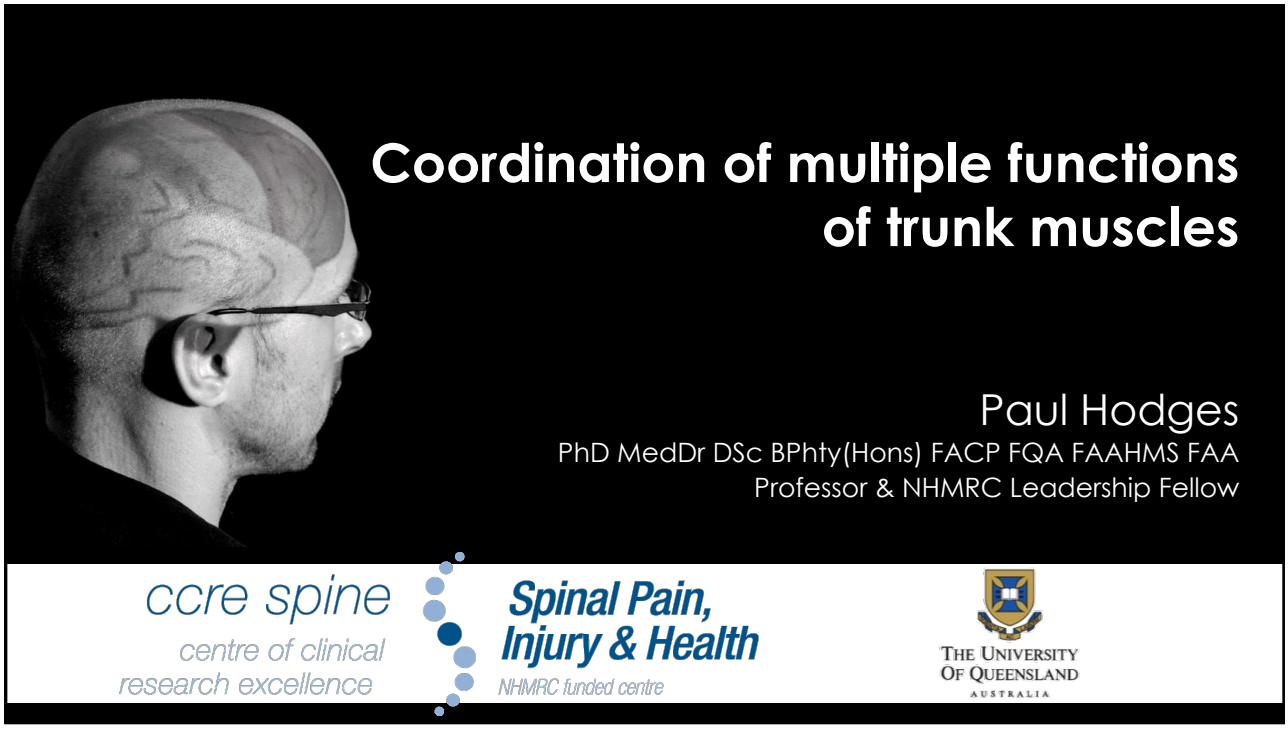
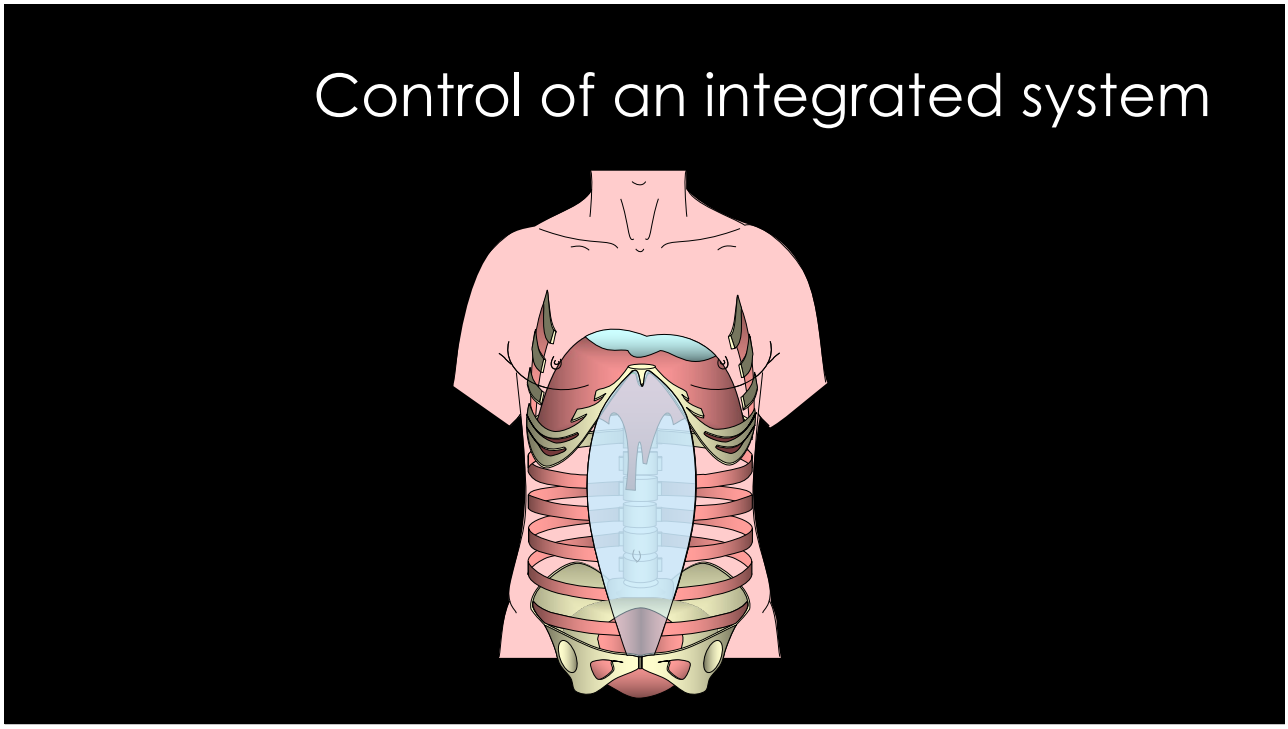
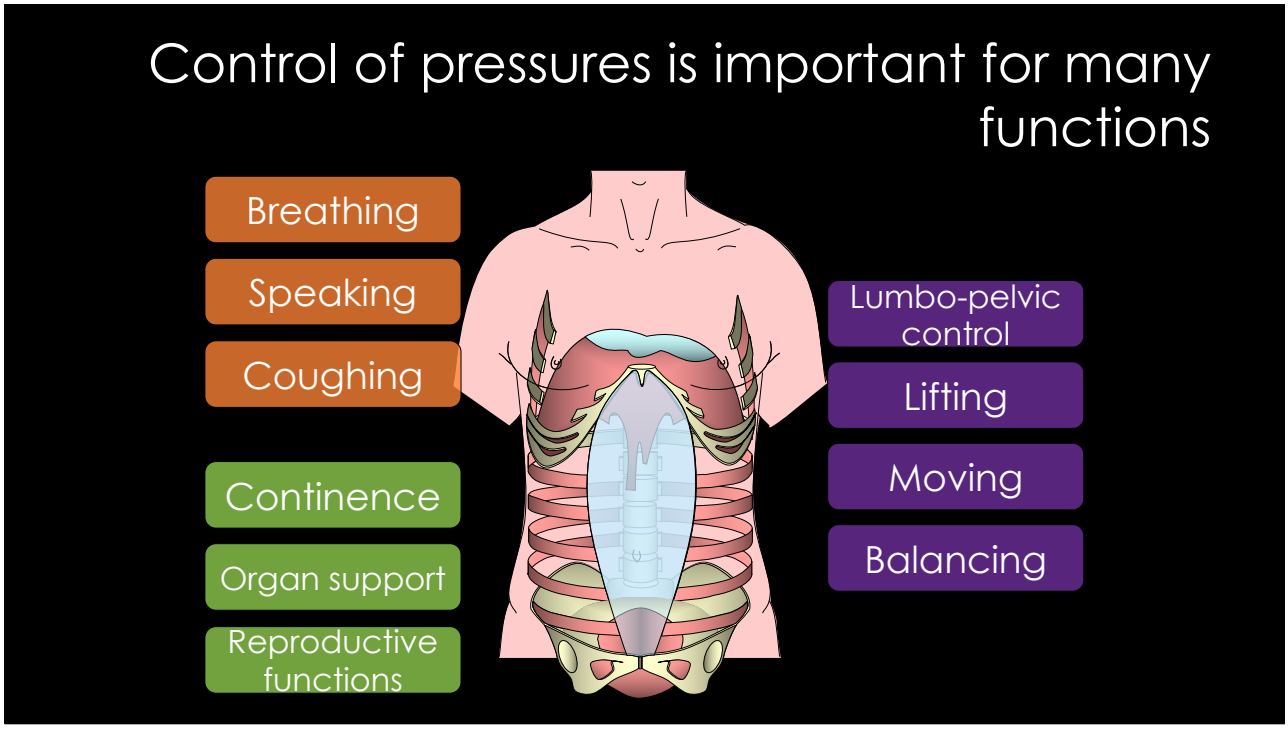

