The Diaphragm's Role in Postural Control & Treatment of the Inspiratory Muscles

1

I have no relevant financial relationships to disclose

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Objectives

1. Describe the role of the inspiratory muscles on postural control
2. Differentiate between available inspiratory muscle devices and their respective advantages/disadvantages
3. Discuss and observe inspiratory muscle training techniques

3

Extrapulmonary roles of the diaphragm

Venous and lymphatic return

Continence

Gastroesophageal functions

Postural Control and Trunk Stabilization

4

Diaphragm's role in trunk & postural control

Anatomical attachments

Models demonstrating intra-abdominal pressure

Experimental data

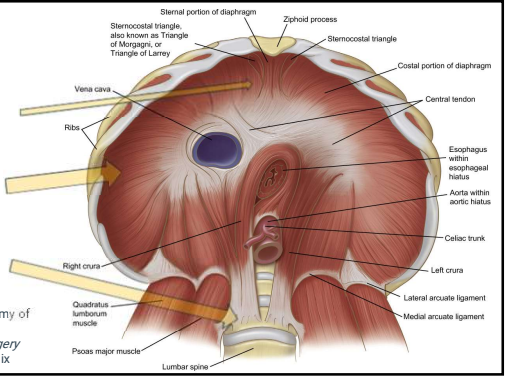
5

Attachments

Sternal

Costal

Crural



Downey, Robert J.. "Anatomy of the normal diaphragm." *Thoracic surgery clinics* 21 2 (2011): 273-9, ix

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Early IAP Model

"…intra-abdominal pressure fluctuates considerably with respiration…could this pressure play a significant role in the mechanics of the trunk?

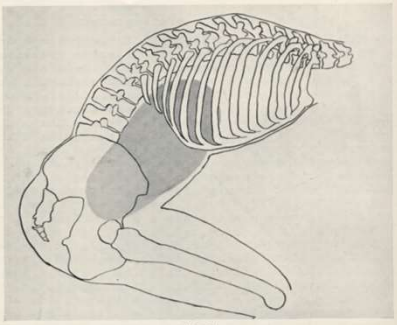

FIG. 3
Diagram to suggest how the abdominal fluid ball, as it is attached to the costal margin, would provide some support for the upper trunk, in case of lifting with the trunk flexed forward.

Bartelink DL, J Bone Joint Surg, 1957

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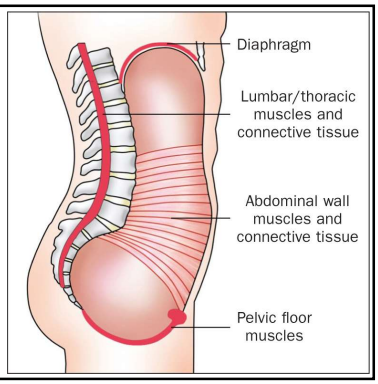
Current IAP Model

Interdependence between

- Thoracolumbar spine
- Lumbar spinal musculature
- Abdominal wall
- Diaphragm
- Pelvic floor musculature



Mills, J, Br J Nurs, 2023

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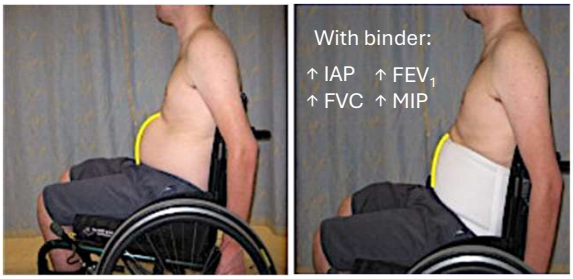
Abdominal Binder Improves Lung Volumes and Voice in People With Tetraplegic SCI



Wadsworth, BM *et al.* Arch Phys Med RehMills, J, Br J Nurs, 2023

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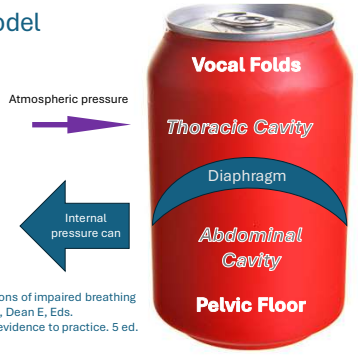
Massery "Soda Pop" Model



Massery M., (2012), Multisystem clinical implications of impaired breathing mechanics and postural control. In: Frownfelter D, Dean E, Eds. Cardiovascular and pulmonary physical therapy: evidence to practice. 5 ed. St. Louis, MO: Elsevier-Mosby; 2012: 633-653.

