POSITIONING AND PULMONARY FUNCTION

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OVERVIEW

A significant relationship exists between posture and pulmonary function. For example, the expiratory flow is the greatest in standing, decreases in upright sitting and significantly decreases in the slumped seated posture (Barks & Davenport, 2012). Breathing occurs in three dimensions: anterior-posterior, superior-inferior and laterally. All daily tasks require a symbiotic relationship between breathing and the posture demands of the trunk such as breathing, coughing, sleeping, eating, talking and moving (Massery, 2012). Respiration function is impacted in several populations such as those with spinal cord injury (SCI).

SPINAL CORD INJURY AND RESPIRATION

Respiratory complications lead to increased morbidity and mortality rates in people with SCI. Compromised breathing is evident in the lying position for individuals with tetraplegia and presents as sleep-disordered breathing (sleep apnea and snoring) and occurs at a higher rate than in the able-bodied population (Hitzig et al., 2011). Furthermore, increased stress is placed on the respiratory system in the seated position for people with SCI, caused by the displacement of the ribcage as a result of a forward flexed posture (posteriorly tilted pelvis, kyphotic thoracic spine and hyperextended cervical spine). The forward flexed seated position negatively impacts the strength and efficiency of the respiratory muscles (Hitzig et al., 2011; Torres-Castro et al., 2016). In addition, many individuals with neurological health conditions may have reduced or lost the ability of intrinsic mobility of the chest wall muscles (Massery, 1994). Additional risk factors that further impact respiration include increased body weight, smoking and exposure to air pollutants.

For individuals with spinal cord injury, diminished trunk control and restrictive breathing are often secondary complications associated with poor positioning and/or inadequate support from the wheelchair seating system. Individuals who self-propel their manual wheelchairs are likely to experience frequent and recurrent periods where their upper limbs are in internal rotation and abduction, during wheelchair propulsion. Not only is this positioning pattern known to result in musculoskeletal injuries associated with overuse of the upper limbs, but this posture is also linked with reduced respiratory inspiration volume (Massery, 1994; Paralyzed Veterans of America, 2005).

Proper positioning may positively influence respiration, allowing for maximal chest wall expansion (Barks & Davenport, 2012; Massery, 2010; Pope, 2007). Chest wall expansion can be facilitated in lying, sitting and standing - as all postures are linked.

PROMOTING RESPIRATION THROUGH ALTERNATIVE POSITIONING

Massery (1994) outlined the postures to promote respiratory inspiration and expiration in lying, sitting and standing. Some of these postures are designed to be assumed short-term for respiratory improvement; however, they are not practical for longer-term pressure distribution or functional activities. These are summarized as follows in Table 1.

SEATED POSTURE AND POSITIONING FOR RESPIRATION

Massery (1994) described upright postures and activities and the challenges related to breathing and balance, with specific reference to the "unsupported spine" (p.12). Pelvic position and alignment dictate the position of the body segments above and below the pelvis. If the pelvic position is in neutral or anterior pelvic tilt, the upper body has the potential for improved upright positioning against gravity – thereby promoting respiration quality and quantity. Massery (1994) stated how the orientation of the neutral or anteriorly positioned pelvis in healthy adults will not only promote respiration but also improve upper extremity positioning and range of motion potential. Massery (1994) outlines the symbiotic relationship between seated posture, positioning and respiration:

- Reduce the kyphotic curve of the spine.
- Adduct the scapula (or encourage a more neutral position).
- Promote neutral or externally rotated upper extremity positioning.
- Promote head position and a neutral chin orientation (p12).

Massery (1994) stated often the mere correction of the pelvis can serve to improve both posture and respiration. Conversely, when the pelvic alignment is in posterior pelvic tilt, the upper body tends to migrate into a forward flex kyphotic posture and reduces the chest and abdomen space thereby impacting the ability for the diaphragm and lungs to contract and expand respectively. This forward flexed posture in upright

LYING	

INSPIRATION:
• Decrease the number of pillows under the head: Respect the length-tension relationship of neck accessory muscles (sternocleidomastoid and scalene muscles).
• In the event of any functional limitations/restrictions to range of motion: For example, someone with upper extremity paralysis but adequate shoulder mobility can maximize inspiration by placing their arms in a supported flexion/abduction/external rotation position to maximally stretch the neck, pectoralis and intercoastal upper chest wall muscles. Gravity will help to increase the end range of the upper extremity.
• Improvement: The following can stretch the anterior muscles of the chest wall:
  • Neutral or retracted scapula with the humerus in an externally rotated position.
  • Hands behind the head.
  • Towels/pillows behind the elbows to support the upper extremity at the end range.
  • Forearm in supination (promoting external rotation of the upper limbs).
  • Towel behind the thoracic spine.
	EXPIRATION:
	• Trunk flexion
	• Shoulder extension
	• Shoulder adduction
	• Shoulder internal rotation

SITTING	
INSPIRATION: • Pelvis position: Leaning forward. Towel placement to create anterior pelvic tilt will promote upper body extension/ reduce kyphotic posture resulting in chest wall expansion. Gravity assisting the diaphragm – the inferior plane of respiration. • Head position: Neutral head and neck: important for swallowing and speech volume. • Shoulder positioning: Reaching with external rotation (rather than internal rotation) results in greater chest wall movements/ thoracic extension for increased inspiratory volumes.	**EXPIRATION:** • Posterior pelvic tilt • Trunk kyphosis • Knee flexion
STANDING	
INSPIRATION: • Requires both trunk flexion/extension. • Initiate standing with inhalation and neck in extension.	**EXPIRATION:** • Forward lean - exhalation • Stand to sit - exhalation - counting out loud to control decent and exhalation.