Coordination of multiple functions of trunk muscles
Paul Hodges
PhD MedDr DSc BPhty(Hons) FACP FQA FAAHMS FAA
Professor & NHMRC Leadership Fellow
ccre spine
centre of clinical research excellence
Spinal Pain, Injury & Health
NHMRC funded centre
The University Of Queensland
AUSTRALIA

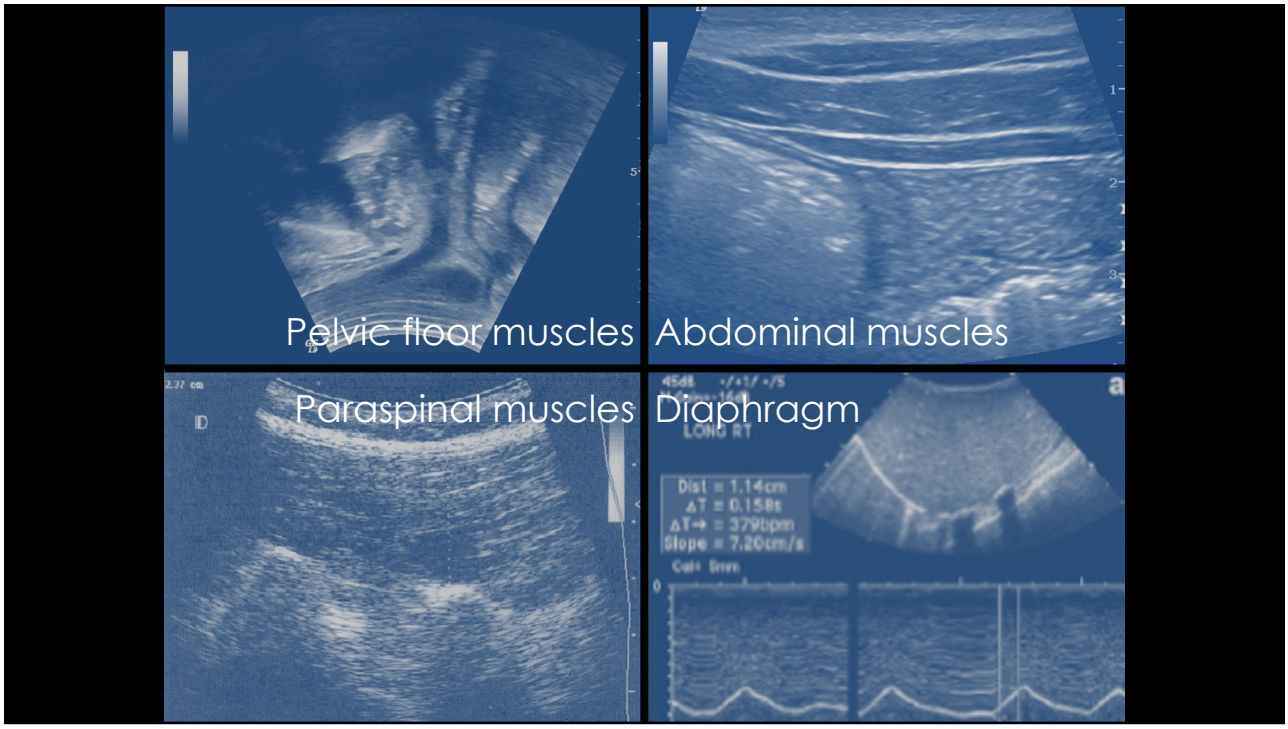
1


Control of an integrated system

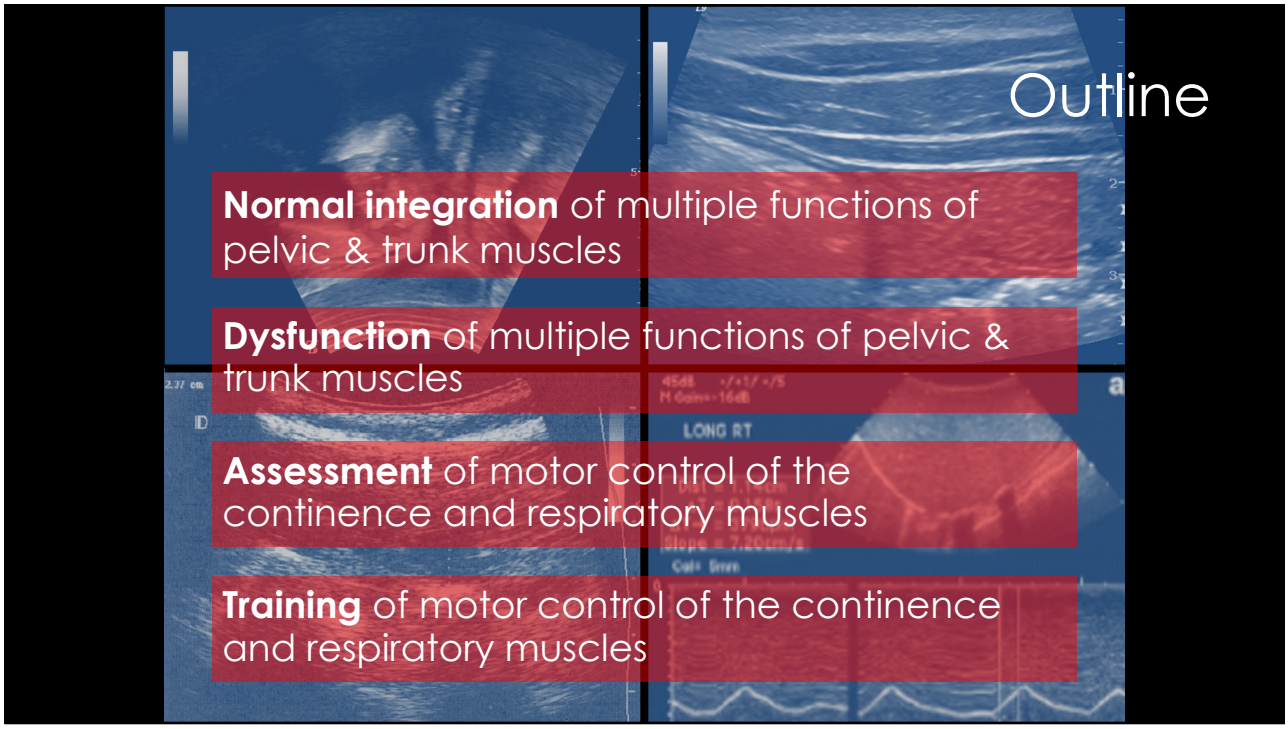
2


Control of pressures is important for many functions
Breathing
Speaking
Coughing
Continence
Organ support
Reproductive functions
Lumbo-pelvic control
Lifting
Moving
Balancing