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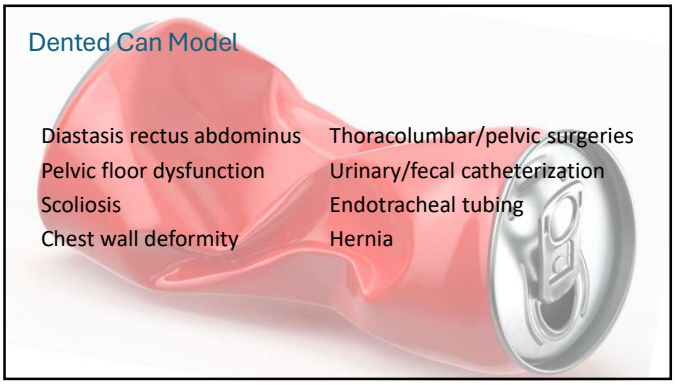
Dented Can Model



Diastasis rectus abdominus	Thoracolumbar/pelvic surgeries
Pelvic floor dysfunction	Urinary/fecal catheterization
Scoliosis	Endotracheal tubing
Chest wall deformity	Hernia

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Experimental data

Diagnostic modality studies (EMG, US, MRI) demonstrating diaphragm's contribution on trunk/postural control[6-10]

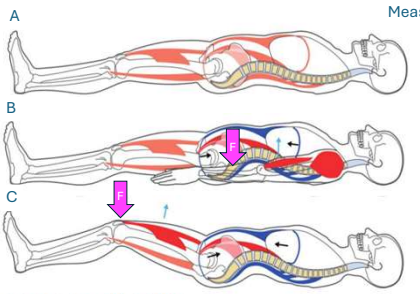
Respiratory muscle strength associations with balance[11-13]

Postural and balance impairment related to respiratory muscle strength in COPD[14-18]

Benefits of IMT on balance and older adults[11,19-20]

12

Stabilizing function of the diaphragm: dynamic MRI and synchronized spirometric assessment



Measured diaphragmatic excursion:

A. Resting, tidal breathing

B. Isometric flexion UEs

C. Isometric flexion LEs

Kolar, P *et al.* J Appl Physiol, 2010

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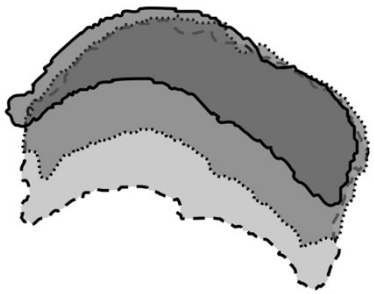
Stabilizing function of the diaphragm: dynamic MRI and synchronized spirometric assessment



Measured diaphragmatic excursion:

Resting, tidal breathing

Isometric flexion UEs

Isometric flexion LEs

Kolar, P *et al.* J Appl Physiol, 2010

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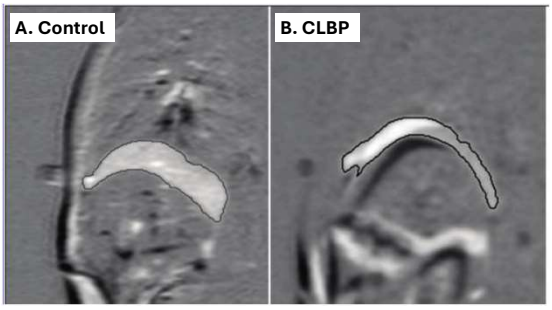
Postural function of the diaphragm in persons with and without chronic low back pain



Kolar, P *et al. J Orthop Sports Phys Ther. 2012*

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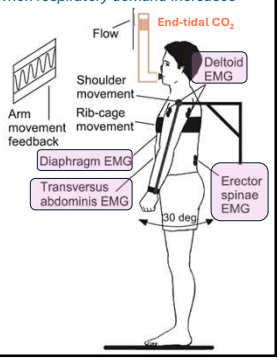
Postural activity of the diaphragm is reduced in humans when respiratory demand increases

- Suggested diaphragm's dual role in postural control and breathing via EMG recordings
- TrA & diaphragm contract automatically in response to a postural challenge before ES
- When ventilation demands ↑, diaphragm's role in breathing always takes precedence



Hodges, PW *et al.* J Physiol. 1997-2000
Hodges, PW *et al.* J Physiol. 2001

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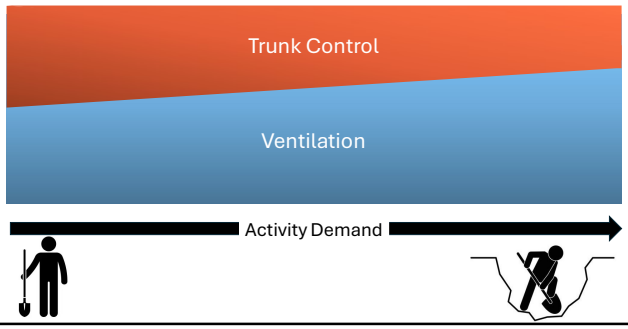
Diaphragm's dual function in ventilation and trunk control



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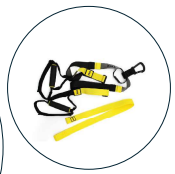
How do you strengthen the inspiratory muscles?



