Assessment of interaction with breathing, posture, abdominal muscle activation

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Breathing

Normal breathing pattern

Inspiration

Expiration

Scalenes
Diaphragm
External intercostals + Diaphragm
Pelvic floor muscles (ecc)
Erector spinae

Obliquus externus & Internus + internal intercostals
Transversus abdominis + superficial abdominals
Pelvic floor muscles (conc)
Breathing Assessment and training

Rectus abdominis
- Caudal displacement of sternum
- AP rib cage diameter
- Small in transverse diameter

Obliquus externus abdominis
- Transverse rib cage diameter
- Small caudad sternum displacement

Obliquus internus abdominis
- Transverse rib cage diameter
- Small caudad sternum displacement

Transversus abdominis
- Smallest insertional expiratory action
- Expiratory action through elevation of diaphragm
- Transversus diameter of rib cage via IAP
Breathing and pelvic floor

- Pelvic floor muscle activation is necessary for breathing
- Breathing may drive changes in pelvic floor muscle activation
  - e.g., forced expiration – greater PFM activation
- Breathing training may aid modification of pelvic floor muscle activation
  - e.g., relaxed breathing may reduce PFM tone
- Specific challenges from respiratory disease – breathing pattern and coughing

Assessment of breathing

Breathing pattern: Assessment

- Movement
  - Observation & Palpation of breathing movements
    - 3 components – evenly distributed with no dominance
      - Upper chest
      - Basal chest expansion
      - Abdominal displacement
  - Symmetry
- Muscle activity
  - Observation, Palpation, electromyography, ultrasound imaging
- Chest wall flexibility
- Effect of motor control correction
- Effect of posture correction
- Effect of loading

Breathing pattern: Assessment

- Respiratory movements
  - Abdominal movement
  - Bibasal rib cage expansion
  - Upper chest breathing
  - Objective
    - Even distribution of movement between regions
    - No region dominating
    - Consider effect of position
      - Reclined – less basal expansion (less abdominal muscle activation)
- Respiratory muscle activity
  - Abdominal muscle activity
    - Palpation
    - Observation
    - EMG biofeedback
    - Ultrasound imaging

Breathing pattern: Assessment

- Respiratory movements
  - Look before touching
  - Do not indicate that you are evaluating breathing
  - Assess natural breathing
  - Consider
    - Is movement equal in each region?
    - Consider what movement is dominant?
    - Common abnormalities in breathing pattern
      - Hypertension
      - Vertical motion
      - Upper chest breathing

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Breathing pattern: Assessment

- Respiratory muscle activity
  - Abdominal muscle activity
    - Consider
      - Is the muscle activity modulated with breathing?
      - Is there activity that is compromising respiratory movements?

- Diaphragm muscle activity
  - Palpation – rib cage and abdominal movement
  - Observation – rib cage and abdominal movement
  - Ultrasound imaging

Breathing pattern: Assessment

- Respiratory muscle activity
  - Diaphragm muscle activity
    - Consider
      - Does the diaphragm shorten (rib/abdomen movement)?
        - Tight/short/overactive diaphragm
        - High IAP with abdominal brace - prevent diaphragm descent
      - What is the quality of shortening/thickening – is it smooth and slow?

Diaphragm ultrasound imaging

- Thickening of costal diaphragm
- Displacement of central tendon
- Change in length of zone of apposition
Breathing Assessment and training

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Liver
Lung
Rib
Diaphragm origin

Zone of apposition

Central tendon

Diaphragm

Change in length of zone of apposition

Change thickness of diaphragm

Thickening of the diaphragm

Subject position: Supine with head on pillow
Transducer: 12 MHz
Transducer placement:
- Identify 8th & 9th intercostals space (find 12th rib and count up)
- Place the transducer along the IC space
- Place the transducer in the anterior axillary line then optimize
  - Too far back the muscle will peel away and you will loose the image
  - Too far forward the muscle will not thicken much with contraction
- Check both spaces and pick the one with the best image
- Optimize the image
  - Select the depth that optimizes the size

Diaphragm displacement
Diaphragm displacement

- **Subject position:** Supine with head on pillow
- **Transducer:** 3 MHz (set to 4 MHz)
- **Transducer placement:**
  - Place the transducer in the anterior axillary line, below the rib cage
  - Angle the transducer craniodorsally to image through the liver
  - Identify the posterior aspect of the diaphragm
  - Too horizontal you will not see the diaphragm
  - Too vertical it may be hard to see the edge
  - Optimise the image
    - Select the depth that optimizes the size
    - Use m-mode