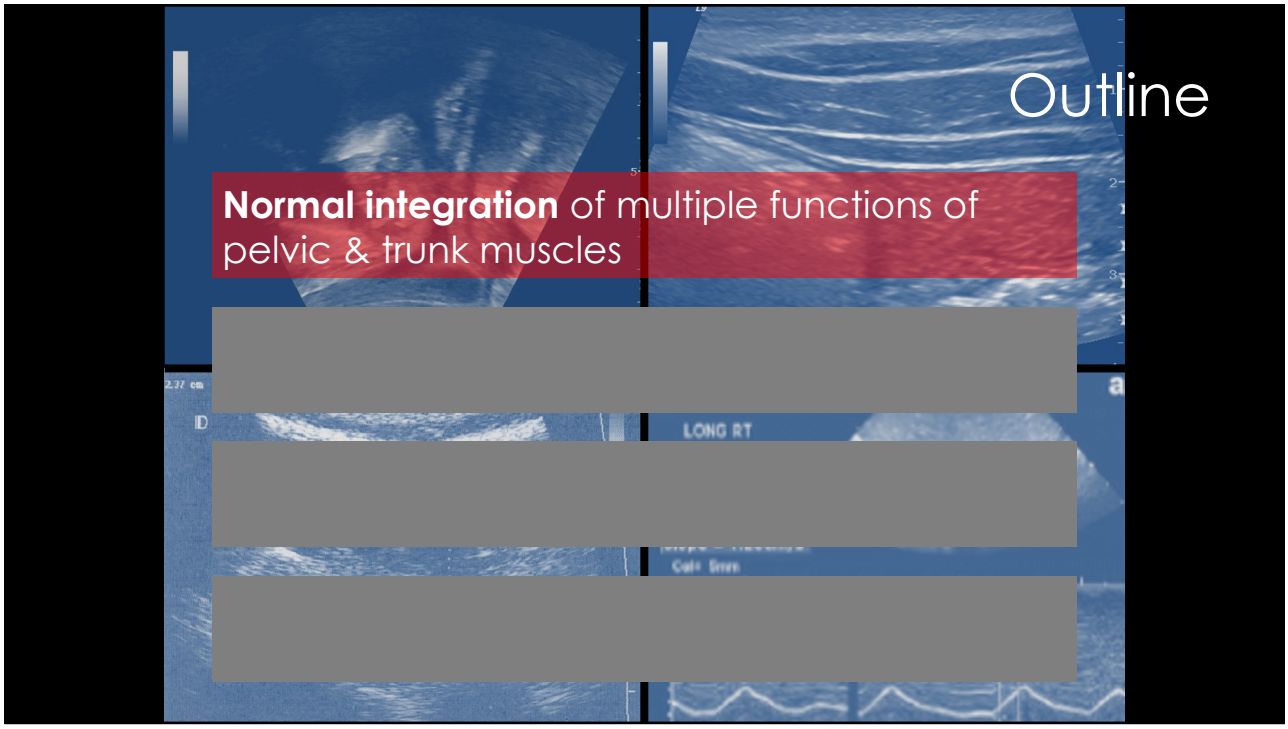
3


Pelvic floor muscles
Abdominal muscles
Paraspinal muscles
Diaphragm

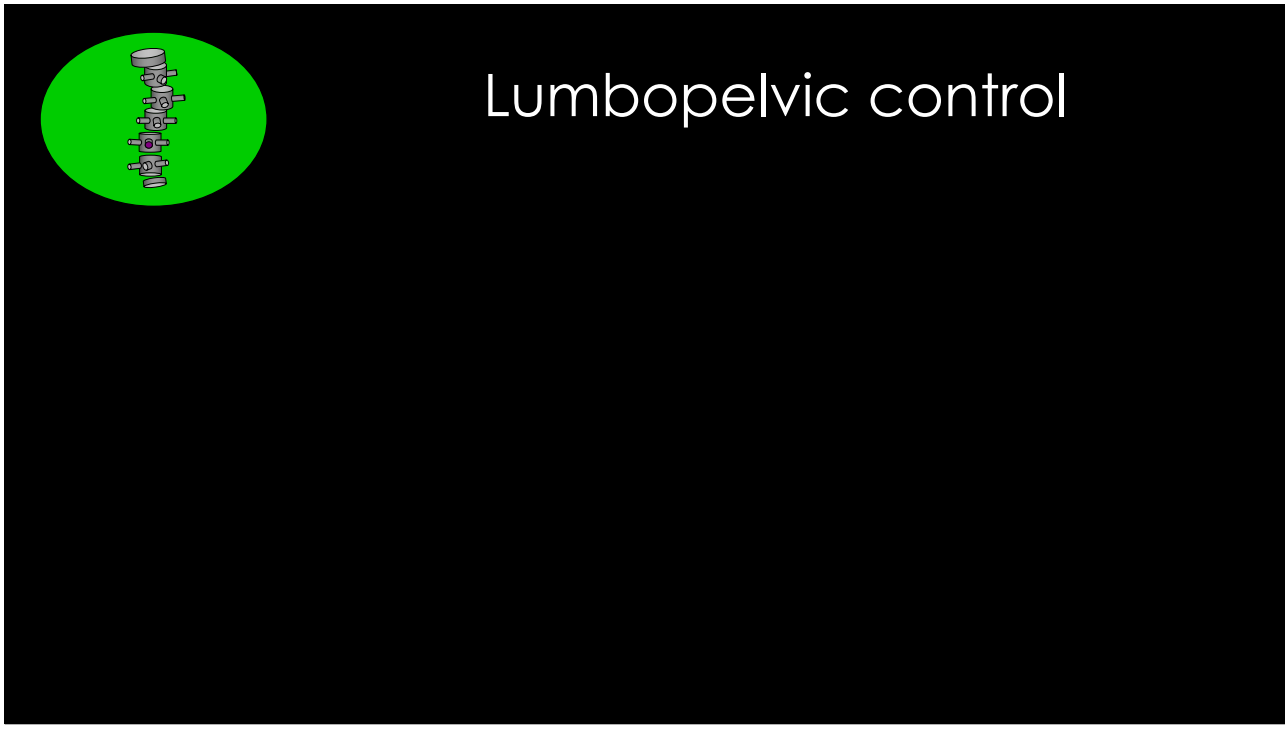
4


Outline
Normal integration of multiple functions of pelvic & trunk muscles
Dysfunction of multiple functions of pelvic & trunk muscles
Assessment of motor control of the continence and respiratory muscles
Training of motor control of the continence and respiratory muscles
LONG RT

