Pelvic Physical Therapy Distance Journal Club
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Adaptation of lung, chest wall, and respiratory muscles during pregnancy: preparing for birth.
LoMauro A, Alverti A, Frykholm P, et al. J of Applied Physiol 2019;127:1640-1650.
Doi:10.1152/japplphysiol.00035.2019.

Introduction:

- Biochemical and mechanical pathways affect anatomy and physiology of the respiratory system during pregnancy, resulting in changes in the subcostal angle and the thoracic and abdominal circumferences.
- Research demonstrates that max inspiratory and expiratory pressures do not change in pregnancy, suggesting that the respiratory muscles preserve function even as the abdominals, diaphragm, and ribcage accommodate the growing uterus.
- The diaphragm is multifunctional and uses only 10% of its force-generating capacity for respiration; has a large reserve of force generation that assists with bracing during delivery and parturition.

Aim/Primary Aim:

- To investigate chest wall geometry, breathing pattern, lung and thoracoabdominal volume variations, and diaphragm thickness and motion during each trimester of pregnancy in primiparous women, using accurate non-invasive techniques
- To examine the effect of the increasing abdominal content on the diaphragm in terms of stretch and loading

Study Design/Study Format: observational, longitudinal, controlled multidimensional study

Methods:

- Inclusion/exclusion criteria: healthy women >18 yo without chronic respiratory or other severe pathology (undefined), and with a BMI of <25 kg/m^2, which is the upper limit of “normal” weight classification. The control population were nulliparous women and the study populations were primiparous women.
- Data collected: All measurements were taken at the end of each trimester in the study population by single operators.
  - Spirometry and lung volumes were measured by body plethysmography.
  - Optoelectronic plethysmography (OEP) was used to analyze chest wall geometry, including subcostal angle, heights, diameters, perimeters, cross-sectional areas, and thoracoabdominal volumes (Fig 1). Volumes and ventilatory pattern were assessed during quiet breathing (QB) and during a slow vital capacity maneuver (SVC).
  - Calculated indices of velocity of diaphragmatic and rib cage muscle shortening
  - Ultrasound was used to measure diaphragmatic thickening fraction and maximal excursion of the dome of the diaphragm

- Statistical analysis: data reported as median, 25th, and 75th percentile; significance = p value of <0.05

Results: 39 total subjects: 18 primiparous, 21 nulliparous women

- Absolute value of vital capacity: no change with the progression of pregnancy during slow and forced maximal maneuvers in both sitting and supine
- No restriction of inspiratory capacity, expiratory reserve volume, or absolute lung volumes with progression of pregnancy
- The ribcage changed shape but volume remained constant with progression of pregnancy (Fig. 3)
- Duty cycle: no difference in position or trimester of pregnancy, similar to controls
- Breathing shifted from the chest to the abdomen with increasing gestation, greater abdominal contribution during the 3rd trimester measurements
- Diaphragm thickness, thickness fraction, and dome excursion remained constant and within range of nulliparous women at all trimester measurements (Fig. 6)
- Body position changes affected both pregnant and control subjects similarly
    - in all women, thickness of diaphragm was 33% less in supine

Discussion:

- Hormonal and mechanical changes during pregnancy result in reduced ribcage height and an upward bucket handle shift at the xiphoid. Study results are consistent as ribcage shape changed but volume remained the same throughout pregnancy, allowing for unrestricted lung function and abdominal expansion.
- During pregnancy, ribcage mm contribution to breathing was reduced, likely due to the altered orientation of the ribs, shortening ribcage muscle length and decreasing contractile force.
- Alternately, abdominal mm contribution to breathing during pregnancy increased, even though the mm lengthen as gestation progresses, and was higher in supine for all subjects.
- As the uterus increases in size, the diaphragm lengthens as a result of ribcage structural changes. Despite the resulting cranial shift of the viscera and its stretching effect, resting muscle thickness of the diaphragm did not change from T1 to T3 (as would be expected). The authors hypothesized that the lack of change in thickness of a lengthened-by-pregnancy diaphragm at end-range expiration might actually be associated with *increased* thickness if the diaphragm could be measured at the same length.

Strengths:

- able to measure multiple parameters of respiratory function related to structural changes of pregnancy using accurate, non-invasive techniques
- increased knowledge of maternal respiratory physiology may help to guide care in high-risk pregnancies
- authors suggest that results can be attributed purely to pregnancy and no other factors

Weaknesses:

- No evaluation of power to determine adequate sample size

- did not define recruitment of study participants
- some measurements speculative due to lack of non-invasive measurements (ethics)
- lack of follow-up into the post-partum period

Clinical Application:

- The first application they propose is a length-adaptive mechanism and/or conditioning effect of the diaphragm throughout pregnancy. They suggest that the diaphragm essentially works eccentrically as it lengthens during pregnancy, resulting in the potential for higher force dev't (or at least counters the decreased compliance of the abdominal muscles), allowing for an active role during parturition.
- Based on a combination of results from this study and a previous study by the authors, they concluded that co-contraction of the diaphragm and abdominal muscles can create expulsive force for delivery successfully with open glottis.
- Study results support upright positions as safer and more suitable for pushing as the force generation of the abdominal muscles during forced expiration is less efficient in supine.

Discussion questions

1. Are there any "tests" you use to assess breathing pattern during pregnancy? Any you think you should add based on this research?
2. Are pelvic PTs providing guidance to pregnant patients regarding breathing and positioning for labor and delivery?
3. Why do rib cage mm contribution to breathing and diaphragm thickness decrease in supine?
4. Realizing that we do not know if the observed changes in rib cage structure return to pre-pregnancy status, we should be assessing these functions post-partum. If these changes persist, is there any evidence on how these changes affect posture, pain, respiratory function, PF function/ disorders?
5. Any other ideas on how to address the ribs and diaphragm prenatal or post-partum?

Other references:

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