

## Pulmonary & Respiratory Basics for School-Based Therapists

By Helen Lim, PT

(Based on Mary Massery's seminar: *If You Can't Breathe, You Can't Function.*)

We as therapists need to recognize that if a child has difficulty breathing or has poor respiratory capabilities, it affects everything s/he does (i.e., walking, talking, participating in class, getting around in school, etc.). Respiration can be affected by asthma, weak abdominals/intercostals (as with cerebral palsy), poor back extensors (anterior respiratory structures can not expand without adequate posterior stabilization), low tone, posterior pelvic tilt, kyphosis, and neck hyperextension (since muscles fatigue easily, there's inadequate length-tension relationship of muscles, and there's less breath support).

Children with compromised respiration will not be able to focus on what the teacher or what you are saying. They will be much more focused on getting enough air & oxygen in.

### SEQUENCE OF NORMAL BREATHING/INSPIRATION:

Normal inspiration entails 3 steps involving respiratory muscle contractions. (Normal, quiet exhalation, however, has a large passive component due to the positive pressure created in the abdominal cavity during inspiration).

First: Gentle rise of the abdomen (activated diaphragm)

Second: Lateral costal expansion

Third: Gentle rise of the upper chest primarily in the superior and anterior planes.

(Many people, however, do not use lateral expansion when standing or sitting upright b/c quadratus lumborum kicks in to stabilize the pelvis & ribs).

**MUSCLES OF VENTILATION** The major muscles of ventilation include the diaphragm, intercostals & abdominals. Accessory muscles of ventilation include the erector spinae, pectoralis, serratus anterior, scalenes, sternocleidomastoid, & trapezius.

#### 1. "Triad of normal ventilation"- Diaphragm, Intercostals, Abdominals:

##### A) Diaphragm

- 1) *Major, most important* muscle of passive ventilation. (It does 75-85% of the work in normal breathing).
- 2) Innervation: Phrenic N. - C3-5
- 3) Primary movements: moves in all 3 planes
- 4) Has dependency on intercostal & abdominal muscles. (Even a fully intact & innervated diaphragm can not work effectively if intercostals and abdominal muscles are impaired or if spinal extensors are inadequate to provide a stable spine).
- 5) Concentric contractions for quiet & forceful inhalation.
- 6) Eccentric contractions for controlled exhalation & speech.
- 7) Attached to ribs 8,9, & 10 and these ribs are the first to move.

- The diaphragm completely divides the thorax.
- When the intact diaphragm distends downward and other respiratory muscles are also intact, a negative force/ gradient is created in the lungs causing air to fill the lungs during inhalation. At the same time, it creates a positive pressure in the abdominal cavity along with the abdominals in order to assist with exhalation.

- Diaphragmatic breathers generally have lower respiratory rates (RRs). Upper chest breathers (i.e., children with asthma) have higher RR's so they have to work harder to meet their bodies' oxygen needs.

### B) Intercostals

- 1) Primary function: To stabilize the rib cage
- 2) Innervation: T1-T12
- 3) Primary Movement: concentric contraction
  - a) Lateral & superior expansion in lower chest (in both quiet & forceful inhalation).
  - b) Anterior & superior expansion in upper chest.
  - c) Forceful exhalation- primarily medial & inferior compression in lower chest; posterior & inferior compression in upper chest.
- 4) Eccentric contractions: needed for controlled exhalation & speech.

- Intercostal muscles link every rib together, thereby providing rib cage stability.
- External intercostals are primarily responsible for inspiration whereas internal intercostals are necessary for forceful expiration, & isometric holding (with assistance from abdominals & diaphragm, i.e., during valsalva maneuvers, during coughing, during urination/ defecation).
- Most important purpose of intercostals is to prevent inward paradoxical movement of rib/ chest during breathing (chest sinking inward with a breath due to negative gradient created in lungs & from inadequate abdominals).

### C) Abdominals

- 1) Stabilize inferior border of rib cage- mid trunk control
- 2) Innervation: T6-L1
- 3) Provides visceral support to organs.
- 4) Provides positive pressure support for diaphragm
- 5) Provides necessary intrathoracic pressure for an effective cough.

- If in quadruped, belly drops, there is insufficient abdominal strength.
- Moving away from midline & moving in diagonals encourages abdominal & intercostal strength. Don't encourage too much straight plane movements because overuse of rectus can lead to pectus excavatum in children with respiratory issues.

### 2) Accessory muscles of respiration

#### A) Erector spinae- *most important* accessory muscles

- 1) Stabilize thorax *posteriorly* to allow normal *anterior* chest wall movement.
- 2) Innervation: T1-S3

#### B) Pectoralis muscles

- 1) Provide anterior & lateral expansion of the upper chest .
- 2) Innervation: C5- T1
- 3) Can be substitute rib cage stabilizer following paralysis of intercostal muscles.

#### C) Serratus anterior

- 1) Provides posterior expansion of the rib cage when upper extremities are fixed.
- 2) Innervation: C5-C7
- 3) Only inspiratory muscles that are paired with trunk flexion movements rather than trunk extension movements.

- If a child has arms flexed forward and seems to prefer trunk flexion, he/she may be using the serratus a lot for breathing. If you bring the child upright, the serratus muscles are shortened (less length-tension relationship), making breathing more difficult. You will have to teach new respiratory techniques to this child.