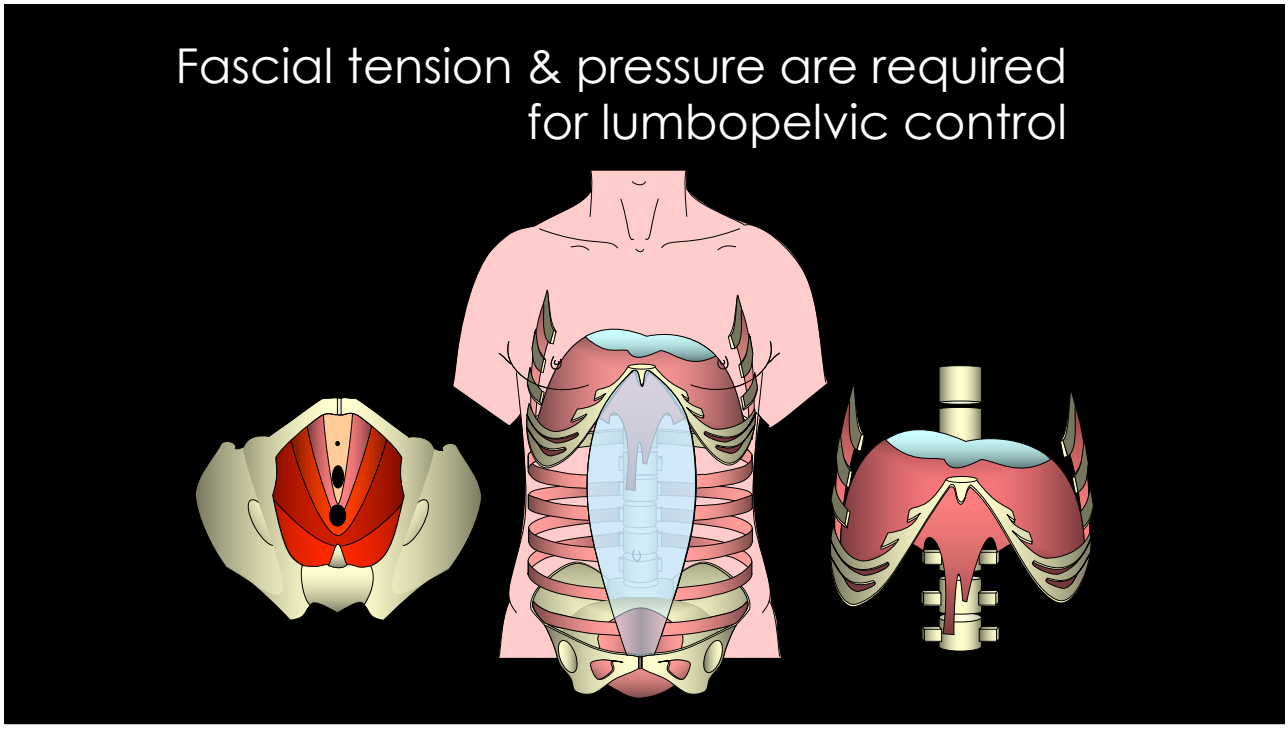
5


Outline
Normal integration of multiple functions of pelvic & trunk muscles
LONG RT

6

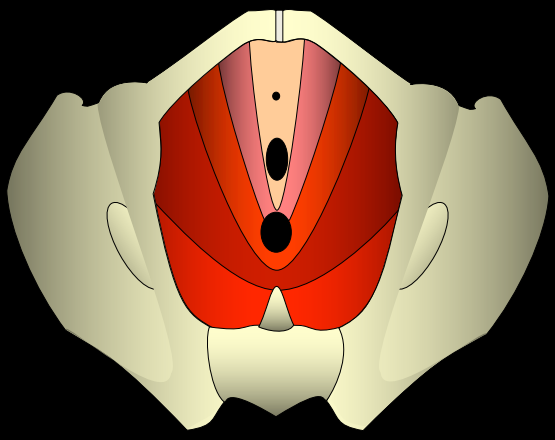

Lumbopelvic control

7


Fascial tension & pressure are required
for lumbopelvic control

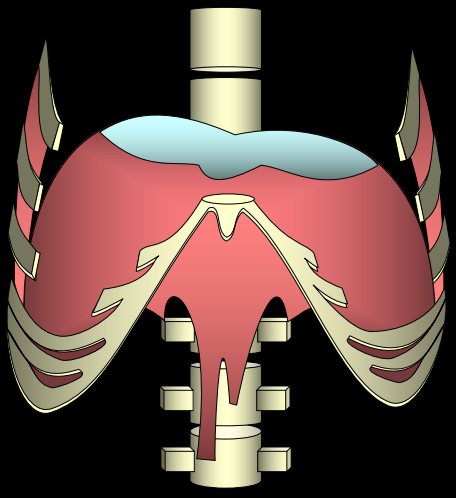
8

Pelvic floor muscles



9

Diaphragm



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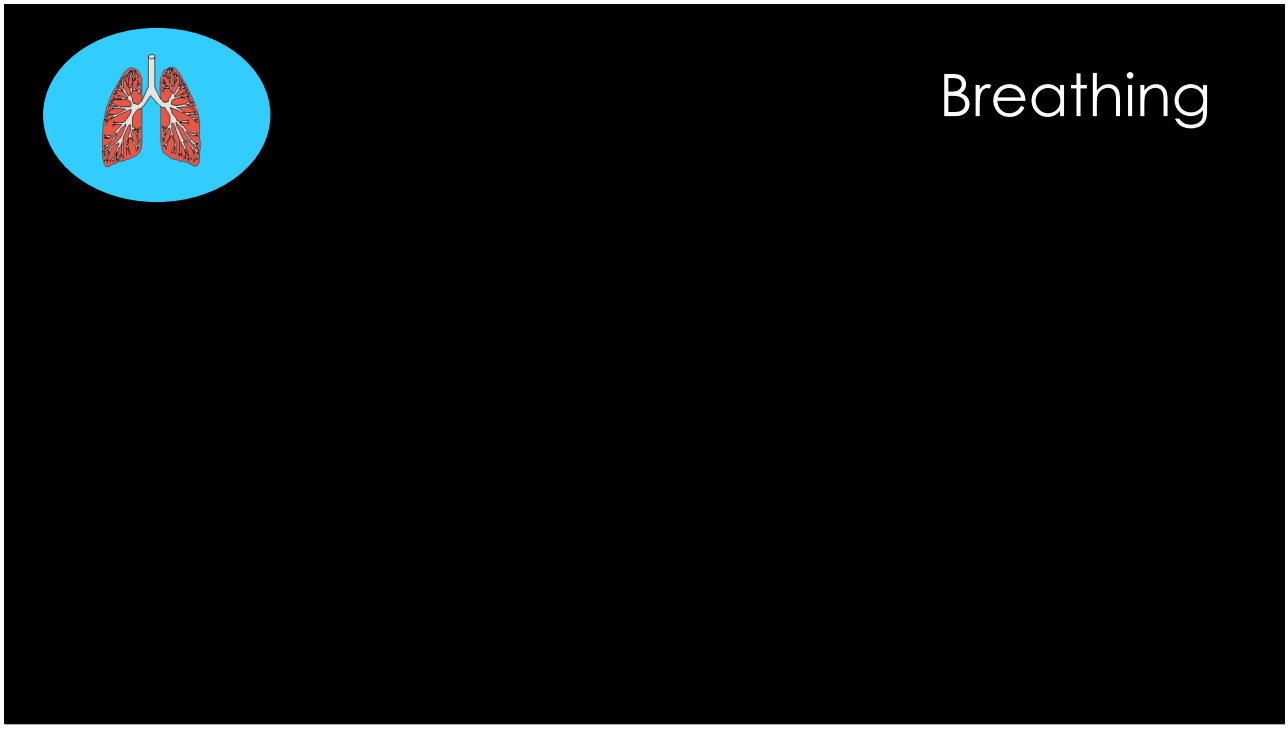