Strengthening the inspiratory muscles is not much different than these techniques

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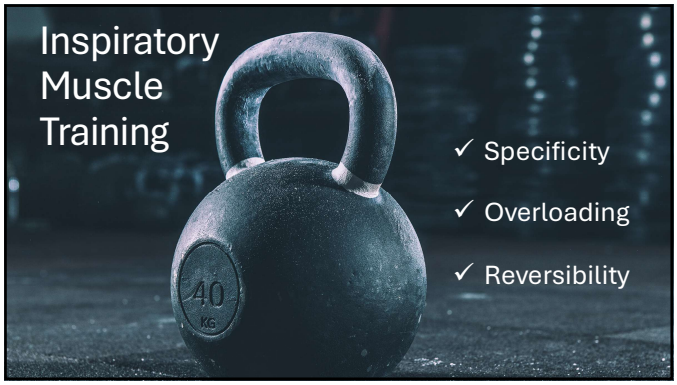

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Contraindications and Precautions

Any uncontrolled disorders which exercise is generally contraindicated

No formally recognized adverse effects

Potential for barotrauma

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Devices: Flow Resistance Trainers

Offers a dial with different sized holes

Load is based on diameter and varies based on orifice size and flow

No calibration of load

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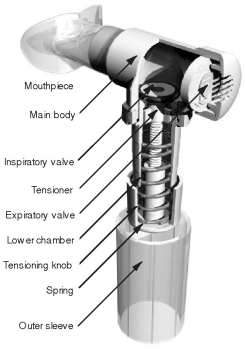
Devices: Threshold Trainers

- Most represented in literature
- User generates inspiratory pressure to overcome threshold
- Load can be quantified



Mcconnell. "Development and evaluation of a pressure threshold inspiratory muscle trainer for use in the context of sports performance." *Sports Engineering* 3 (2000): 149-159.

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PHILIPS Respironics Threshold IMT

- Unidirectional flow with one-way valve
- Large price increase since COVID-19 (was $25-30)
- Resistance = 9-41 cm H_2O
- Current price ~ $60-90

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PrO2FIT TM

- Resistive loading device that connects mobile app
- Allows measurement and training with data stored to the cloud
- Resistance = unlimited
- Price ~ $400

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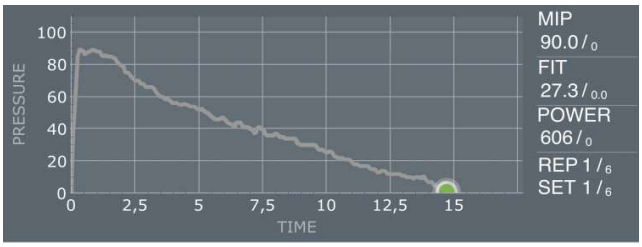
PrO2FIT TM



OK to use this baseline to train? **Recreate** **Train** **Done**

Formiga, MF *et al.*, Int J Chron Obstruct Pulmon Dis, 2020

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Powerbreathe

UK based company offering several options of threshold devices

Resistance = varies by device but typically 20-180 cm H_2O

Price ~ $50-90

"Classic"

"Plus"

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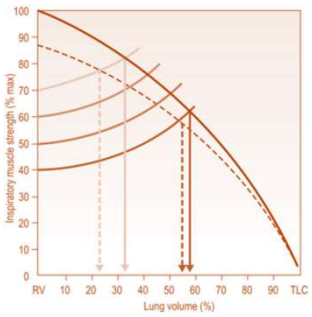
Recommended Dose

Recruit from RV to largest lung volume possible

At very least 30% MIP to begin

30 breaths, 2x/day, 8-12 weeks

MIP MCID is 17.2 cm H_20



McConnell, Alison. (2013). Respiratory Muscle Training: Theory and Practice.

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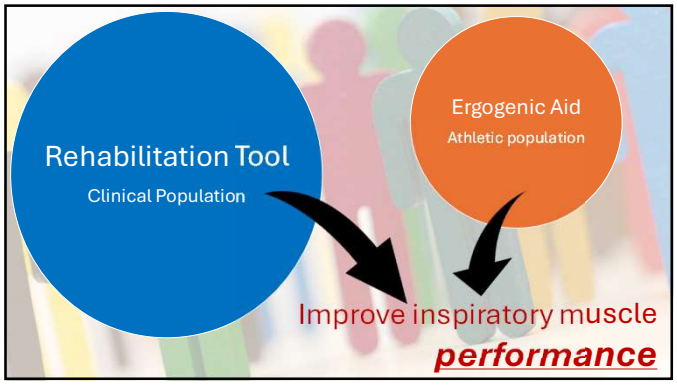

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Thank you!

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