#### D) Scalenes

- 1) Provides superior and anterior expansion of the upper chest/ ribs.
- 2) Innervation: C3-C8

#### E) Sternocleidomastoid

- 1) Also provides superior & anterior expansion of the upper chest/ ribs
- 2) Innervation: C2-C3 and Accessory Nerve

• We all use this to some extent. If we don't use SCMs, our chests would fall inward b/c of the negative pressure gradient. It's only a problem if SCMs are used excessively as seen with children with asthma or with upper chest breathers.

#### F) Trapezius

- 1) Provides superior expansion of the upper chest
- 2) Innervation: C2-C4 and Accessory Nerve

• Traps fatigue too easily to use for breathing b/c they have to pull up the whole weight of the upper extremities & shoulder girdle- tremendous amount of excess weight in order to generate a breathing response. If a child uses traps a lot (i.e., breathing with shoulder shrugging), must ask yourself why he/she resorts to this. The diaphragm, on the contrary, is extremely efficient b/c it helps respiration without carrying the excess weight of body segments.

### AIRWAYS

#### 1) Upper airways

a) Comprised of the nose, mouth, pharynx, & larynx.

b) Function:

- To cleanse, heat, and humidify the air before it goes to the lungs, &
- To provide resonance for phonation

• Just having a tracheostomy predisposes children to more colds & pneumonia b/c air does not go through or have the benefits of the upper airways.

• Children with tracheostomies do not have any real serious precautions, but caution with prolonged neck flexion which may close up the tracheostomy airway. Don't get water in it- even a little can lead to aspiration (so caution with showering & bathing).

c) Cilia- mobilizes secretions upward & cleans the lung

- 1) Sol layer- 90% water ( so important to have adequate hydration!!)
- 2) Gel layer- sticky, catches pollutants
- 3) Cilia present to about 12th generation of lung divisions

• Cilia are little hair-like structures with a top gel layer which is designed to work better when child is upright. If cilia can not work optimally, secretions will have ample time to remain in the lungs and cause bacterial infections (i.e., in children with asthma). We as therapists need to address this so that children can be in school longer.

• Cilia require hydration to work so it is especially important to remember this for our children who are mouth breathers (ie., from poor head control, poor classroom positioning, or oral motor dysfunction). Some children, unfortunately, do not drink enough water or get enough to drink from their caregivers because more energy will then be expended to go to the bathroom or for caregivers to change them. (Milk tends to increase secretions so waterbased drinks are better for children with compromised respiration.)

• Check hydration if child has swallowing and/ or drooling issues- these are red flags.

- Parents/ caregivers can check for proper hydration in the child by looking at the color / odor of the urine. If pale (in absence of kidney / heart disease) & there is little odor, the child is well hydrated.

## 2) Lower airways:

- a) Vocal folds ( which protect opening of lower airways)
  - b) Glottis (the opening/ potential space between & around folds)
  - c) Trachea, bronchi, alveoli
- The right side of the lungs comes down more vertically thus attributing to an increased risk of aspiration, especially during feeding. May want to recommend that a fluidoscopy be performed.
  - There is less risk for aspiration if the child is sitting up and the head is prevented from extending back. (Food then has a better likelihood of going into the esophagus instead of the trachea).
  - Spending a lot of time in supine or in a reclined position often leads to a pooling of secretions in the posterior aspect of the lungs.

## **PHYSIOLOGY**

### A. Control of breathing

- 1) Respiratory centers in the brain stem- all 3 interact to give us normal breathing variations
  - a) Respiratory center in medulla-breathing that is not quite normal in character
  - b) Apneustic center in pons-inspiratory gasps
  - c) Pneumotaxic center in pons- balances the above centers
- 2) Chemoreceptors-CO<sub>2</sub> sensitive
  - a) Central receptors-located in medulla
  - b) Peripheral receptors-located in carotid bodies
- 3) Reflexes
  - a) Cough/ gag
  - b) Muscle spindle

### B. Mechanical Factors in Breathing

- 1) Compliance
    - a) Lung compliance- COPD vs healthy lung vs preemie lungs
    - b) Chest wall compliance- SCI vs healthy
- Don't want too much lung compliance because distended lungs lead to air entrapment. Want lungs to expand adequately, but not to remain there. Over-compliance can occur 2<sup>o</sup> to rib cage changes.
- 2) Airway resistance
  - 3) Ventilation/ perfusion matching - V/Q (affected by blood flow, etc.)

### C. Arterial blood gases (ABG)- want homeostasis

- 1) PaO<sub>2</sub> normal 80-100 mmhg
- 2) PaCo<sub>2</sub> normal 35-45 mm Hg
- 3) pH normal 7.35-7.45
- 4) O<sub>2</sub> saturation 97%. If O<sub>2</sub> saturation is less than 90%, it's harder for the hemoglobin to bond to CO<sub>2</sub>.