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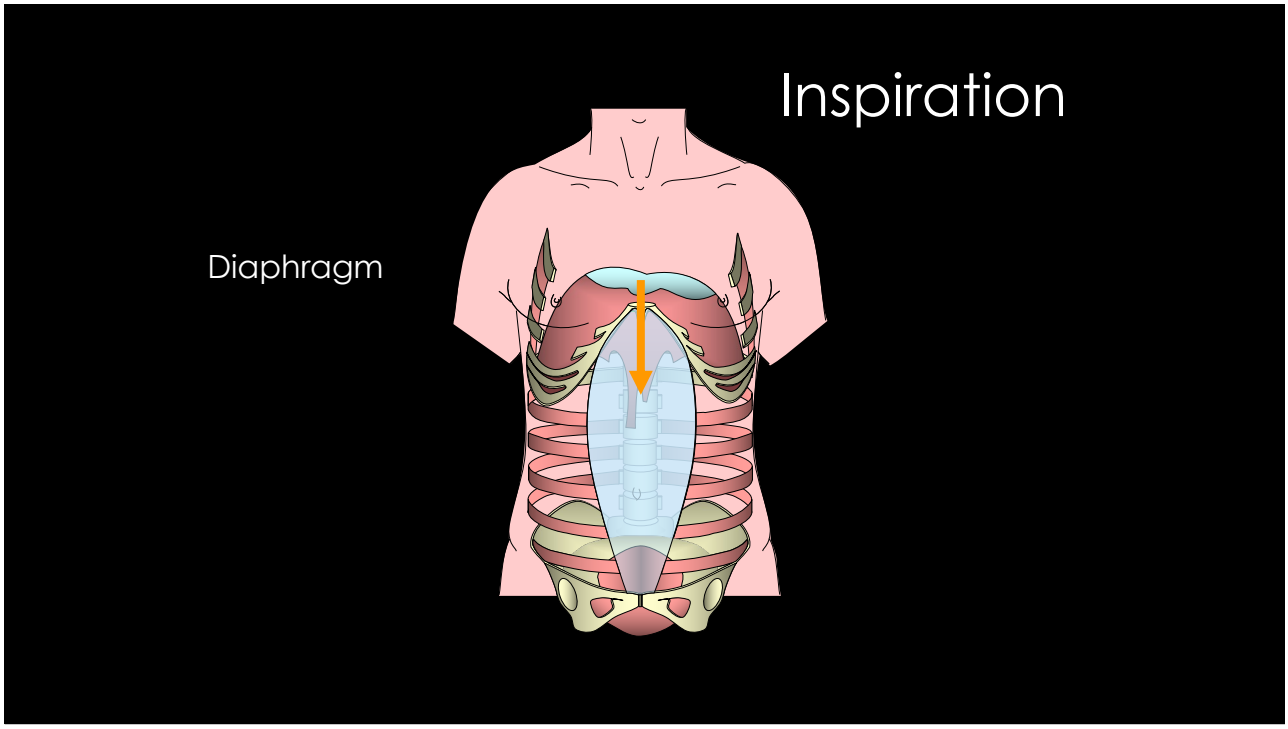

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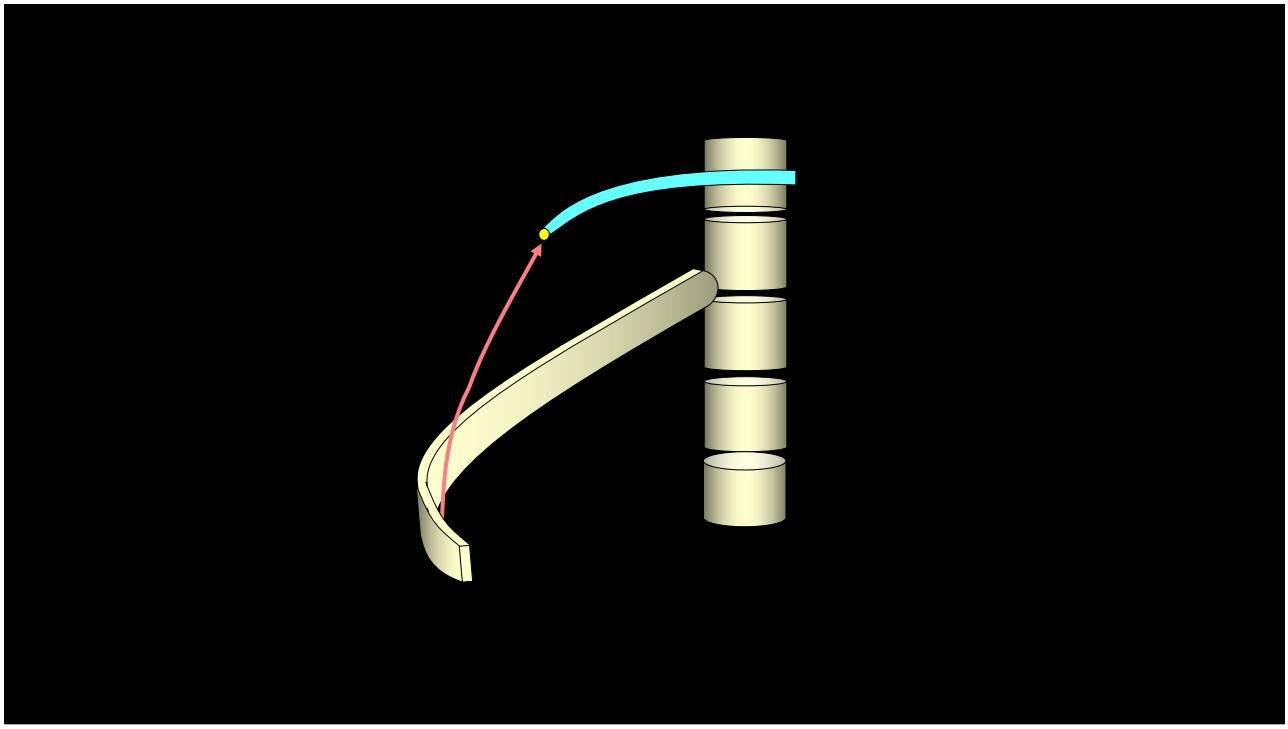
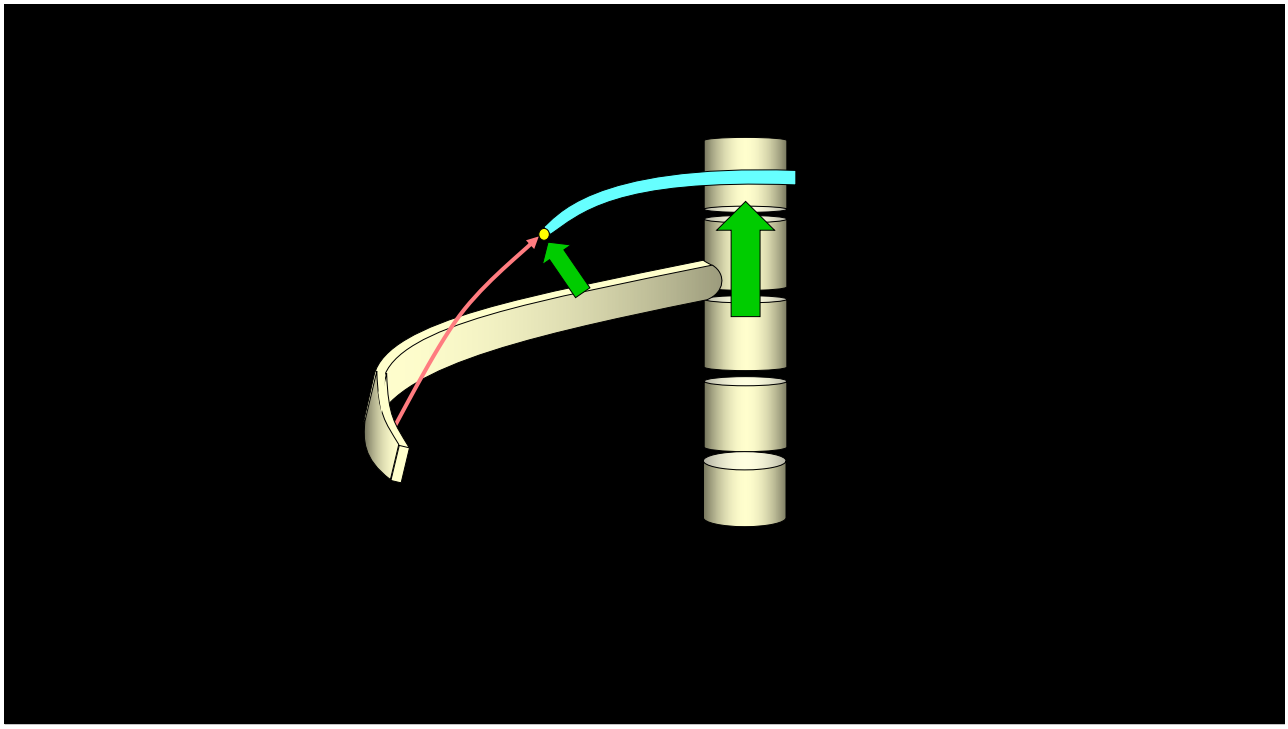


