension power, and the greatest IAP, was found with the large volume inspiratory effort/breath-hold condition.
- Even normal inspiratory lung volumes showed higher IAP and hip power than the expiratory condition.
- The expiratory condition showed the least hip extension power and the least IAP.

Conclusions:
- Lung volumes positively increase IAP.
- IAP has a positive causal effect on hip extension isometric power in healthy adults.
  - Kevin’s ability to stand was dependent on wearing a PMV (hisp valve) to:
    - Lung volumes to ITP to IAP to LE power!!
- Important extrapolations of Massery’s research!
  - Proximal pressures increase distal force production!
  - Trunk extension movements like sit-to-stand are likely enhanced with inspiration (increased lung volume, greater anti-gravity hip strength) and form the basis of ventilatory strategies (covered later in course).

Glottal Control: More Take-Aways

Treatment trends for patients with neurologic weakness or otherwise poor postural control:
- Tracheostomies: Use PMVs! (Passy Muir Valves)
- Exercise: Add pushing / prone activities to engage glottis and regulation of ITP and IAP
- Postural Control and airway clearance: Use voicing in weight bearing postures, during resistive tasks, and for general airway clearance
Airway Obstruction: Sleep disordered breathing adversely effects brain development

- Halbower 2006, (Mahoney 2012)
  - Previously correlated behavioral / cognitive impairments with OSA (decreased executive function, increased risk of ADHD)
  - Novelty of current research: demonstrated structural changes in the neurodevelopment of the brain for children with chronic untreated OSA
  - f-MRI and functional memory tests: decreased frontal lobe activity (executive function), hippocampus activity, working memory, attention, and verbal memory.
  - Chemical brain changes: decreased NAA/Cho ratios (N-acetyl aspartate to choline) in the left hippocampus and left frontal cortex

- Removing the obstruction (adenoid-tonsillectomy) changed the brain. 6 months later ...
  - Normalized neuronal metabolites in frontal cortex.
  - Hippocampus activity improved
  - Executive function increased in verbal memory and attention
  - Improved chemical changes (NAA/Cho ratio)
  - Early diagnosis and treatment of mod-severe OSA could have profound effects on the trajectory of brain development... WOW!
MIDDLE OF THE CAN
The diaphragm and internal organs

The Diaphragm:
Is it just a respiratory muscle?

Triad of Normal Ventilation
Diaphragm: **Dependent** on the abdominals & intercostals for effective and efficient contractions

*Additional* support from vocal folds and pelvic floor

DeTroyer 2015 & 2016, Massery 2013
The Diaphragm

- Stability from what?
  - Positive pressure
  - Intercostals & abdominals
  - Vocal apparatus & pelvic floor
- Concentric & eccentric movements

The Intercostals and Abdominals

Anterior Trunk
Superficial Layers
Dual Nature: Postural Control & Breathing

- **Hodges 2000**: Diaphragm is simultaneous a respiratory & postural muscle
  - Needle EMG showed increased diaphragm response with increased postural demand (stance)

- **Hodges 2001**: When faced with conflict between physiology (breathing) and physical support, the diaphragm will **ALWAYS** choose breathing over postural control
  - Subjects stopped UE arm swing when respiration was compromised

- **Abundant research has confirmed these findings in the ensuing two decades!**
Dual Nature: Postural Control & Breathing

- Hamaoui 2014
  - 12 subjects
  - Bilateral electric stimulation of the phrenic nerves in sitting and standing resulted in a balance disturbance in both postures.
  - Unilateral stimulation: more significant balance impairment than bilateral.
  - Clinical bottom line:
    - Diaphragm plays an active role in normal balance response in upright.
    - Unique clinical application: unilateral diaphragm weakness/paralysis may cause a greater disturbance to balance than a symmetrical diaphragm impairment.
      - i.e. scoliosis, stroke, other asymmetric conditions

Diaphragm and Internal Organs

- Gastrointestinal (GI) system
  - Diaphragm: an “anti-reflux” muscle

The 3 Great Vessels: Relationship to Diaphragm

- Aorta
- Esophagus & lower esophageal sphincter (LES)
- Inferior vena cava
GI / GERD Research

- GERD can cause or contribute to numerous medical and physical impairments such as:
  - Arching, torticollis, upward eye gaze, toe walking, colic
  - such as Sandifer's Syndrome
  - Ear infections/hearing loss, sinusitis, dental erosion, vocal fold dysfunction
  - Asthma, including nocturnal symptoms, and other lung diseases


CLINICAL IMPLICATIONS

- Eye gaze → reading
- Asymmetry → postural development
- postural control → extension dominant
- UEs → bilateral midline activities, such as reading, writing, puzzles, etc.