## **NORMAL CHEST DEVELOPMENT**

### **A. Newborn:**

1. Shape & size
    - a) Narrow intercostal spacing (minimal space in between ribs)
    - b) Horizontal rib alignment (= rib cage more stable and acts like a pelvis)
    - c) Triangle shape (frontal plane), barrel chest/ rib cage (A-P plane)
  2. Musculoskeletal development- stability vs. mobility of thorax
  3. Parallels gross motor development
  4. Breathing patterns
    - a) Obligatory diaphragmatic breathers (& nose breathers)
    - b) No functioning accessory muscles
    - c) No pulmonary reserves
- Newborn chest: chin closer to chest so no scalenes or SCM use. (Not optimal length tension relationship of scalenes & SCMs for contraction.)
  - Rib cage separate from lower thorax with big belly. Thorax takes up only 1/3 of trunk.

### **B. 3-6 months:**

- 1) Shape & size
  - a) More rectangular (due to stretch of anterior chest wall as in prone prop)
  - b) Rib cage is still smaller than thorax; ribs still horizontally aligned.
- 2) Musculoskeletal development and functional movement
- 3) Parallels gross motor development. When child first moves, he/she log rolls. All 12 ribs & spine act as 1 bony plate so can't anatomically rotate. Therefore, don't work on trunk dissociation/ rotation yet. In supine, upper chest shows more movement against gravity.
- 4) Breathing patterns
  - a) Still primarily diaphragmatic breathers but will use a little more pects/ chest now (upper chest anterior expansion possible)
  - b) Respiratory rate decreasing (becoming more efficient).
  - c) Inspiration- pectus excavatum type movement-chest moving inward b/c abdominals & intercostals not developed enough to provide positive pressure to counteract some of the negative forces created in the lungs. If abdominal & intercostal muscles don't develop, will begin to develop severe problems/ permanent pectus excavatum (a posterior displacement of the sternum; funnel chest).

### **C. 6-12 months:** Most significant stage of normal chest development.

- 1) Shape & size
  - a) More rectangular
  - b) Chest/ ribs now elongating and rotating downward
  - c) Lung size increased 4x since birth
- 2) Musculoskeletal development & functional movement (i.e., every accessory mm is available for use now; now have better length-tension relationship for SCMs, scalenes, & traps).
- 3) Parallels gross motor development. Child can now go against gravity (i.e., can sit by self). Sitting is a position which does not prevent chest from movement in any direction (i.e., posteriorly) - a good thing! The more time the child spends in upright, the more gravity helps pull ribs down. Child begins trunk & neck dissociation. For 1st time, ribs act as separate segments. Now child can go through transitional movements/ rotation (no longer limited to straight plane movements).
- 4) Breathing patterns
  - a) Diaphragm and all accessory muscle patterns now available.

- Children who skip crawling don't get intercostal & quadratus lumborum elongated and as developed. They have decreased coordination b/w intercostals & quadratus lumborum, & decreased trunk rotational movements.
- Most babies now sleep in supine rather than prone due to SIDS. (We are the only mammals which do not sleep in prone). Consequently, Mary Massery has seen an increase in aspiration pneumonia. Back extensors not stimulated as much and the anterior chest wall is not stretched as much as when child spends time in prone (propped on elbows or with head raised).

**D. Over 12 months of age-trends continue, but at a less dramatic pace.**

There is a continual lengthening of the rib cage and a blending of the rib cage & abdomen (this is the goal as it allows optimal trunk & rib function). Rib cage now takes up 1/2 of the thorax.

If the lower chest is more barrel shaped or ribs are flared- obliques & quadratus are not pulling in to keep from barreling.

If a 3 1/2 year old child has horizontal ribs, he/she most likely hasn't spent much time in upright or standing. Gravity is needed to help ribs migrate downward.

**E. Trends in Aging**

1. Increased *lung* compliance (decreased elastic recoil of lung tissue)- can take in air easily, but there's an increase in pulmonary problems b/c can't clear secretions as well & there's more air entrapment.
2. Decreased *chest* wall compliance (stiff chest) or chest closed up (because of kyphosis in many elderly patients).
3. Decreased lung volumes and expiratory flow rates

**F. Comparison of infant & adult chest/ trunk function and alignment**

<u>Chest</u>	<u>Infant</u>	<u>Adult</u>
Size	Occupies 1/3 trunk cavity	Occupies > 1/2 trunk cavity
Shape	Triangular frontal plane Circular A-P plane	Rectangular frontal plane Elliptical A-P plane
Upper chest	Narrow, flat apex	Wide, convex apex
Lower chest	Circular, flared lower ribs	Elliptical, integrated with abdominals
Ribs	Evenly horizontal	Rotated downward
Intercostal spacing	Narrow; limits mvmt	Wide, allows for individual mvmt
Diaphragm	Adequate; minimal dome shape	Adequate; large dome shape
Accessory muscles	Non functional	Functional

**COMPENSATORY BREATHING PATTERNS**

Our goal is dependent on whether the problems are neuromusculoskeletal or medical in nature; always check if it is medical first in order to rule it out. Know what are normal and abnormal

lung sounds (crackling/ wheezings). (Can have child listen to himself/ herself with the stethoscope first and then say it's now my turn).

A. Brain stem lesions to respiratory centers

1. Cheyne-Stokes breathing
2. Central neurogenic hypoventilation
3. Apneusis\*
4. Cluster breathing
5. Ataxic (or Biot's) breathing\*
6. Ondine's curse\*

(\* = usually requires mechanical ventilation)

B. Paradoxical breathing (seesaw breathing)

1. Paralyzed intercostal and/ or abdominals
  - A. Upper chest collapses during inspiration
  - B. Belly rises excessively. (Diaphragm unchecked by whole triad).
2. Paralyzed diaphragm
  - A. Lower chest and abdomen collapse during inspiration
  - B. Upper chest rises excessively b/c using intercostal & accessory muscles instead.