13



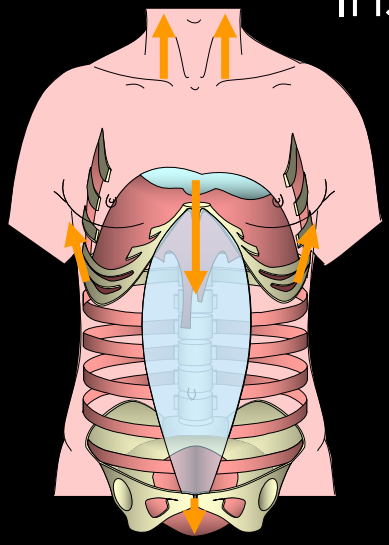
14

Inspiration

Scalenes

Diaphragm

External Intercostals + Diaphragm



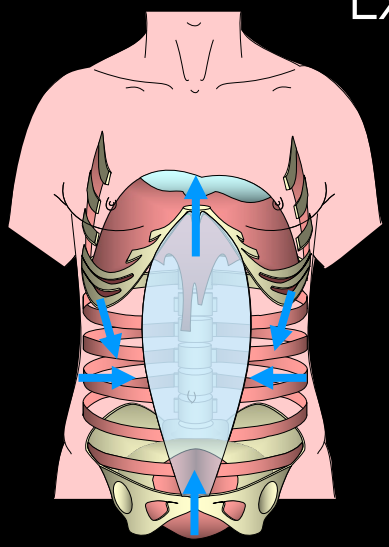
Erector spinae

Pelvic floor muscles (Eccentric)

15

Expiration

Obliquus externus & Internus + internal intercostals



Erector spinae

Transversus abdominis + superficial abdominals

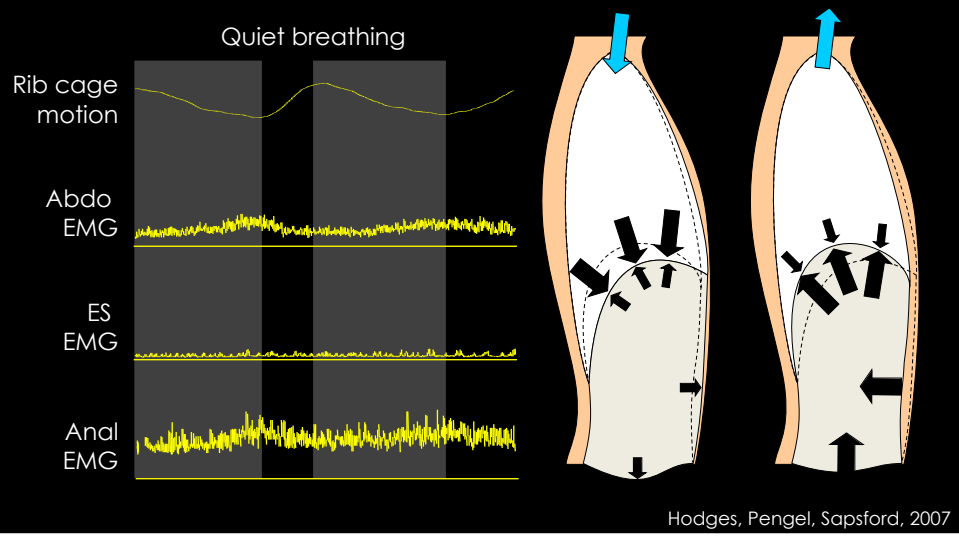
Pelvic floor muscles (Concentric)