Application: Jonathan 7 months old
- Severe GERD & Torticollis
- Nissen Fundoplication

Research
Diaphragm and the GI System

- LES / diaphragm coupling: seminal work
  - LES needs the diaphragm to control GERD
  - Shafik 2004, Pandolfino 2007
Research
Diaphragm and the GI System

- Treatment: LES / diaphragm junction incompetence
  - Nobre e Souza 2013 & Sun 2015: IMT (inspiratory muscle training) and biofeedback improve LES function and decrease GERD symptoms
  - Casale 2016: systematic review
  - IMT may decrease GERD
  - Keles 2018: children with CP improved postural control with 6 wks of IMT
  - WOW!

Diaphragm and Internal Organs

- Vascular system:
  - Diaphragm: an arterial flow enhancing muscle (aorta)
  - Diaphragm: a venous return muscle (inferior vena cava)

The 3 Great Vessels: Relationship to Diaphragm

- Aorta
- Esophagus & lower esophageal sphincter (LES)
- Inferior vena cava
Research: The diaphragm’s relationship with vascular system

- Venous return coupling: diaphragm aids venous return
  - Seminal work: Pinsky 2005
  - Recent confirmations and expanded research:
    - Fasshauer 2014
    - Uva 2015
    - Dagar 2016
    - Kocjan 2017
    - Mora 2018

The Diaphragm: It’s not just a respiratory muscle!

- Multiple simultaneous roles
  - Respiratory muscle
  - Postural control muscle
  - GI muscle
    - Anti-reflux
    - Lower GI motility
  - Venous return muscle

BOTTOM OF THE CAN
The pelvic floor
Pelvic Floor

Beyond continence: chronic constipation

- Arriana 11 y/o
  - Constipation was a major limitation to her functional goal of conversational speech
  - What?!?!

Bed Wetting

Sleep disordered breathing (SDB) & nocturnal enuresis

- Waleed 2011
  - 33/47 children with nocturnal enuresis also had SDB
  - OSA surgery resulted in 88% improving nocturnal enuresis
  - Nearly half (15) were cured completely

- Zaffanello 2017:
  - Systematic Review: SDB is a major contributor to nocturnal enuresis
  - Conclusion: children with nocturnal enuresis should be screened for SDB as the underlying cause
Final Thought

- It is possible and necessary to address the physiology of breathing and postural control simultaneously in ALL therapy programs.
- Our patients are depending on us to help them fly!

THE END

References

References


References

Additional References


Additional References

I. STATIC OBSERVATIONS (DEVELOPMENTALLY APPROPRIATE)

<table>
<thead>
<tr>
<th>SHAPE</th>
<th>ANTERIOR VIEW</th>
<th>LATERAL VIEW</th>
<th>POSTERIOR VIEW</th>
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<td>SIZE</td>
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<td>SPINAL CURVES</td>
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II. ASSESSING BREATHING PATTERNS

A. Normal sequence of a quiet breath (if there was a single normal pattern 😊)

1. **First**: diaphragm contracts inferiorly with an easy onset, reflected with a subtle rise of the upper abdomen.
2. **Second**: diaphragm’s central tendon is stabilized by the increased intra-abdominal pressure, improving the biomechanical coupling between diaphragm and intercostals as reflected by a gentle expansion laterally of the lower chest.
3. **Third**: upper accessory muscles activate to support patency of upper airway and the upper chest as reflected by a gentle rise in the upper chest primarily in a superior-anterior plane

B. Four common primary breathing patterns

1. **Diaphragm pattern – primary expansion seen in abdomen**
   a) The diaphragm is coupled mechanically with abdominal/pelvic floor muscles below and intercostals above for greatest efficiency.
   b) Positive abdominal pressure (IAP) supports the biomechanics of the diaphragm, clinically noted by upper abdominal expansion during inhalation.
   c) A lower abdominal rise is associated with 2 extremes:
      (1) extremely low tone or paralyzed abdominal muscles such as in spinal cord injuries or Down Syndrome,
      (2) or the opposite: highly trained singers, wind or brass instrument musicians, etc. who have learned to maximize the diaphragm’s inferior descent for maximal skilled breath support

2. **Lateral pattern – primary expansion seen in lower chest, lateral plane**
   a) Minimal abdominal excursion is noted.
   b) Intercostals are the strongest component of the diaphragm-abdominal-intercostal coupling, reflected clinically by strong lateral expansion of lower rib cage during inhalation.
   c) Often associated with athletes who have good rib cage mobility such as gymnasts, dancers, yoga instructors, etc.