C. Lateral breathers (due to weakness, not paralysis of trunk muscles)

D. Asymmetrical breathers (hemiplegia, post-surgical, etc.)

E. Shallow breathers (typically high tone patients)

F. Altered speech support patterns (poor breath support or poor eccentric control)

G. Upper accessory muscles only (none of the triad muscles functioning)

H. Diaphragm and upper accessory muscles only (paralyzed intercostals)

I. Isolated diaphragm (no support from the rest of the triad- intercostal and abdominals)

**SUMMARY OF SIGNIFICANT RISK FACTORS** (leading towards ventilatory dysfunction in the neurological patient).

- A. Gravity's influence on skeletal development. (Gravity can be used for or against me, my choice)
- B. Gravity's interaction with muscle strength and muscle tone in order to provide the body with oxygen. Gravity acts on the body & on ventilation at all times.
- C. Resultant breathing patterns and efficiency
- D. Changes in vocalization/ communication

**ASSESSMENT:**

A. Check for outward signs of respiratory dysfunction. Anytime you see any of the following, check respiration:

1. Apparent dyspnea (shortness of breath, difficulty breathing)
2. Overuse of accessory muscles (i.e., children with asthma, children with wide throats)
3. Furrowed brows (concentrating)
4. Flaring nares
5. Cyanosis (O<sub>2</sub> deprivation) or clubbing of fingers (long term O<sub>2</sub> deprivation/ respiratory complications)
6. Use of supplemental devices
  - A. Overt: ventilators, oxygen, etc
  - B. Subtle: body jacket
7. Change in nail bed
8. Colds that persist a long time.

## **B. Musculoskeletal**

1. Chest shape and size- check to see if they are appropriate to the child's age.
2. Rib spacing and alignment. Can lose shoulder range with rib immobility. Can also affect body's ability to dissociate/ rotate.
3. Neuromuscular tone (Children with high tone may have difficulty breathing b/c rib cage still close together as 1 plate- not dissociating). Overactive rectus (ie. in children with CP)- pulls down the base of sternum, causing pectus excavatum (usually accompanied by inactive or weak obliques).
  - Baclofen- relaxant/ tone reducer for extremities can indirectly affect respiration.
  - Check respiration function in children with hemiplegia- can have 1-sided/ unilateral atrophy.
4. Assess child's ability to maintain own trunk upright. (Respiration will be affected by very hypotonic & weak trunk muscles, neurological issues, etc.)
5. Upright posturing - of head, shoulders, pelvis, etc. relative to the thorax. Children post stroke or hemiplegia- if working on shoulder, need to also address respiration issues. First 90 degrees of shoulder flexion occurs at the gleno-humeral joint. Beyond that, the ribs have to open up & there has to be adequate thoracic extension. Forward head & kyphosis will therefore limit shoulder mvmt. Also assess when child raises arm up in class, do they tuck their head & exhale in order to assist with lifting arm? Teach these kids to breathe *in* to assist with arm raising.
6. Spine alignment in different postures. Alignment affects function so always assess. In upright, pelvis affects breathing. Children with excessive lumbar lordosis, you can get a little more posterior pelvic tilt via crossing leg(s) on a foot stool or chair; this will encourage more diaphragmatic breathing. Children with neutral alignment & slight anterior pelvic tilt, you will get more upper chest breathing b/c more optimal length-tension of related muscles.
  - Some kids can reflux- regurgitation of stomach acid into esophagus and sometimes, into the trachea). Remember also that any child with swallowing issues (i.e., choking on food or fluids) are at risk of aspiration & aspiration pneumonia. Proper positioning is therefore very important for these children.
  - If a pt does not like going upright b/c can't breathe, talk, or eat, need something to assist abdominal muscles such as an abdominal binder to increase the positive support pressure. binders also good for elderly people or others who lay in bed most of the time.
  - Pectus excavatum- can worsen if a child is trying to breathe in but can't get air in. S/he will work harder to do so, thus creating an even greater negative force in the lungs. Pectus excavatum can cause you to actually lose thoracic extension. With pectus excavatum- ribs also consequently move laterally. Overuse of rectus muscles can lead to increased pectus excavatum in children with respiratory issues.
  - To encourage more anterior chest use- ER arm & put hands behind head to open up all anterior chest. Can also do while walking and in supine (with hands behind head & with a vertical towel roll). Shoulder ER has the most significant affect on opening up the chest. Conversely, you can adduct arms to close the chest and to encourage more diaphragmatic breathing.
  - Forward head & tight cervical extensors affect breathing & vice versa.
  - To maximize air intake- teach child to breathe from the bottom up (first from the belly & then from upper chest).
  - Musculo-skeletal deficits- make sure child maintains optimal muscle ranges so that the child goes into puberty in a good situation & comes out other side of puberty with better alignment.

Towel rolls under ribs (not waist) and full shoulder abd/flex so lateral bending thorax can help open up rib space on non-weightbearing side. (No pillow in neck or by legs b/c want maximally rounded curve. Foam rolls may be too hard.)

