


Danish Physiotherapy Annual Conference
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**Integrating Cardiopulmonary
and Postural Control
Strategies in Pediatric and
Adult Populations**

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



Conflict of Interest

None



Part 1

Theory and Principles

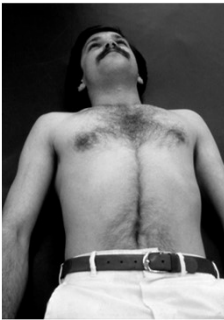
Pressure!

- 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



Pressure!

- Recumbent / upright
- Pediatric / adult




Pressure: Problem Established!

- Now how does it relate to breathing mechanics . . .

What Supports the Skeleton?

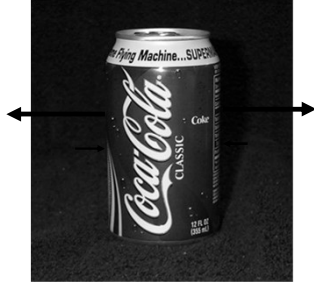
The "Soda-Pop Can" Model of Postural Support



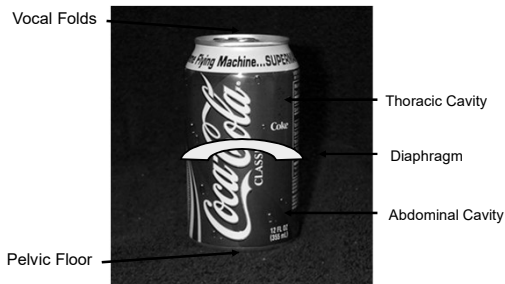
Massery 2005 & 2006

A Postural Control Model Using a Soda-Pop Can

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

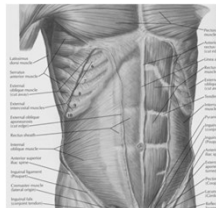


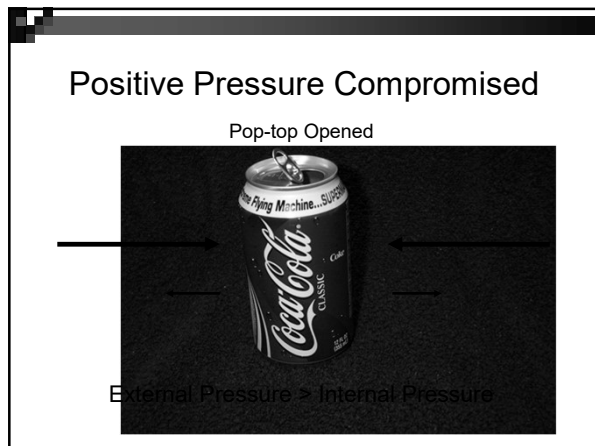
A Postural Control Model Using a Soda-Pop Can



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!











Research Summary

- Abundant research now confirms: the trunk muscles are simultaneously respiratory & postural muscles
 - Shoulders
 - Intercostals
 - Paraspinals
 - Diaphragm
 - Abdominals
 - Pelvic floor

Hodges 2000 & 2007, Gandevia 2002, Shirley 2003, Caron 2004, Butler 2007, O'Sullivan 2007, Kuczyński 2008, Sjodahl 2009, Hamaoui 2010 & 2014, Hudson 2010, Uga 2010, Kyvelidou 2013, Smith 2014

Emerging Research: Vocal Folds as Postural Stabilizers

- Limited studies thus far:
 - Early 2000's: primarily studying maximal effort and glottal closure
 - Hayama 2002, Elias 2004, Hagins 2004
 - Orlikoff (2008): modulation of effort and consequential glottal response
 - My research (2013): minimal effort (small perturbations) and glottal response to the balance challenge.

The Top of the Can

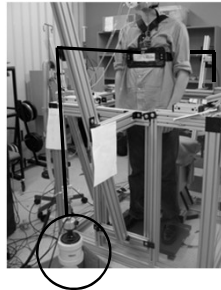
Vocal Folds & Supporting Structures:
“Gate-Keepers” of Pressure Regulation

- Are YOUR vocal folds really related to postural demand?

**STAND UP AND
SEE FOR
YOURSELF!**

Vocal folds as postural stabilizers

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



Massery 2013

Vocal folds as postural stabilizers

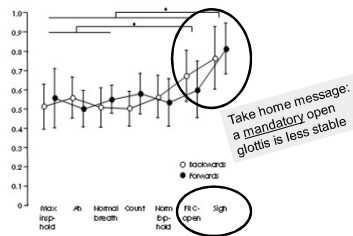


Massery 2013

- The 7 breathing/voicing conditions included
 - ☐ 1 glottis naturally open condition
 - ☐ 2 glottis forced-open conditions
 - ☐ 2 partially open glottis (voicing) conditions
 - ☐ 2 glottis closed (breath-hold) conditions