3. **Upper chest pattern #1 – primary expansion seen in anterior-superior plane**
   a) Minimal lower chest / abdominal excursion.
   b) Primary expansion occurs in upper chest by activation of upper accessory muscles, notably SCM, scalenes, and upper intercostals
   c) Generally, less efficient than diaphragm or lateral breathing pattern.
   d) Often associated with increase work of breathing, such as asthma, airway restrictions, GERD, anxiety, etc.

4. **Upper chest pattern #2 - primary expansion seen in superior plane**
   a) Single plane of movement, superior, during inhalation efforts using the trapezius muscle.
   b) Generally, the least efficient of all common breathing patterns. Expansion options are limited.
   c) Often associated with complaints of chronic neck pain, shoulder pain and/or headaches.
   d) Like the other upper chest pattern, it is often associated with factors that cause an increase in the effort to breathe.
III. DYNAMIC OBSERVATIONS: IN PAIRS, OBSERVE BREATHING IN TWO DIFFERENT POSTURES. ASSUME A COMFORTABLE RESTING POSITION IN EACH POSTURE.

<table>
<thead>
<tr>
<th>NORMAL QUIET BREATHING: TIDAL VOLUME</th>
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<td>PRIMARY BREATHING PATTERN</td>
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<td>RESPIRATORY RATE</td>
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<td>QUALITY OF PATTERN</td>
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<th>MAXIMAL INSPIRATORY EFFORT: VITAL CAPACITY</th>
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<tr>
<td>PRIMARY BREATHING PATTERN</td>
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<tr>
<td>QUALITY OF PATTERN</td>
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IV. INTERPRET RESULTS
A. Did the breathing patterns change in the different postures?
B. Was the tidal volume and vital capacity pattern the same, except for volume?

V. MANUAL OBSERVATIONS
A. Confirm breathing pattern with manual palpation. (Remember that touch by itself can change patterns by facilitating or inhibiting chest movements.)
   1. frontal view: palpate upper, mid, and lower chest expansion
   2. posterior view: palpate upper, mid, and lower chest expansion
B. Sternal alignment, landmarks, and clinical implications
   1. Sternal notch
   2. Sternal angle
   3. Rib 2
   4. Rib 3 (measurement site for upper accessory muscle chest wall excursion)
   5. How does the position of the sternal angle influence posture and chest wall movements? (demonstration with class participants)
C. Assess other trunk muscles alignment, function and fascia (not covered in this course)

VI. OBJECTIVE MEASUREMENTS
A. Pulmonary Function Tests (PFTs): if available and appropriate
B. Chest wall excursion (CWE): circumferential expansion using a tape measure

<table>
<thead>
<tr>
<th>Tidal Volume</th>
<th>3rd rib (axilla)</th>
<th>Xiphoid</th>
<th>1/2 distance from xiphoid to naval</th>
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<tr>
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<td>Side-lying</td>
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<tr>
<td>Vital Capacity</td>
<td>3rd rib (axilla)</td>
<td>Xiphoid</td>
<td>1/2 distance from xiphoid to naval</td>
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<td>Upright</td>
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<td>Side-lying</td>
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</table>
C. Typical supine measurements for tidal volume CWE (Massery unpublished data):

1. 3rd rib site - total excursion approximately 2/8th" (~ .6 cm)
2. xiphoid site - total excursion approximately 3/8th" (~ .95 cm)
3. 1/2 distance site - excursion approximately 4/8th" (~ 1.3 cm)
4. measurements fairly consistent from age 3 through adulthood regardless of patient's size or age
5. pediatric (1 - 3 y/o): same measurement sites: ~1/8th", 2/8th", 3/8th"
6. no infant norms

D. Measurements for vital capacity (published and unpublished data):

1. **Best practice measurement per Massery:** supine
   a) Variable: 1½ - 3½ inches (~ 4 – 9 cm)
   b) should get larger as you move down the chest wall sites
   c) variable according to size, body type, posture, movement patterns, etc.
   d) measurement will tell you the patient's recruitment pattern for a deep breath (i.e. recruitment of the upper accessory muscles vs. intercostals vs. more diaphragm, etc)

2. **LaPier 2000 & 2002:** supine and standing
   a) Excellent inter & intra-tester reliability for CWE at xiphoid and axillary sites in both supine and standing. ICC > .92 for all four measurements.
   b) 120 Healthy adults 20 – 70+ years old. Divided into 6 groups by decade of life.
   c) Results: large variability in CWE during VC maneuvers. Comparison to norms may not be possible, but may be appropriate for individual patients.
   d) CWE decreased with age from 20-70+ years, but large variability.

