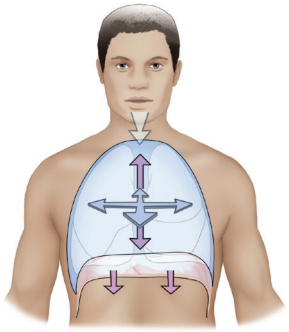
BREATH OF FRESH AIR

surestep Megan Smith, CO | Former Director of Education & Research | info@surestep.net

Take a deep breath. In and out. In and out. What moves? Really pay attention. In and out. In and out. You should feel movement in multiple places and different planes of motion.

Did you feel your abdomen move? What about your ribs? Superior chest wall? My guess is that you felt at least one area and maybe all three!

There are variances in "normal" breathing patterns, with some being more efficient than others. In normal inhalation, the diaphragm contracts inferiorly toward the pelvic floor, causing a slight rise of the upper abdomen. Next, the lower chest expands laterally. Lastly, upper chest will rise slightly in the anterior/superior direction **(Figure 1).**



• **Figure1**
Typical movement during quiet breathing

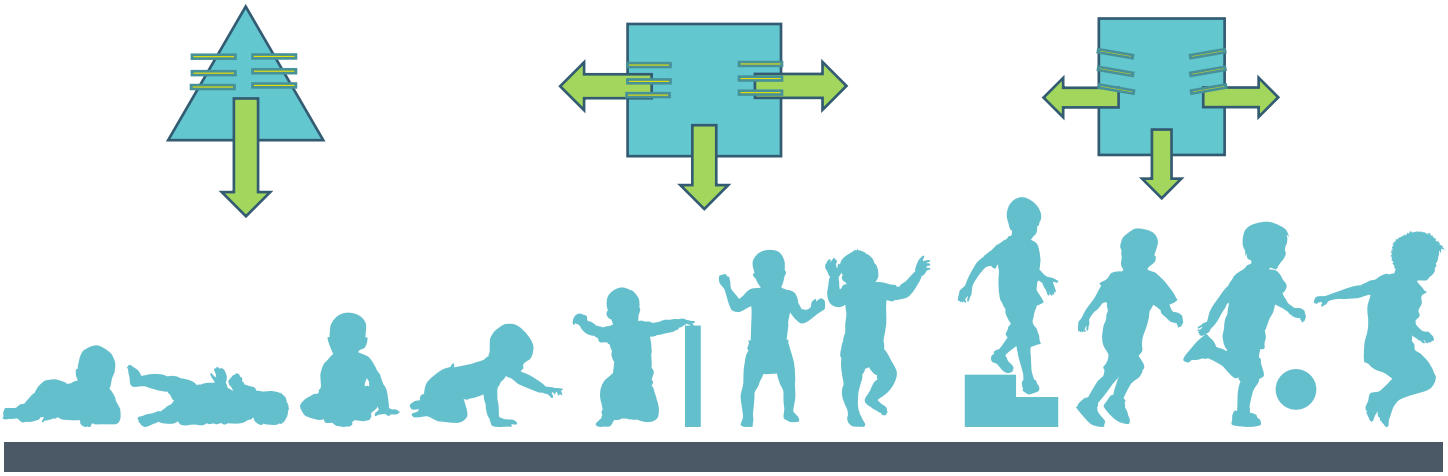
What if these areas couldn't move because they were restricted? How would you feel? Would it change your endurance levels? What about your ability to stand, walk or talk?

Children with neuromuscular deficits frequently present with postural control and gait deficits. As orthotists, we are familiar with evaluating for and fitting lower extremity orthoses. But many of these patients also present with poor trunk control and/or scoliosis. The effectiveness of lower extremity orthoses can be affected by a patient's breathing and trunk posture. To maximize the effectiveness of our interventions, we must understand the connections between postural control, breathing and gait and how we can facilitate better function and coordination of all three.

As you discovered, breathing happens in all 3 planes of motion and is a dynamic component of postural stability. Breathing, postural control and trunk pressure are necessary for optimal motor function and participation. When compromised, the diaphragm will support respiration before supporting postural control.

How are they related?
Postural control starts to develop in infancy. Typically developing children play on the floor to gain experience "pushing" against gravity in a variety of positions. The ability to push is achieved by creating intra-abdominal and intra-thoracic pressure (IAP & ITP) and is vital to chest wall and postural control development. The development of breathing and the chest wall does not happen due to only the passage of time, but with the inputs, variability and practice of movement.

Breathing always wins over postural control



• **Figure 2.** The development of the chest wall and breathing are related to the inputs, variability and practice of movement

Infants have a triangular shaped trunk and are innate belly breathers – with little to no rib cage movement. Between 4 and 6 months of age, IAP increases and the diaphragm attains its position in the transverse plane. Around 6 months of age, costal breathing is fully established. The chest should change shape from triangular to rectangular and lumbar lordosis should be present. Non-coincidentally, this is also when infants are working in prone on the floor, rolling and pushing into various positions. As the child continues to progress in upright gross motor skills, the ribs shift to a slightly downward sloping position and the chest wall elongates.

