Breathing and Upright Posture: Simultaneous Needs

Presenter: Mary Massery, PT, DPT, DSc

Summary
As a cardiopulmonary physiotherapist rather than a seating and mobility (S&M) specialist, the presenter will propose a novel model based on a soda-pop can to establish a link between breathing, postural control and postural alignment for the seated patient, and will then make clinical suggestions.

Aims and Objectives
1. Identify the link between breathing, postural control and postural alignment.
2. Suggest postural support strategies to minimize and/or prevent restrictions on breathing while still managing trunk alignment in an upright seated position.
3. Apply these concepts to clinical cases where respiration was a major limiting factor in the patient's health and participation.
4. Present ideas for future research in this area.

Background
Breathing and postural mechanics are intertwined [1, 2] and should not be handled separately when designing a person's wheelchair and seating system. Wheelchair and seating systems for the non-ambulatory patient need to address the problems of optimizing upright alignment (musculoskeletal alignment), mobility (neuromotor control of locomotion) and skin integrity (cardiovascular). Perhaps less obviously, the seating practitioner should also be evaluating how wheelchair positioning affects breathing mechanics and vice versa.

Soda-pop can model of postural control: The aluminum shell of a soda-pop can is not structurally strong; easily crushed when empty or when the top is opened. However, when the can is intact, the internal pressures generated by the carbonated beverage make the aluminum can functionally quite strong and difficult to crush. Likewise, human skeletons are weak; easily crushed if the muscles supporting the skeleton, our "aluminum can", are unable to generate necessary internal pressures to counteract gravitational and atmospheric pressures acting upon it.[3, 4] Patients with profound weakness or paralysis such as in spinal cord injuries (SCI), suffer crushing forces upon their skeletons, overtime causing severe restrictions to the musculoskeletal system and internal organs, thereby restricting lung expansion.[5-7] The respiratory compromise is profoundly worse for children who acquire an injury prior to the time of skeletal maturation, as their developing skeletons are more adversely affected by gravity on their developing frames.[8]

A chronically slumped posture, the result of collapsing forces, can cause a multitude of postural deficiencies including:
1) a thoraco-lumbar kypho-scoliosis which compresses the anterior rib cage, often causing a mid trunk fold at the xiphoid process, thus restricting breathing mechanics
2) a compensatory forward head position on top of the thoracic kyphosis which compromises swallowing mechanics thereby increasing the risk of aspiration and mechanically compromising the recruitment of accessory muscles for increased lung volumes
3) a compensatory upper quadrant position including protracted scapula and humeral internal rotation, impairing shoulder mechanics as well as chestwall muscle recruitment for breathing, and
4) a posterior pelvic tilt with excessive hip external rotation thus further compressing forces at the mid trunk and pelvic floor further impairing the diaphragm's mechanical advantage.[9]

The diaphragm plays multiple simultaneous roles.[3, 10, 11] Each one is as vitally important as the other. Positioning strategies should take these roles into consideration. The diaphragm needs pelvic floor and abdominal muscle support to create intra-abdominal pressures in order to stabilize

the diaphragm's central tendon during inspiratory contractions.[12] This, in turn, supports the efficiency of the intercostal contractions above the diaphragm for maximizing inspiratory lung volumes.[13, 14] This coupling action between the diaphragm and intercostals produces greater drops in pleural pressures than either muscle alone.[15] Thus, preserving the mechanical advantage of both the diaphragm and the anterior chest wall is crucial for optimal breathing mechanics.[16, 17]

Discussion

Taking alignment, trunk internal pressure regulation and the newest research in the biomechanics of breathing, the seating practitioner should consider breathing mechanics in wheelchair prescriptions. For patients with weak trunks, supporting a lumbar lordosis and maintaining an open anterior chest wall appears critical to maximizing lung volumes and diaphragmatic function (controlling sagittal plane). Internal pressures may need support as well, especially intra-abdominal pressures. Suggestions to optimally support breathing mechanics are presented, but in no way exclude other ideas from seasoned seating practitioners. More research is needed.

Abdominal binders: may help to restore intra-abdominal pressure for breathing mechanics and pelvic alignment.[18, 19],

Passy Muir© or other Speaking Valves: Patients with tracheostomies who can tolerate a speaking valve will improve their ability to control intra-thoracic positive pressure because the vocal folds are restored as the expiratory pressure regulator.[20],[21-23]

TLSO: A thoraco-lumbo-sacral orthosis, also known as a "body jacket", needs an abdominal cutout for optimal diaphragmatic excursion.[24] An abdominal binder may also be needed for patients with abdominal muscle weakness.

Chest straps and lateral trunk supports: Straps effectively keep patients safely in wheelchairs, but they also bind the chest, encouraging a flexed spine and posterior pelvic tilt. Lateral trunk supports, also common devices, can decrease scoliotic forces, but they do not control the sagittal plane.[25]

Tilt- in- space seating: Research shows decrease pressure over the ischium in tilt-in-space wheelchairs.[26] However, whether to use a tilt and the angle of the tilt must be carefully assessed because of the increased risk for aspiration and the potential for aspiration pneumonia.

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Correspondence details
Mary Massery, PT, DPT, DSc
Massery Physical Therapy
3820 Timbers Edge Lane
Glenview, IL, 60025 USA

Email: mmassery@aol.com
www.MasseryPT.com