VII. LISTEN (not covered in class)

A. Auscultation of breath sounds
   1. listen from one side to the other at the same horizontal position on the thorax
   2. listen in a symmetrical posture

B. Quality of phonation
   1. number of syllables/breath or length of vowel sound
   2. voice variations/pitches/volumes

C. Cough effectiveness
   1. assess all 4 phases of cough (inhalation, hold, building pressure, expulsion)
   2. assess productivity
FACILITATING EFFICIENT BREATHING PATTERNS AND ENDURANCE TRAINING: NEUROMOTOR TECHNIQUES FOR DIAPHRAGM, CHEST AND OTHER BREATHING PATTERNS


I. WHY CHANGE A BREATHING PATTERN?

A. Because it is inefficient

II. PRINCIPLES TO BE APPLIED FOR ALL TECHNIQUES

A. Positioning to facilitate desired breathing pattern

B. Importance of voice commands

1. Soft and rhythmic voice facilitates a diaphragm pattern
2. Loud and demanding voice facilitates an upper chest pattern
3. Use words like infer “pull”, like "breathe into my hand" or “draw the air in”
4. Don't use words that say “push”, like "push against my hand" as that would infer pushing the air out rather than pulling the air into the lungs.

C. Active participation of the patient throughout techniques

D. Immediate incorporation of new breathing pattern into functional activity

III. TECHNIQUES TO FACILITATE GREATER DIAPHRAGMATIC BREATHING (MOST TECHNIQUES DEMONSTRATED ON BLUE DVD)

A. Sniffing

1. Sequence: 3 quick short sniffs, then 2 sniffs, then 1 longer sniff, eventually to easy, slow breathing
2. Verbal cues: focus on asking for less and less effort, quieter breath sounds
3. Can be early in treatment plan to initiate diaphragm training or later in treatment progression to regain control in more demanding physical activities.
B. Lateral-costal chest expansion

1. Used for both diaphragmatic and intercostal facilitation. Variation is in your graded manual input and your verbal tones.

2. Promotes symmetrical chest wall movements when applied bilaterally.

3. Therapist places his/her hands bilaterally on lower lateral chest wall. Follow chest wall down and in toward navel during exhalation. Add a "slow" controlled stretch to emphasize facilitation of the peripheral fibers of the diaphragm, rather than focusing on the intercostals.

4. Unilateral Modification: Promotes symmetrical chest wall movements when applied bilaterally, but can be used unilaterally to emphasize expansion on one side (i.e. Stroke, scoliosis or other asymmetric conditions). Use PNF “Timing for Emphasis” technique to emphasize one side of the mid/lower chest over the other. Typically used to:

   a) Encourage trunk rotation, especially in mid and lower trunk, and especially for unilateral pathologies like stroke, scoliosis, or other asymmetric conditions
   b) Encourage scapular retraction without elevation.
   c) arm reach to the side of facilitation (coronal plane) such as external rotation, and/or shoulder extension, and/or abduction (PNF D1 UE pattern). Expanding the ribs is necessary for protective extension responses on that side.
   d) Incorporating eye gaze and head rotation to the facilitated side

C. Diaphragm "Scoop"

1. Controlled, fine motor technique to maximize diaphragm excursion and recruitment,
2. Sidelying is an optimal patient posture.

   a) The therapist places his/her hand around the level of the navel.
   b) Using a "J" stroke, supinate your hand (scooping up the viscera), and then move up and under diaphragm (the long “stem” of the “J”). Follow the patient's expiratory pattern, don't rush the exhalation.
   c) Give a slow controlled stretch up under the central tendon of the diaphragm via the patient's viscera to give specific proprioceptive input to the diaphragm to maximize an inferior diaphragm excursion response with the following inspiration.
   d) Allow the diaphragm to descend into your hand (the long “stem” of the “J”) before backing out the “circular portion of the J.”
   e) Common mistakes: rushing the respiratory cycle and/or moving directly through the abdomen with a straight line of force rather than scooping under and then up toward the diaphragm (“J-stroke” pattern), and then reversing that pattern during inspiratory phase.