Precautions/ contraindications- Fxs, any diagnosis with bone density compromise, 1 time steroid use, cancer, non-prolonged weightbearing.

Watch pt- may have difficulty getting to positions even though they say they are ok.

Breathing pattern should be different in all position b/c different muscle stretch, length-tension relationships, posture demands (i.e., in standing will see more upper chest & lateral breathing & less diaphragmatic breathing b/c quadratus & abdominal need to stabilize body to prevent falling). In supine, may use more diaphragm & inferior lateral breathing because quadratus does not have to hold/ stabilize the body. Shouldn't see more upper chest in supine, but some pts put their shoulders back so that the spine is extended--improves length-tension of accessory muscles. For our children with weakness, may be difficult for them to breathe in supine because of gravity pushing downward on the chest.

Sidelying-red flag if using upper chest motion b/c arms usually in front, thus closing up the chest. Will instead see either lateral costal breathing (b/c although going against gravity, need to meet ventilation requirement) or will see diaphragm, lower intercostal, and traps breathing b/c front chest closed by arm.

### C. Breathing patterns & respiratory rates

1. Identify compensatory breathing patterns.
2. Determine how hard child is working to breathe.
3. Evaluate for chronic nighttime hypoxemia
  - A. O2 sats less than 90%
  - B. Poor night time sleepers, wakes often- ask if child sleeps throughout the night.
  - C. Headaches
  - D. Difficult to get up in the morning; may be confused or irritable
  - E. Complains of fatigue, often falls asleep during the day. Daytime focusing is difficult b/c tired.

Ask how the child sleeps on his/ her back. Then ask what the most common sleep position is. If can't sleep supine-it's b/c of gravity. If can't sleep on side with arms in front- it's b/c chest is closed up. If sleep with arm up with pillow in back- it's to open up the chest. Ask parents if they hear snoring (kids are not supposed to snore) so this should alert you to adenoid problems.

### D. Phonation

1. Assess loudness
2. Assess length of vocalizations
  - A. Should be able to hold a vowel for ten to twelve seconds
  - B. Should be able to say eight to ten syllables per breath
3. Assess quality
4. Assess changes with posture

Phonation-almost all kids want to talk so we are supporting this such as with respiratory toys (blowing/ inhaling/ exhaling toys) and abdominal binders.

Weak abdominals- Listen to child when they talk & come from supine to sitting. Laughing, crying, loud speaking, and yelling require concentric control. Quiet, soft speech requires eccentric control as with abdominals & intercostals.

If voice is better in prone, stabilize lower anterior chest (b/c otherwise too much anterior mvmt.). Some children will need peripheral diaphragm stabilized so can talk better.

Tx Ideas: Use of towel rolls, ant/post tilt, abdominal binders, chin tucking, etc. If these do not work, then will need manual techniques.

#### **FOUR PHASES OF AN EFFECTIVE COUGH**

1. Adequate inspiration & lung volume
2. Adequate hold (Ability to close glottis to build up adequate pressure)
3. Adequate force (Abdominals/ intercostals to cause pressure against glottis in order to open it up). Coughing is a body flexion activity, but if child can't generate sufficient force, may see kids put head/ body into extension to get some pressure against the glottis.
4. Adequate expulsion (& timing)

- Innovative cough techniques can help child stay in school longer for educational reasons and in order to receive the much needed therapy to develop vital respiratory skills for increase function.
- Ineffective cough- will hear secretions, but secretions not coming up due to the weak cough.
- Children with asthma- should have peak flow test (\$18)-can blow in the peak flow & cough into it.
- Flow rate-want big round mouth piece otherwise too much resistance to airflow. Shallow breathers gets less cough per breath so encourage deeper breaths.

#### ***Coughing impairments:***

Phase 1 impairments- can be due to quadriplegia, any pain (i.e., neck/ back pain) & neuromuscular disorder, asthma, CF, bronchopulmonary dysphasia or musculoskeletal issues.

Phase 2 impairments (glottis closure impairments): sounds very airy & hear no "uh, huh" cough sounds.

Can be due to neurological issues with vocal folds, hemiplegia, recent intubation, any congenital deficits involving cranial nerves/ brain stem/ cerebellum.

Phase 3- Hear "huh, huh"- tends to be high pitch. Impairments due to neuromuscular or medical issues, pain, CF, asthma, bronchopulmonary dysplasia, etc.

Phase 4- Expulsion/ timing phase impairment- can be due to brain injury. Pt may take deep breath, but has difficulty timing exhalation, or exhaling fully.