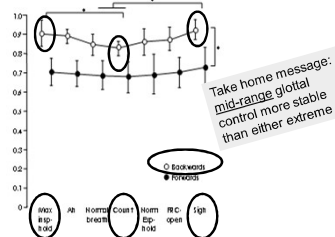
Peak horizontal linear displacement of the thorax during perturbation trials

Seven breathing conditions	Abbreviations
Maximal inhalation, then breath-hold	Max insp-hold
/Ah/ voicing	Ah
Natural Breathing	Normal breath
Counting out loud	Count
Normal exhalation, then breath-hold	Norm exp-hold
Normal exhalation, then airway left open (no breath-hold)	RIC-open
Sigh (HF sound)	Sigh



Peak horizontal linear displacement of CoP during perturbation trials


Seven breathing conditions	Abbreviations
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Take Home Messages


- Engaging the glottis was necessary to optimize thoracic stability and upright balance responses.
- A mandatory open glottis was less stable than any other glottal condition for thoracic stability and overall balance.
- Clinical suggestions for patients with neuromotor disease and/or core weakness
 - Exercise: Add pushing / prone activities
 - Postural Control and airway clearance: Use voicing in weight bearing postures, during resistive tasks, and for general airway clearance
 - Trachs: Use PMVs if possible! (Passy Muir Valves)

CLINICAL PROBLEM: Kevin, 13 y/o
 Brainstem tumor at 10 y/o. Anoxic episode with L CVA at 12 y/o with profound R weakness including R diaphragm




CLINICAL PROBLEM: Kevin, 13 y/o
 Brainstem tumor at 10 y/o. Anoxic episode with L CVA at 12 y/o with profound R weakness including R diaphragm

- Failure to wean from the vent.
- Weak diaphragm; chest muscles are inhibited by tight chest strap, which . . .
- Inadvertently limits potential for intercostal & neck accessory muscle breathing, and . . .
- Lap belt placement encourages a posterior pelvic tilt, which . . .
- increases trunk flexion and forward head posturing which increases aspiration risk
- **NO WONDER HE COULDN'T WEAN OR SAFELY SWALLOW!**



Kevin: 14 y/o
 Dx: Brainstem tumor, diaphragm weakness



Add the vocal folds to the full equation:
Kevin and Dad in early standing



- Without 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.

Pushing Power!



7 months later



Matthew



Changes from
1½ y/o to 4 y/o



Support Trunk Pressure

- If the patient can't generate, regulate and maintain trunk pressures, then help them.
 - Abdominal binders
 - Other compressive garments
 - TLSOs (body jackets) or other rigid trunk support
- If they can learn to regulate their own trunk pressures for postural support, then teach them.
- Or do both!

Jacob



3 y/o



Almost 4 y/o

Jacob



4 y/o



5½ y/o

TLSO abdominal cutout improves PFTs

(Frownfelter 2014)

- Wearing a TLSO reduced PFTs compared to controls not wearing a TLSO at rest and after exercise ($p < 0.001$).
- **Novelty:** PFTs improved for TLSOs with abdominal cutouts compared to traditional full-contact TLSOs



TLSO: No abdominal opening



TLSO: abdominal opening

TLSO abdominal cutouts improve PFTs: Conclusions

- TLSOs restrict pulmonary function in healthy adults.
- An abdominal cutout in the TLSO increased pulmonary function, especially with activity, suggesting that cutouts should be considered when fabricating TLSOs for individuals with compromised breathing such as with neuromuscular disorders, scoliosis, or spine surgery.