3. Progression - ask the patient for movement of UE or some other body part to encourage coordination of breathing with movement.

4. Therapist must breathe out loud with the patient to establish a rate and rhythm that both therapist and patient can follow.

5. Can be used as a manual muscle test for the diaphragm bilaterally or unilaterally as well as a treatment technique.
D. Upper chest inhibition

1. In supine or sitting, place forearm across upper chest at level of sternal angle. Turn forearm down into a pronated posture for a more comfortable input for the patient. Gently press inferior and posterior (diagonal line) during patient's exhalation. Then "hold" your position during the next inspiration to cause mechanical inhibition of the upper chest. Limiting chest excursion will “force” a motor response from the diaphragm to meet the physiologic needs of the next inspiration.

2. Typically progressed to facilitation with the Diaphragm Scoop technique described above.

3. If the patient is anxious about his/her breathing, inhibiting the upper chest may be perceived as threatening. In which case, the Scoop or Lateral-costal technique may be a better option.

E. Normal timing or normal sequencing

1. Advance technique used to promote overall sequencing of chest wall movements and to smooth out the motor plan.

2. Tell patient to breathe into your right hand as you touch the patient’s upper abdomen, then your left hand as it moves up to the mid chest, and finally the right hand again as it moves up to the chest. Smoothly transition from each hand position.

3. The purpose is to create a fluid movement progression from the diaphragm at the onset of inhalation to a gentle rise of the upper chest at the end of inhalation maximizing inspiratory volumes and intended to reinforce an efficient recruitment of respiratory muscles.

IV. TECHNIQUES TO FACILITATE GREATER UPPER CHEST BREATHING (MOST TECHNIQUES DEMONSTRATED ON BLUE DVD)

A. Diaphragm inhibiting technique

1. Most often used in supine. Purpose of technique is to increase upper chest expansion during inhalation in order to balance the contributions of both the diaphragm and upper chest.

2. Patients who benefit from this technique typically over-recruit their diaphragm (belly breathing) and under-utilize chest expansion such as patients with low tone or patients with stiff chests.

3. Hand placement is the same as "Diaphragm Scoop", but now you follow the patient's diaphragm to its end expiratory position and then "hold" your position during the next inspiratory effort. Limiting the diaphragms inferior excursion will “force” a motor response from the chest to meet the physiologic needs of the next inspiration. (This is the opposite from the upper chest inhibition technique)

4. Typically progressed to facilitation with the Pectoralis Stretch technique described below.
B. **Pectoralis Stretch** (upper chest stretch)

1. The purpose is to expand the upper chest for increased inspiratory volumes, improved upright posture and/or improved UE reach. It is often used in sitting to encourage all 3 activities.

2. The therapist typically stands behind the patient and places his/her hands diagonally on the patient’s upper chest, in line with the pectoralis muscle fibers.

3. During exhalation, the therapist applies manual pressure on the chest inferiorly, medially, and slightly posteriorly at the same rate at the exhalation phase. At the end of exhalation, the therapist applies over-pressure (controlled stretch) in the same direction of the exhalation pattern (inferior-medial) and then asks for an immediate inspiration.

4. The patient should respond with a greater inspiratory effort because of the proprioceptive input as well as a pulmonary physiologic response.

5. May be modified to stress the reverse recruitment of the pectoralis muscle from medial to lateral (demonstrated on blue DVD).

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B. **Pectoralis Stretch unilaterally**: PNF “Timing for Emphasis” technique

1. The purpose of the unilateral pattern is to emphasize one side of the upper chest, typically used to:
   
   e) Encourage trunk rotation, especially in upper trunk, and especially for unilateral pathologies like stroke, scoliosis, or other asymmetric conditions
   
   f) Encourage scapular retraction without elevation of the trapezius
   
   g) Encourage reaching on the side of the facilitation into external rotation, and/or flexion, and/or abduction (PNF D2 UE pattern) such as needed for hanging up clothes from the dryer, or putting dishes away from the dishwasher, or reaching back to get the seatbelt, preparing for a sliding board transfer, protective extension, etc.
   
   h) Incorporating eye gaze and head rotation to the facilitated side

2. The therapist starts the technique as described in the bilateral Pectoralis Stretch technique, but at the end of exhalation, the therapist “holds” one side of the chest while facilitating inhalation on the opposite side. The “held” side is prevented from expanding during the next inspiratory phase, thus creating an over-flow response to the opposite side which should result in greater expansion and trunk rotation.