#### **WHAT CAN YOU DO IN 90 SECONDS OR LESS THAT HAS A PROFOUND & LASTING EFFECT?**

##### **I Upright postures**

##### **A. What type of breathing pattern do you want to encourage?**

1. More diaphragmatic activation
2. More accessory muscle activation
3. More symmetrical activation (of left & right sides of the body)
4. More of a balance of all the above

##### **B. How can you get it?**

1. Pelvis and mid trunk
  - A. Anterior tilt- tends to facilitate more upper chest breathing
  - B. Posterior tilt- tends to facilitate more diaphragm breathing
2. Shoulder/ upper extremities

- A. Full facilitation of upper accessory muscles: shoulder flexion/abduction/ external rotation
- B. Full facilitation of diaphragmatic and lower chest muscles: shoulder extension/ adduction/ internal rotation
- C. Subtle changes are dependent on the varying degrees/ ranges of the following: -
  - 1. Scapular retraction/protraction
  - 2. Shoulder flexion/extension
  - 3. Shoulder abduction/adduction
  - 4. Shoulder external /internal rotation
  - 5. Forearm supination/pronation
- D. Head and neck alignment
  - 1. Forward head
  - 2. Neutral chin tuck
    - a. Swallowing
    - b. Speech

C. How to achieve these alignments with simple adaptations

- 1. Towel rolls for increase anterior tilt and opened anterior chest wall
  - A. Ischial roll in sitting
  - B. Spine rolls
    - 1. Thoracic vertical roll
    - 2. Thoracic horizontal roll
    - 3. Lumbar roll
- 2. Wedges
- 3. Household furniture

D. Wheelchair considerations

- 1. Abdominal/trunk support
  - A. Soft support-i.e., abdominal binders
    - 1. Placement-around xiphoid process to iliac crest
    - 2. How tight? Tight enough to support but not inhibit diaphragmatic excursion
  - B. Rigid support: body jackets (total contact TLSO)
    - 1. Recommend abdominal cutouts-from xiphoid process to umbilicus (to allow for normal diaphragm/ abdominal excursion).
    - 2. Abdominal binder can be used over the opening
- 2. Lateral trunk supports
- 3. Head supports
- 4. Spine supports-lumbar and thoracic curves
- 5. Foot placement-effects pelvic position

If a child has no pulmonary reserve, it may be unrealistic to expect him/ her to push the W/C all day. May need to consider a power W/C for such a child.

**MOVEMENT STRATEGIES: INTEGRATING THE NEUROMUSCULAR, MUSCULOSKELETAL, RESPIRATORY & SENSORY SYSTEMS**

When encouraging children (with respiratory issues) in a task, proceed by identifying the desired task (i.e., rolling, reaching, dressing, transfers, etc.) and then proceed to identify the type of thoracic trunk pattern & muscle contraction that is needed.

- 1. What is ventilatory strategy?
  - a. Definition: the use of intentional pairing of inhalation and exhalation

patterns with movement in order to enhance the overall motor tasks.

## 2. Integrating systems effectively

### A. Trunk pattern

1. Pair extension with inhalation (as during transition to standing up)
2. Pair flexion with exhalation (as with reaching down to put socks on)

### B. Types of respiratory muscle contractions needed for a given task

#### 1. Isometric vs isotonic

##### a) Isometric-reaching up to change a light bulb

- Paired with stability activities (i.e., standing still, momentary valsalva maneuver). Momentary breath hold is ok, but not if used all the time or during *movement*.

##### b) Isotonic

- Paired with movement activities (i.e., any activity that requires movement of the trunk).

#### 2. Concentric vs eccentric movements

##### a) Concentric- moving up against gravity

##### b) Eccentric- coming back into gravity in a controlled manner.

## Types of muscle contractions used in respiration

### 1. Inhalation (normal quiet breath) -always concentric

### 2. Exhalation:

#### a) Passive-during quiet breathing (due to positive pressure in abdominal cavity which helps push air out of the lungs).

#### b) Eccentric- when used during quiet controlled breathing or speaking. Eccentric contractions are more energy efficient; less O<sub>2</sub> required.

#### c) Concentric- when used forcefully such as in coughing, yelling, or any resistive motor activity (generally more gross motor related activities).

Concentric/eccentric -fast twitch mm; To get diaphragmatic breathing-slow twitch mm.

## Sensory

### 1. Eyes lead the movement (as with people with C1 quadriplegia like Christopher Reeves)

- a) Eyes up- helps with inhalation & with getting trunk extension.
- b) Eyes down- helps with exhalation & getting trunk flexion.

### 2. Auditory

#### a) Loud & demanding voice of therapist or instructor facilitates

- 1) more upper accessory muscle breathing
- 2) more upper thoracic trunk extension
- 3) a quicker inspiratory effort

#### b) Soft, quiet voices facilitate

- 1) More lower chest, diaphragmatic breathing
- 2) Neutral trunk
- 3) A slower inspiratory effort

3. Gentle sensory percussion/ vibratory type input can increase kinesthetic awareness of respiratory muscles & structures.

## **VERBAL TECHNIQUES/ REFINING BREATH CONTROL**

A. Can use movement of extremities to get assistance with speech & vice versa; we can use speech/ counting to help with eccentric control or with movement such as walking.

1) Pair eccentric body movements with quiet everyday speech (i.e., have child slowly bring down what is in his/her hands as they count).

2. Pair concentric body movements with forceful speech (i.e., such as yelling during karate moves).

B. Interrupted air flow- i.e., have child say ABCs & when you say stop, child has to hold breath until you tell him/ her to resume.

C. Whistling- positive pressure-keeps airways little more open during expiration

D. Songs- great benefit from singing in the bathtub, church choir, etc.- quick inspiration followed by long/ prolonged expiration.

E. Winds & brass instruments (any instrument that uses the mouth) is beneficial. Velocity of air increases in the vocal cords as sides close in. (Like colorado river- water flows slowly until it gets to the narrow grand canyon).