16

Contribution of the pelvic floor muscles to breathing

17

Function: Respiration



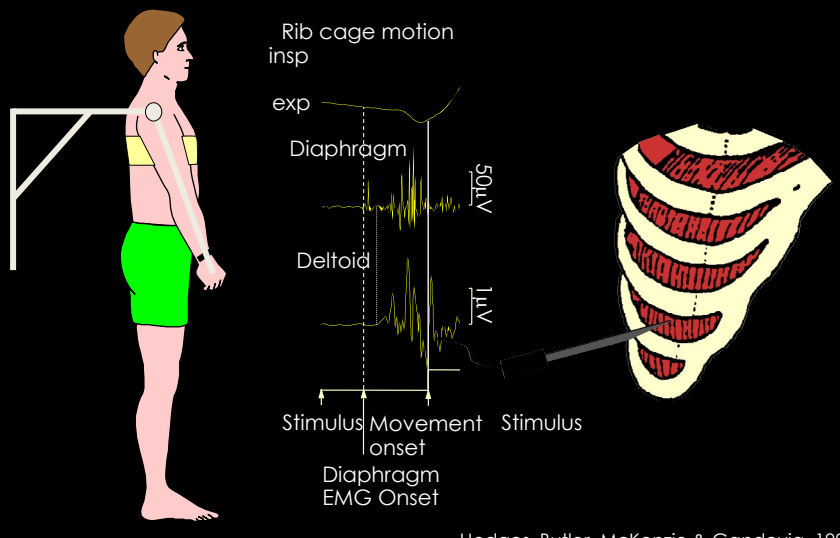
Hodges, Pengel, Sapsford, 2007

18

Respiratory muscles & lumbopelvic control

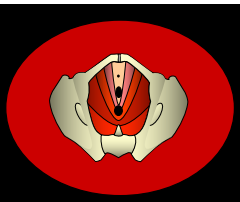
19

Diaphragm contributes to **predictive** postural control



Hodges, Butler, McKenzie & Gandevia, 1997

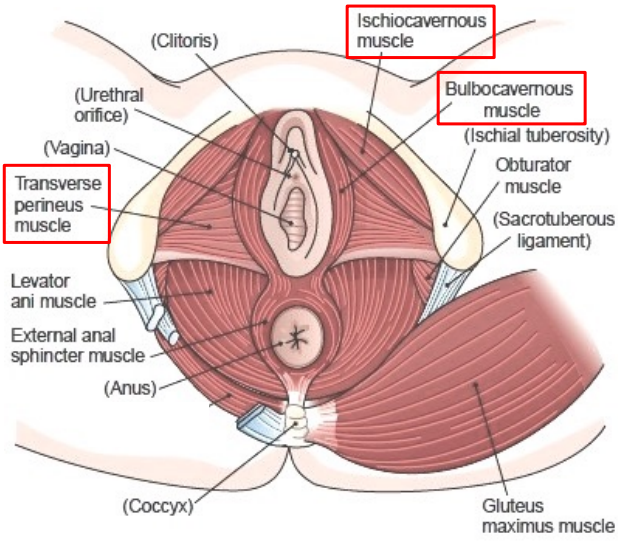
20



Continence & pelvic organ support

21

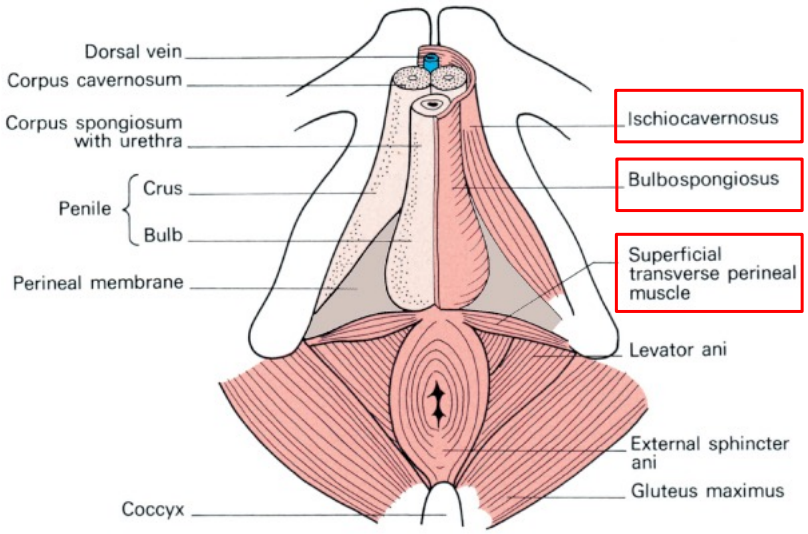
Superficial muscle layer: Female



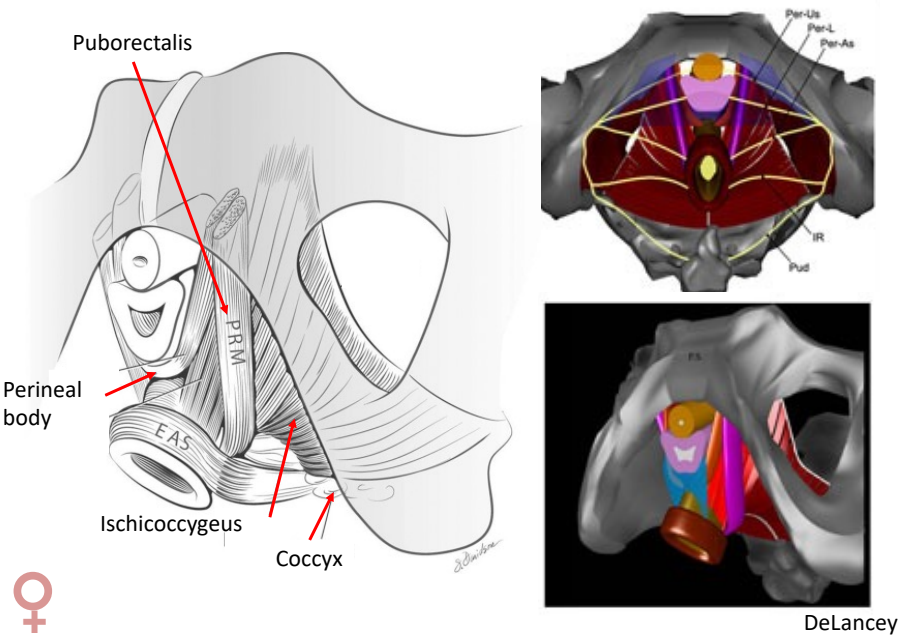
♀

22

Superficial muscle layer: Male

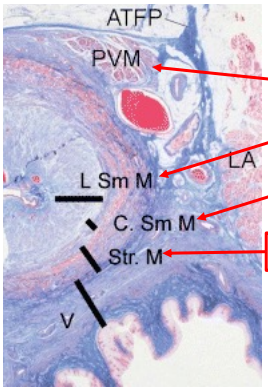


23

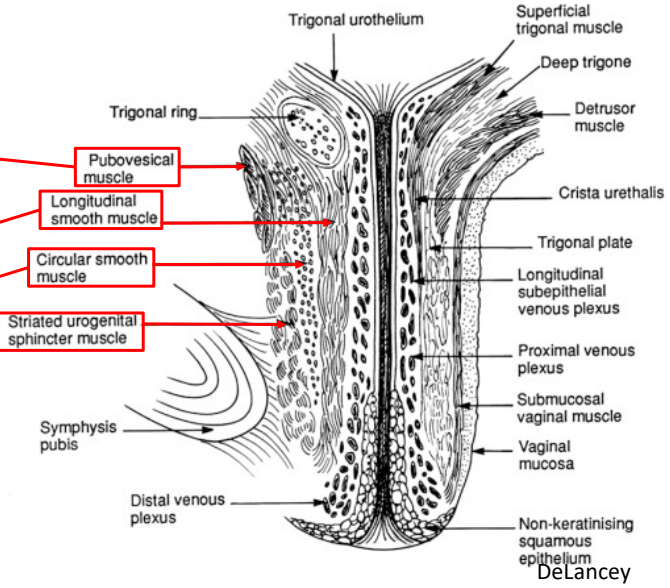


24

Peri-urethral muscle: Female



Strohbehn

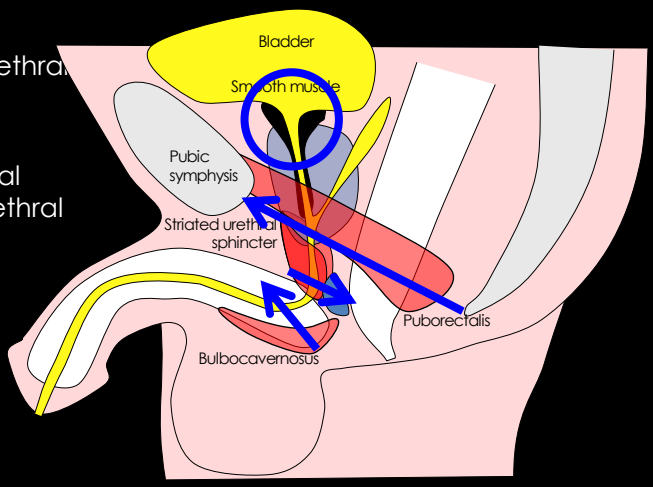


DeLancey

25

Levator ani & urethral muscle: Male

- Pelvic floor muscles
  - **Smooth muscle sphincter** (Lissosphincter, internal urethral sphincter)
  - **Striated urethral sphincter** (Rhabdosphincter, external urethral sphincter, peri-urethral striated muscle)
  - **Levator ani** (Puborectalis, puboviscerallis, pubococcygeus)
  - **Bulbocavernosus**
  - **Urethral mucosa**