Length of zone of apposition

- **Subject position:** Supine with head on pillow
- **Transducer:** 12 MHz and 3 MHz
- **Transducer placement:**
  - Identification of the origin of the diaphragm
    - Place 12 MHz transducer longitudinally in the anterior axillary line at approx the 8-9th IC space
    - Identify the landmarks (ribs, liver, diaphragm)
    - Ask the subject to breathe and move the transducer caudally until you can see the ribs
    - In rib space below the origin the muscle in the location of the diaphragm will not thicken with inspiration (TrA)
    - Slip of TrA may be noticeable deep to diaphragm
    - Muscle will thin a little and the diaphragm will not increase in thickness as much with inspiration
    - The rib at which this transition occurs is the origin of the diaphragm
    - Mark the rib with a pen to use as a landmark for the imaging of the zone of apposition

Breathing pattern: Assessment

- **Pelvic floor muscle activity**
  - Activation of PFM during breathing
  - Tonic hold with subtle lengthening (exp) & shortening (insp)

⇒ Assess breathing pattern and activation of abdominal muscles during breathing
Assessment: Breathing

- Evaluate breathing pattern during:
  - Quiet breathing

- Breathing movements
  - Abdominal displacement
  - Lateral rib cage expansion
  - Upper chest elevation

- Muscle activation
  - Abdominal muscles
  - Diaphragm muscle

Breathing pattern: Assessment

- Postural assessment
  - Neutral spine
    - Optimal breathing pattern
    - Slump – upper chest
    - Thoracolumbar ext – basal expansion
    - Rotated – decreased basal, increased abdo.
  
Lee & Hodges 2006

- Assess impact of posture correction

"Neutral spine"

- Aim:
  - Cervical lordosis
  - Thoracic kyphosis
  - Lumbar lordosis
  - Neutral pelvic tilt
  - Sagittal balance/alignment
  - Frontal alignment

- Benefits:
  - Optimal loading
  - Avoid creep
  - Reduce global muscle overactivity
  - Increase local muscle activity

- Consider:
  - Pathology (e.g. stenosis)
  - Spinal mobility
  - Not static – functional range

Posture/alignment

Key

- Control of
  - Lumbar lordosis/pelvic tilt
  - Thoracolumbar junction
  - Thoracic kyphosis
  - Sagittal/frontal alignment

- Lumbar lordosis - greater multifidus, greater low TrA/OI
- Thoracolumbar ext - greater TL ES
- Slump – minimal activity of extensors
  
Claus et al, 2010

- Sway – “hang” on OE

Muscle activity in different postures
Assessment: Postural alignment
- Evaluation of sagittal and frontal alignment
- Evaluation of spinal curvature
- Evaluation of muscle activity

Breathing pattern: Assessment
- Muscle activation
  - Assess impact of motor control correction
    - Activation of local muscles
    - Relaxation of global muscles

Breathing pattern: Assessment
- Muscle activation & correction
  - Are muscle activation deviations present?
  - Is muscle activation affecting breathing?
  - What is the effect of contraction of transversus abdominis?
  - What effect does muscle activation correction have on breathing pattern?

Test of “independent” transversus abdominis activation
- Relaxed
- Deep abdominal contraction
- Abdominal bracing

Parasagittal section
Breathing Assessment and training

Parasagittal section

Breathing presentation #1
• Prominent expiratory activity of abdominal muscles in supported positions
  – NORMAL
    • Supported positions – relaxed abdo. muscles
    • Upright positions – Standing +/- respiratory activity of abdo. muscles
  – ABNORMAL
    • Pronounced abdo. Muscle activity in supported postures

Breathing Presentation #2
• Tonic activity of abdominal muscles that limits respiratory motion of chest wall
  – Restrict - bibasal expansion/diaphragm motion
  – Enhance - Upper chest breathing

Interpretation
• Increased OE activity
  – Consequence of pain?
  – Increased resistance to expiration (COPD/Asthma)

• Decreased upper chest movement
  – OE holding rib cage down – decreased basal expansion & abdominal wall displacement
  – Vertical motion only strategy left
  – Posture – thoracolumbar extension – change rib motion

Breathing Presentation #3
• Inability to maintain deep muscle contraction with breathing
  1. Loss of deep muscle (including PFM) contraction during inspiration
     – Inability to hold during inspiration
  2. Upper chest breathing
     – Restrict abdominal movement
  3. Shallow breathing
  4. Increase activity of global muscles

Interpretation
• Inability to hold PFM
  – Unable to ecc. contract PFM
  – Inc. pelvic floor descent due to compromised basal expansion
Breathing Presentation #4

- Reliance on abdominal/pelvic floor displacement for breathing
  - Challenge to hold PFM contraction with large change in muscle length

Assessment: Muscle control

- Evaluation of deep abdominal activation
  - Which muscles?
  - What sequence?
  - What quality

Breathing pattern: Assessment

- Effect of loading
  - How does addition of load affect breathing?