### **\*\*Games to reinforce breath control**

A) Ping Pong (blowing balls across the table to opponent)

B) Maze (with ping pong ball)- can make one out of a cardboard box

C) Red light-green light-pair stopping & going mvmt with stop & go of breathing.

D) Straws- using straws to blow away feathers, colored scraps of paper, etc.

E) Any sip/ suck activities- Make it fun, measurable, & into a contest. (Just saying you did a good job is not enough for kids).

F) Be original, create your own!

## **MUSCULO-SKELETAL TREATMENT TECHNIQUES**

### **A) Stretching entire thorax**

1) *Passively stretch* rib cage letting gravity do the work

a) sidelying over towel/ pillow roll

b) supine over thoracic roll

2) *Actively stretch* using upper extremity patterns & ventilatory strategies

a) Sidelying suggestions (using towel roll under lower ribs)

1) Incorporate full shoulder abduction with inspiration. Return with controlled exhalation. Emphasize expansion throughout rib cage on the non-weightbearing (WB) side. Also emphasize separation of ribs from pelvis.

2) This time grab a heavy object such as a table leg at the peak of your reach and hold it for a few seconds to maximize the mid and upper chest stretch on the non-WB side.

3) Incorporate shoulder external rotation with inhalation, emphasis on active upper anterior chest and passive lateral chest expansion.

• Child with hemiplegia or unilateral rib problem- you can have him/ her lie on 1 side more than the other or can encourage him/ her to use both sides equally.

• If sidelying is difficult-- (ie, shoulder pain & scapular limitation), always look at quadratus lumborum to see whether it is allowing the ribs on the non-WB side to open up.

b) Sidesitting: a modified position for sidelying.

You can use the same techniques as for sidelying (i.e., using towel roll & then coupling shoulder abduction with inspiration). Side sitting: encourages 7,8, & 9th ribs to open on one side & close on the other side. Just be cautious with children with orthopedic hip issues b/c sidesitting puts one leg into a lot of hip adduction & internal rotation.

c) Supine suggestions (using a vertical or horizontal towel roll)

1) Incorporate full shoulder abduction with inspiration (emphasis on lateral expansion). Return with controlled exhalation.

2) Shoulder pinches with inhalation (emphasis on lateral and anterior expansion primarily in upper chest). Return with controlled exhalation. Can make this more fun by telling the child that you have a large paint brush and you are putting glue on their shoulder blades so they will stick onto the floor.

3) Incorporate shoulder flexion with inspiration to encourage bilateral mid- and upper chest anterior expansion. Return with controlled exhalation.

• Caution with children with pectus excavatum- don't want child in reclined position for breathing activities because gravity will just push down against the chest into greater pectus excavatum.

d) **Standing**

1) If child's ribs 8, 9, & 10 are tightened together, you can have child weightshift (with *both* feet still on the floor) to the side of rib tightness. This will open up the rib spaces on that side.

2) Stand to sit activities with emphasis on eccentric control. If you have the child count down, talk, or sing, eccentric control will increase.

3) Can have child pretend to be a statue. Tell them "Don't let me move you". Can get isometric hold of respiratory muscles.

e) **Sleeping-** recommend that the child sleep equal amounts of time on each side. Helps give spine & rib cage even input & rotation.

f) **Long sitting/ short sitting:** Encourage abdominal/ obliques strengthening. One idea is for therapist to place one finger/ hand on child's anterior shoulder of the reaching arm and provide resistance as the child reaches diagonally for a toy. Can also put stacking cups on the child's foot. Have the child move and dump the cup to the side of him/ her.

**B) Joint Mobilizations**

In some children, trunk extension occurs almost entirely in the upper T-spine and not lower T-spine. May, therefore, need some anterior glide mobs here.

May also need to do individual rib mobilizations:

1) Have child inhale, "hold", then therapist mobilize rib segments.

2) Mobilize only 3-4 segments at a time. Reassess change before mobilizing further.

**C) Myofascial release**

• Respiratory issues may be due to bounding down of connective tissue & fascia from previous surgeries or habitual posturing. Treating the fascia can assist with the mobility of body segments.

**FACILITATING EFFICIENT BREATHING PATTERNS (for normal, quiet breathing)**  
(Principles and Practice: chapter 22 by Massery & Frownfelter)

If you can help the child improve his/ her breathing--you will be helping their cognitive development, attention, speech, eating, etc. Breathing affects everything we do & if we can't breathe, we can't function optimally.

Need active participation of the child throughout techniques. Children like to be timed b/c it becomes a contest- will be highly motivated because will see concrete outcome.

Need immediate incorporation of new breathing pattern into functional activities.

Techniques to facilitate efficient breathing are:

- A. Sniffing
  - 1. Sequence of verbal cues
  - 2. Choice the most optimal verbal cues
- B. Lateral-costal chest expansion
  - 1 Used for both diaphragmatic and intercostal facilitation
  - 2. Excellent means to promote symmetrical chest wall movements.
- C. Flutter devices- helps in generating positive pressure.
- D. Postural drainage is a technique good for recurrent respiratory problems. Can do while child is prone on a wedge with the head inclined down.
- E. Costophrenic assist (to help lower chest breathing) -child takes an easy breath in & as s/he blows air out, therapist facilitates a few quick stretches down & into the umbilicus. This helps facilitate taking a deeper breath in.
- F. Incentive Spirometer
- G. Active cycles of breathing

All of the above techniques work well, but the best ones are those the child will follow-through with (the ones with best pt compliance).