Patients with neuromuscular deficits often lack practice and variability as well as the ability to push and will pull themselves into positions due to a lack of IAP & ITP. Immature development of the diaphragm and respiration limit development of the chest wall and restrict pulmonary function, GI function, speech and postural control. These can have great impacts on overall function, gait and caregiver dependence.

How can we help?
Orthotic interventions, both lower extremity and trunk, can play a role in improving postural control and breathing! A TLSO should be considered when a child presents with reduced lumbar lordosis, poor head control, poor trunk control, increased pulling into positions and developmental delay. But we must be sure our patients can move and breathe in them.

Studies have shown that TLSOs impact gait and pulmonary function in typical adults. Patients with neuromuscular deficits can benefit from TLSOs; however, it is important to monitor pulmonary function. Postural control must be mid-range for maximum efficiency. Dynamic balance between stability and mobility of the trunk is required for optimal postural control and breathing.

Traditionally, TLSOs are fabricated with a thick, rigid plastic without breathing modifications. Oftentimes, orthotists aim to improve alignment without evaluating or considering respiratory function. TLSOs with abdominal cutouts, when compared to TLSOs without abdominal cutouts, have been shown to improve pulmonary function at rest and post-exercise in typical adults.

Flexible TLSOs that support the trunk and allow mid-range movement with breathing modifications that mimic typical breathing patterns should be considered for patients with compromised pulmonary function. These modifications include abdominal cutouts with binders, lateral rib gill modifications and anterior chest gill modifications **(Figure 3)**.

TLSOs can positively affect trunk position, postural control and spinal development. Clinicians should not evaluate gait, postural control and alignment without evaluating breathing and chest wall development. To maximize functional results of TLSOs, clinicians should work closely with the patient's care team include breathing modifications to improve trunk strength and postural control.

and

• **Figure 3.**
Three available breathing modifications: Abdominal cutout; Lateral rib gill; Anterior/Superior Chest gill

References

1. Chapman E, Hansen-Honeycutt J, Nasypany A, et al. A Clinical Guide to the Assessment and Treatment of Breathing Pattern Disorders in the Physically Active: Part 1. Int J Sports Phys Ther. 2016;11(5):803-805.
2. Frownfelter D, Stevens K, Massery M, Bernardoni G. Do Abdominal Cutouts in Thoracolumbarsacral Orthoses Increase Pulmonary Function? Clinical Orthopaedics and Related Research. 2013;472(2):720-726.
3. Hernandez L, Manning J, Zhang S. Voluntary Control of Breathing Affects Center of Pressure Complexity During Static Standing in Healthy Older Adults. Gait & Posture. 2019;68:488-493.
4. Hodges P, Sapsford R, Pengel LHM. Postural and Respiratory Functions of the Pelvic Floor Muscles. Neurology and Urodynamics. 2011;26:362-371.
5. Hudson A, Butler J, Gandevia S, et al. Interplay Between the Inspiratory and Postural Functions of the Human Parasternal Intercostal Muscles. 2010;103(3):1622-1629.
6. Janssens L, McConnel A, Pijnenbrg M, et al. Inspiratory Muscle Training Affects Proprioceptive Use and Low Back Pain. Medicine & Science in Sports & Exercise. 2014;47(1):12-19.
7. Keles M, Elbansan B, Apaydin U, et al. Effects of inspiratory muscle training in children with cerebral palsy: a randomized controlled trial. Brazilian Journal of Physical Therapy. 2018;22(6):493-501.
8. Khanali M, Arazpour M, Hutchins S, et al. The influence of the thoracolumbarsacral orthosis on standing balance in patients with adolescent idiopathic scoliosis: a pilot study. Disability and Rehabilitation Assistive Technology. 2014; Early Online:1-6.
9. Kocjan J, Adamek M, Gzik-Zroska B, et al. Network of breathing. Mulitfunctional role of the diaphragm: a review. Advances in Respiratory Medicine. 2017;85:224-232.
10. Konz R, Fatone S, Gard S. Effect of restricted spinal motion on gait. Journal of Rehabilitation Research & Development. 2006;43(2):161-170.
11. Massery M, Hagina M, Stafford R, et al. Effect of Airway Control by Glottal Structures on Postural Stability. J Appl Physiol 2013;115(4):483-490.
12. Massery M. Chest Development as a Component of Normal Motor Development: Implications for Pediatric Physical Therapists. Pediatric Physical Therapy. 1991;3(1):3-8.
13. Massery M. 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.
14. Morillon S, Thumerelle C, Cuisset J, et al. Effect of Thoracic Bracing on Lung Function in Children with Neuromuscular Disease. Ann Readapt Med Phys. 2007;50(8):645-650.
15. Pavao S, Nunes G, Santos A, et al. Relationship between static postural control and the level of functional abilities in children with cerebral palsy. Brazilian Journal of Physical Therapy. 2014;18(4):300-307.
16. Van Criekinge T, Truijen S, Hallemans A, et al. The influence of thoracolumbarsacral orthosis on gait performance in healthy adults during walking. Acta of bioengineering and biomechanics / Wroclaw University of Technology. 20(4). 10.5277/ABB-01201-2018-02.