TABLE 1 Summary of Postures for Inspiration and Expiration
Note. Summarized from Massery (1994) What's positioning got to do with it? (see Figure 1).

sitting has been associated with individuals with diagnoses such as SCI, neurodegenerative health conditions and those presenting with low muscle tone in the trunk. Massery (1994) acknowledged that prolonged active sitting to promote a neutral or anteriorly positioned pelvis is challenging for individuals with health conditions and may require passive assistance.

IMPLICATIONS FOR PRACTICE

Positioning practices can be implemented to help mitigate respiratory complications and have a positive impact on the quality and quantity of respiratory function. Providing solutions in lying, sitting and standing for the implementation of small daily changes to positioning may be a viable solution for people with SCI who are concerned with their respiratory function.

SEATED POSITIONING:

Provision of posterior support in the seated posture promotes the lumbar curve and decreases thoracic kyphosis for those individuals with reducible postural asymmetries. Greater expansion of the rib cage can be promoted leading to improved quality of inspiration

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Place a rolled up towel vertically between your shoulder blades along the spine.

Be sure to have your palms facing the ceiling

For exhalation = Palms facing DOWN

For inhalation = Palms facing UP

For lying, sitting or standing postures: to promote inhalation, arms should be away from the body to expand the chest.

For lying, sitting or standing postures: to promote inhalation arms should be away from the body to expand the chest. If possible, hands to the head or near to the head.

FIGURE 1 **Postures for Breathing**
The following are postures that will promote the intake of air into the lungs during inspiration. The opposite postures and arm placement will promote exhalation.

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(Torres-Castro et al., 2016). Many off-the-shelf back supports can provide generic or customized support to the upper pelvis and lower spine to promote a neutral pelvic tilt and spinal extension, thereby the expanding the chest. Used in combination with anterior trunk supports, counterforce can be provided to ensure that the appropriate level of support is in place to promote respiration. Introducing posterior supports should only be implemented after a comprehensive mat eval of the person and their posture to prevent hyperlumbar lordosis or micro stress and shear on the lumbar region.

SCI clients with non-reducible asymmetries and established postural habits and patterns may require a more custom approach as "off-the-shelf" solutions will not align with body contours (Pope, 2007).

Providing support to the lower abdomen in the seated posture can also be a beneficial intervention. Decreased abdominal muscle strength is noted in people with SCI as a result of their level of injury. In the seated position, abdominal structures are less supported due to decreased abdominal wall muscle tone, resulting in lowering of the diaphragm. Supporting the abdomen can support respiration and provide a measure of postural support to the trunk. Wadsworth et al. (2009) reviewed studies relating to the use of abdominal binders for breathing, speech and cardiovascular function for individuals with an SCI. The review concluded that abdominal binders improve the vital capacity of individuals with SCI. Variables relating to the use, materials, size (girth and height) and positional orientation of the abdominal binder need to be investigated to ensure the desired outcome. Wadsworth et al. (2012) reported that an individually fitted abdominal binder improved forced vital capacity, forced expiratory volume and resulted in maximum sustained vowel time in people with newly acquired tetraplegia.

SUPINE POSITIONING:

To promote expiration, the adoption of a supine lying position results in the weight of the abdominal contents providing support and elevation to the diaphragm in a cephalad direction and results in the ability to achieve greater excursion of the diaphragm. In a study of 10 healthy adults, it was concluded diaphragmatic movement in the supine position is greater than in the sitting position, especially in the posterior part of the diaphragm (Takazakura et al., 2004). To further aid individuals with tetraplegia, the head of the bed can be lowered from supine (tipped downwards) by 15 degrees to achieve a 6% increase in vital capacity (Berlowitz, 2016). While this position is associated with gains in respiration, the likelihood of being implemented is reduced. This position limits functional engagement and requires the individual to have access to a bed with this function.

CONCLUSION

Careful attention is needed during the assessment and provision of Complex Rehab Technology (CRT), specifically regarding equipment, positioning and

the location of positioning supports. The provision of external supportive surfaces must respect the three dimensions in which respiration occurs. Furthermore, the team must take into consideration the level of client injury and how this impacts the inspiratory muscles (T11) and the expiratory muscles (L3) (Torres-Castro et al., 2016). Fortunately, even introducing small postural changes in the positioning of the upper limbs can serve to assist and promote both inspiration and expiration in lying, sitting, and standing postures.

Addressing postures in lying, sitting and standing, in addition to providing positioning supports, can lead to improved pulmonary function. We know that standing postures yield the greatest respiratory potential and that slumped seated postures provide the least. For individuals with spinal cord injury with diminished trunk control, restrictive breathing is a secondary complication associated with poor positioning/inadequate support from the wheelchair/seating system. This must be addressed in the provision of equipment and positioning recommendations. Challenges exist regarding creating awareness and educating those who may be at a greater risk of decreased respiratory function as they continue to age with an SCI, as they may no longer be actively seeking or engaged in therapy services or interventions.

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