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C. **Lateral-costal stretch**

1. Described in previous diaphragm section, but now used with sharper manual cues and verbal commands to "demand" the recruitment of the intercostals (greater fast twitch fibers) along with the diaphragm.

2. Can use PNF Timing for Emphasis technique as well for more axial rotation activities.

3. Often effectively paired with trunk rotation for gait and balance activities.
D. Serratus push up

1. This is the only technique that uses trunk flexion with inhalation.
2. Hands over scapula. Resist lateral excursion of scapula during "push up" (inhalation phase).
3. Have patient exhale eccentrically such as occurs during talking or controlled easy blowing.

II.GLOSSOPHARYNGEAL BREATHING (GPB)
AN ALTERNATIVE BREATHING PATTERN FOR PATIENTS WITH SEVERE NEUROMOTOR DIAGNOSES

A. History

1. Developed by patients with polio who were on iron lungs and published by several authors in the early 1950’s (Dail 1951, Zumwalt 1956).
2. Currently used by almost exclusively by patients with severe neuromuscular deficits, particularly those on ventilators and/or those with vital capacities (VC) of less than 1 liter. (Bach 2012, Johansson 2012, Bianchi 2014)

B. How is it done?

1. Patients must be cognitively intact to learn the technique.
2. Sitting. Rectangular jaw movement to maximize the volume in the buccal cavity

C. Effectiveness

1. Numerous research and case study documentation
2. increase in VC by 25% to 200% (common results from paralyzed patients), but remember that these patients typically have very low VCs to start with.
3. can be a useful tool in weaning patients from the vent (full time or part time)

D. Use of GPB varies widely

1. Some use it all some or all waking hours to minimize time on a ventilator.
2. Some use it to take a deeper breath (to maximize inspiratory capacity) such as prior to a cough, talking louder or talking longer
3. It is a voluntary maneuver and thus cannot be used while sleeping.
V. ALTERING RESPIRATORY RATES AND FACILITATING GREATER LUNG VOLUMES (MAY NOT BE COVERED IN CLASS BUT CAN BE FOUND IN FROWNFELTER TEXTBOOK 2006 AND OTHER EDITIONS)

A. Counter-rotation in sidelying (Massery)
   1. Start by gently log rolling the patient in sidelying. Try to move in rhythm with his/her respiratory rate to match their natural body rhythm.
   2. Progress to larger increments of trunk ROM and add trunk counter-rotation.
   3. If the patient’s lungs are capable of increasing lung volumes, this may increase VC and decrease respiratory rate leading to relaxation and lower high tone.

B. Counter-rotation in sitting (butterfly technique) (Massery)
   1. Same concept as above
   2. Do in straight planes or on a diagonal

C. Re-patterning technique (Frownfelter)
   1. “Catching up to an asthmatic breath”
   2. Start with exhalation - blow out through pursed lips to slow down exhalation
   3. Add a momentary pause at the peak of inspiration
   4. Now, slow down the whole pattern as patient is able

VI. ENDURANCE TRAINING

A. Incorporate new breathing patterns into multiple practice sessions in normal ADL activities to promote functional carryover

B. Ventilatory muscle trainers: promote strength and endurance of the new pattern.
   - **Inspiratory trainers such as:** P-flex, Threshold IMT, The Breather, and others
   - **Expiratory trainers such as:** Resistex, Threshold PEP, The Breather, and others

C. Research
   1. **Lomax 2011** – combining an inspiratory muscle training and inspiratory muscle warm up prior to endurance training was more effective than either alone or no training
   2. **Shaw 2011** – combining IMT and aerobic training for patients with asthma improved PFTs and chest kinematics better than either alone or no training.
   3. **Gosselink 2011** – meta-analysis 32 RCTs: IMT for COPD patients appears beneficial for exercise performance
   4. **Britto 2011** – RCT: IMT training for patients with chronic CVAs for 30 minutes/day, 5 days/week, 8 weeks. Significant increase in respiratory strength and endurance, but not significant improvements in function or QoL. Including IMT training in acute rehab may be beneficial for CVA. **Nuzzo 1997** case study reported similar findings.