### **ABDOMINAL BINDERS**

Extremely beneficial for many children with respiratory issues. As previously mentioned, they are elastic/ dynamic and provide support to the abdominals & help produce the positive pressure necessary for exhalation, coughing (& mobilizing secretions out of the lungs), etc. Abdominal binders are generally only needed in upright (sitting & standing) and should be on tight enough to provide support, but not too tight to restrict normal diaphragmatic excursions. If too tight- will increase trapezius & upper chest breathing. For children who are upper chest breathers- make binders looser so won't encourage compensation with traps & upper chest.

Start using with small increments of time during the day, but then use the binder all the time when upright.

Children with ataxic characteristics do very well with abdominal binders; their bodies become more "organized".

Down syndrome & low tone children- usually start walking at 24 months, but with an abdominal binder, they can walk closer to 12 months of age. It helps provide the proximal stability needed for distal (extremities) mobility.

Helpful to buy 2 so pt can have one washed while the other one is in use.

As per Mary Massery, neoprene abdominal/ body jackets- generally don't allow enough pressure gradient so elastic abdominal binders are better.

Body jackets (i.e., TLSO)- more rigid than binders, but can't prevent scoliosis. It can, however, minimize or slow down the progression. In addition, it can prevent trunk kyphosis. Body jackets should have a cut out in front (ziphoid to umbilicus) for normal abdominal/ diaphragm excursion. Otherwise child will become trapezius breathers (very fatiguing & inefficient).

## **Additional Notes**

Children with asthma are physically able to breathe/ get air in even if it means taking a deep breath. Airway resistance for them occurs where the actual gas exchange occurs distally. Don't teach these children upper airway techniques because will see an overuse of SCMs & traps. Instead teach them more diaphragmatic breathing or breathing with a balance of diaphragm & upper chest.

Important to increase hydration in children with asthma so that the cilia can work sufficiently to mobilize secretions from the lungs.

Pharmaceuticals- bronchodilators- need to use at least 30 minutes before heavy activity.

Children with Duchenne's (DMD) have significant respiratory/ pulmonary issues and often die earlier (at 19-21 years) because of this (rather than cardiac or musculoskeletal issues). Many will eventually need a ventilator. Give these children abdominal binders & as much respiratory support as possible to avoid pulmonary infections (i.e., make using the incentive spirometer a fun game or contest).

Any degenerative disease- beneficial to provide abdominal binders to address the cardiopulmonary issues.

At least 50% of children with Down syndrome have heart issues so ask for a cardiac work-up.

If chest wall is flattened out- they most likely spent a lot of time in supine where gravity acted on it.

If children have difficulty breathing during school or therapy, notify nurses and have them call the EMS. Do not attempt to take the child yourself to the hospital. You don't want to be liable because you were a minute too late.

With certain sports where one side is used dominantly, may see that obliques are not well formed on the non-dominant side so ribs may not be flattened. May see elevated sternal angle in swimmers, flute player, etc. because of the constant need to take a deep breath during the activity. Wt lifters have tight thorax b/c they need thoracic stability to lift. Good to teach athletes diaphragmatic breathing.

## Equipment Resources

1. Abdominal binders can be custom ordered through:

Jan Gillespie, Business Manager  
Saunders Industries, Inc.  
1708 East Industrial Park Dr.  
Paola, KS 66071  
888-240-7845

2. TLSO (thoraco-lumbo-sacral-orthosis or body jacket): can be ordered from any reputable orthotist.

Make sure that the orthotist incorporates an abdominal cutout (roughly from the xiphoid process to the umbilicus) into the design to allow for normal visceral excursion during inspiration.

An abdominal binder can be used over the opening to provide more support, yet still allowing for movement.

3. a) Inspiratory muscles trainers (P-Flex and Threshold)  
b) Expiratory muscle trainers (PEP - positive expiratory pressure)  
c) Peak flow meters  
can all be purchased through:

Respironics / Health Scan Asthma and Allergy Products  
908 Pompton Ave. Unit B2  
Cedar Grove, NJ 07009-1292  
800-962-1266

4. Flutter mucus clearance device can be purchased through:

Scandipharm  
22 Inverness Center Parkway  
Birmingham, AL 35242  
800-950-8085

Mary Massery  
(847) 803-0803

★ 5. **Respiratory toys** can be purchased through:

PDP Products  
14398 N. 59th  
Oak Park Heights, MN 55082  
612-439-8865

6. **Passy Muir valves** can be purchased through:

Passy & Passy, Inc.  
4521 Campus Dr., Suite 273  
Irvine, CA 92715  
800-634-5397

7. **Incentive spirometers and a whole host of other respiratory equipment** can be purchased through your local respiratory equipment vendor or at:

Apria Health Care  
565 Lamont Rd  
Elmhurst, IL 60126  
(630) 941-6400

8. **Mechanical In-Exsufflator (cof-flator)** can be purchased through:

JH Emerson Company  
22 Cottage Park Avenue  
Cambridge, MA 02140-1691  
800-252-1414

**List compiled by Mary Massery.  
Author has no financial association with any of the above companies.**

**1999**

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