Frownfelter 2014

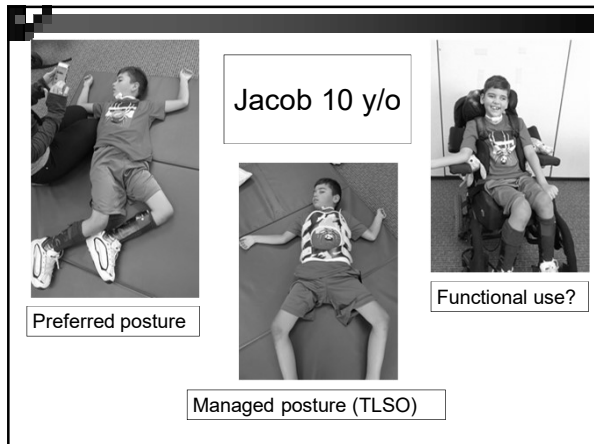


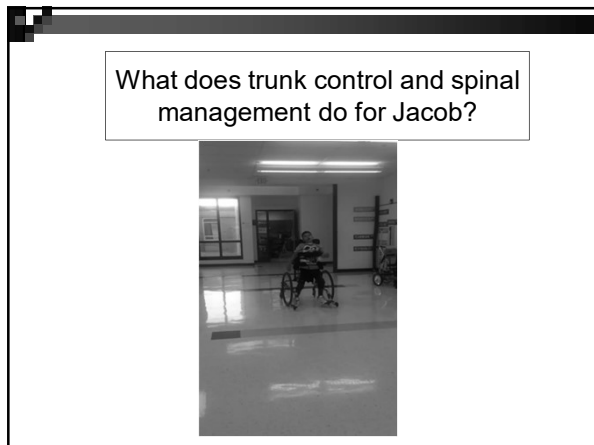
Jacob 6 y/o

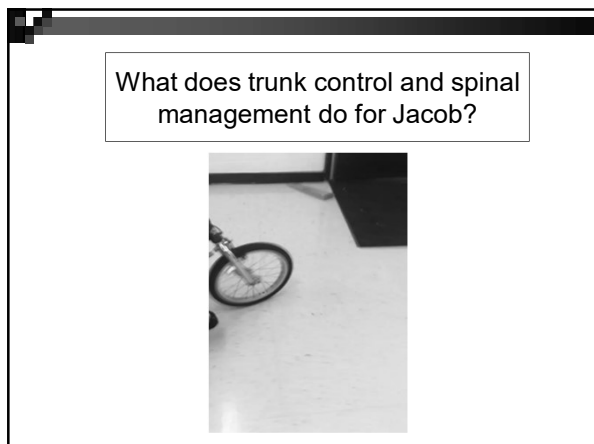


7 y/o



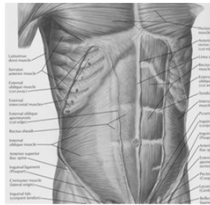






New definition of "Core"

- Core stability extends from the vocal folds on top to the pelvic floor on the bottom and includes every muscle in between!
- All the trunk muscles support postural stability and simultaneously support their primary functions such as respiration, cough, limb force production, spinal control, continence, etc.
- Breathing, postural control, and the trunk pressures needed for optimal motor function, cannot be assessed or treated separately!



It's all about the can!



MASSERY PHYSICAL THERAPY

Mary Massery, PT, DPT, DSc
3820 Timbers Edge Lane
Glenview, IL 60025
wk: 847-803-0803
fax: 847-803-8654
e-mail: mmassery@aol.com
website: www.MasseryPT.com

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Part 2

Treatment Suggestions

Positioning Considerations

- Optimize breath support and trunk alignment
 - Spine/chest
 - Lumbar lordosis critical for breathing and posture
 - Towel rolls, other simple devices to align spine
 - Pelvis position
 - Anterior tilt – increases chest recruitment for breathing/posture
 - Posterior tilt – blocks chest. By default, increases diaphragm recruitment
 - Shoulders
 - UE Flex, Abd, ER
 - Increased chest recruitment/alignment, increase head control
 - UE Ext, Add, IR
 - Increase diaphragm recruitment, increase trunk flexion, swallow

Massery 1994

Ventilatory/Movement Strategies

- A ventilatory strategy is the intentional pairing of inhalation & exhalation patterns with movement in order to enhance the overall motor task.



Principles of Ventilatory Strategies

- Thoracic spine movements: coordinate with respiration
 - Flexion – exhalation
 - Extension – inhalation
- Matching breathing pattern or strategy
 - Inhalation
 - Increased thoracic spine extension needed?
 - Neutral thoracic spine needed?
 - Exhalation
 - Passive?
 - Eccentric?
 - Concentric?
- Matching sensory strategies
 - Visual cues
 - Auditory cues

Massery 1994, Doidge 2007, Butler 2014, Lamberg 2014

The Movement: Reaching up to kitchen cabinet

Thoracic Spine Movement
Matching Respiratory Phase
Type of muscle contraction needed
Matching Respiratory Response (ventilatory strategy)
Matching visual strategy
Matching auditory strategy
SAMPLE: Reaching up to kitchen cabinet

The Movement: Reaching up to kitchen cabinet		
Thoracic Spine Movement	Flexion	Extension
Matching Respiratory Phase		
Type of muscle contraction needed		
Matching Respiratory Response (ventilatory strategy)		
Matching visual strategy		
Matching audible strategy		
SAMPLE: Reaching up to kitchen cabinet		

The Movement: Reaching up to kitchen cabinet		
Thoracic Spine Movement	Flexion	Extension
Matching Respiratory Phase	Exhalation	Inhalation
Type of muscle contraction needed		
Matching Respiratory Response (ventilatory strategy)		
Matching visual strategy		
Matching audible strategy		
SAMPLE: Reaching up to kitchen cabinet		

The Movement: Reaching up to kitchen cabinet			
Thoracic Spine Movement	Flexion		Extension
Matching Respiratory Phase	Exhalation		Inhalation
Type of muscle contraction needed	<i>Concentric</i>	<i>Eccentric</i>	<i>Concentric</i>
Matching Respiratory Response (ventilatory strategy)			
Matching visual strategy			
Matching audible strategy			
SAMPLE: Reaching up to kitchen cabinet			

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