Breathing pattern: Assessment

- Effect of loading
  - How does addition of load affect breathing?
    - Breath holding +/- Poor control of alignment when instructed to breathe
    - Excessive abdominal bracing/excessive intra-abdominal pressure
    - Increased vertical motion

Assessment: Muscle control

- Evaluation of bracing and control of loading
  - Quality of control
  - Methods for feedback
  - Threshold for loss of control
  - Asymmetry of control
Breathing Assessment and training

Breathing pattern: Assessment

Basic assessment - sequence
- Observe breathing pattern
- 3 components
- Palpate movements
- Assess muscle activity
  - Palpation
  - EMG
  - US imaging - abdominal wall, diaphragm
- Consider posture and muscle activation strategy
- Assess affect of correction of posture and muscle activation
- Assess affect of loading
- Assess chest wall flexibility

Training of breathing

Breathing: Training goals

- Optimise respiratory movements
  - Encourage even distribution of movement between regions
  - Change breathing pattern to simplify spine control
  - Train symmetry
- Optimise respiratory activity of trunk muscles
  - Reduce tonic muscle activity compromising respiratory motion
  - Reduce excessive respiratory activity of trunk muscles
- Optimise posture to optimise breathing
- Optimise thorax dynamic control (thoracic spine & rib cage) to optimise breathing
- Optimise efficiency of breathing pattern in disease
- Train breathing pattern with motor control progressions

Breathing pattern: Techniques

- Optimise respiratory movements
  - Respiratory training techniques
    - Manual facilitation
    - Quick stretch
    - Positioning
    - Feedback - manual, elastic
  - Need motion of upper chest, basal rib cage and abdomen
    - If high abdominal movement - difficult to sustain TrA contraction
    - If low bibasal - often large OE to compress
    - If high upper chest - OE prevent other motion

Muscle activation: Techniques

- Increase activity of TrA/ MF/ PFM
  - Whole body posture (stretch on muscle)
  - Spinal posture (greater activity in neutral)
  - Instruction
  - Co-contraction with other muscles
  - Manual facilitation
  - Imagery
  - Feedback (Observation, palpation, US)
  - Taping

Breathing pattern: Techniques

- Optimise respiratory activity of trunk muscles
  - Reduce tonic/excessive activity
  - Maintain deep muscle activity during respiration
    - Feedback
    - Gradually increase inspiratory volume to threshold
    - Optimise breathing pattern
    - Commence with expiration
Breathing Assessment and training

Muscle activation: Techniques

• Reduce activity of OE/OI/RA/TL ES
  – Whole body posture (more activity, more support)
  – Spinal posture (less activity of global in neutral)
  – Instruction
  – Breathing techniques
  – Feedback (EMG, palpation)
  – Decrease effort
  – Connective tissue techniques, trigger point, dry needling
  – Inhibitory taping
  – Imagery

Breathing pattern: Techniques

• Optimise posture to optimise breathing
  – Retrain neutral posture

Assessment: Postural alignment

• Evaluation of sagittal and frontal alignment

• Evaluation of spinal curvature

• Evaluation of muscle activity

Postural correction: Techniques

Cognitive correction

• Instructions
  – e.g. roll forwards on tailbone, breathe into base of ribs
  – Imagery
  – e.g. lengthen spine
  – Manual guidance
  – e.g. hand on sacrum to facilitate anterior rotation of pelvis
  – Manual cues
  – e.g. finger on xiphoid and navel to control T-L junction
  – Dissociation tasks
  – e.g. separate L/L motion
  – Muscle activation
  – e.g. palpation, observation, EMG biofeedback
  – Cues/reminders
  – e.g. taping

Breathing pattern: Techniques

• Optimise thorax dynamic control (thoracic spine & rib cage) to optimise breathing
  – Thoracic spine mobility/motor control – exercise, manual therapy
  – Rib cage mobility/motor control – exercise, manual therapy

• Optimise efficiency of breathing pattern in disease
  – Optimise breathing movements & muscle activity
  – Increase fitness – pulmonary rehabilitation
  – Flexibility – muscle length & thorax dynamics
Breathing pattern: Techniques

- Train breathing pattern with motor control progressions