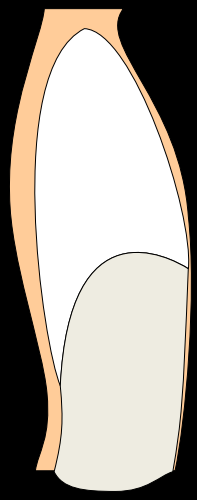


26

Actions of pelvic floor muscles

- Pelvic organ support
- Urethral anal/rectal pressure
- Intra-abdominal pressure generation
- Sacroiliac forces

→ Control of pressures



27

Function: Urinary continence

URETHRAL PRESSURE > BLADDER PRESSURE

Smooth muscle and elastic mechanisms

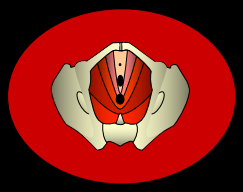
Striated levator ani muscles
- Compress distal urethra against pubis
- Stabilise the bladder neck
- Rigid surface against which IAP can compress the urethra

Striated periurethral muscle

Detrusor (Bladder smooth muscle)

Muscles of the abdominal cavity
- Abdominal muscles
- Diaphragm

28

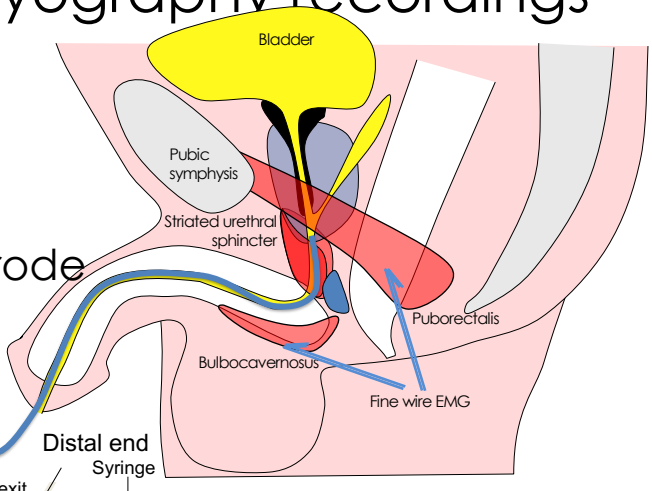


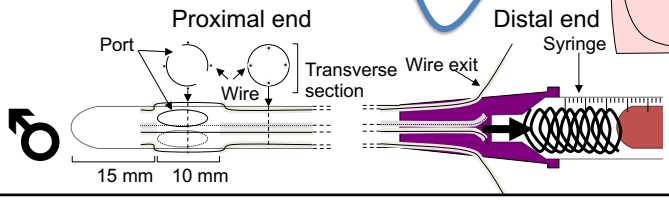
Pelvic floor muscles and lumbopelvic control

29

Electromyography recordings

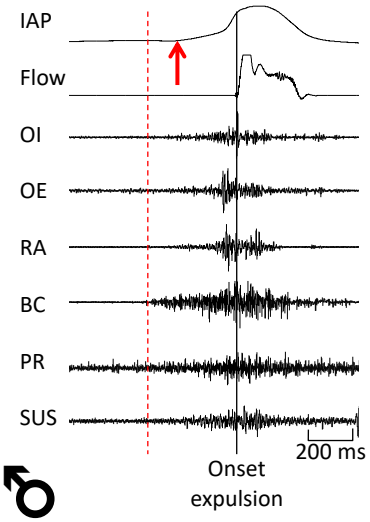
- Fine-wire EMG
  - Puborectalis
  - Bulbocavernosus
- Transurethral electrode
  - Striated urethral sphincter



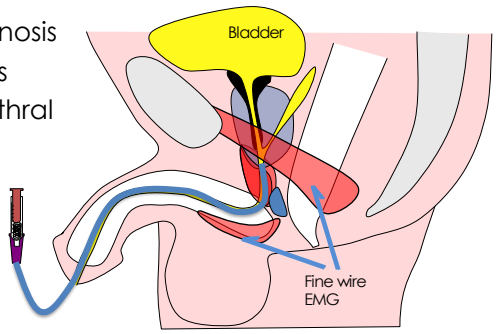


30

Evoked cough: Pelvic floor muscle EMG



Pre-activation
- Bulbocavernosis
- Puborectalis
- Striated urethral sphincter

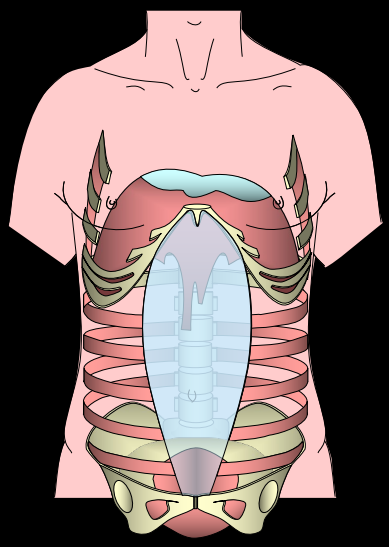


Stafford & Hodges (2014), unpublished data

31

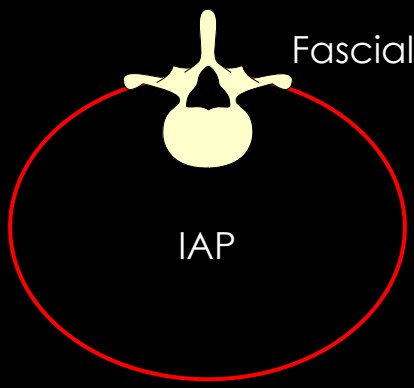
Function: Postural control

- Intra-abdominal pressure essential for spine control
  - Pelvic floor muscle activation
    - Maintain continence when IAP increases
    - Enable IAP to increase



32

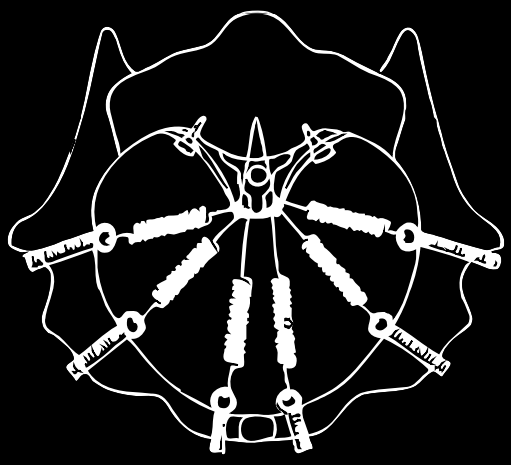
Pelvic floor muscles assist generation of IAP and fascial tensioning



33

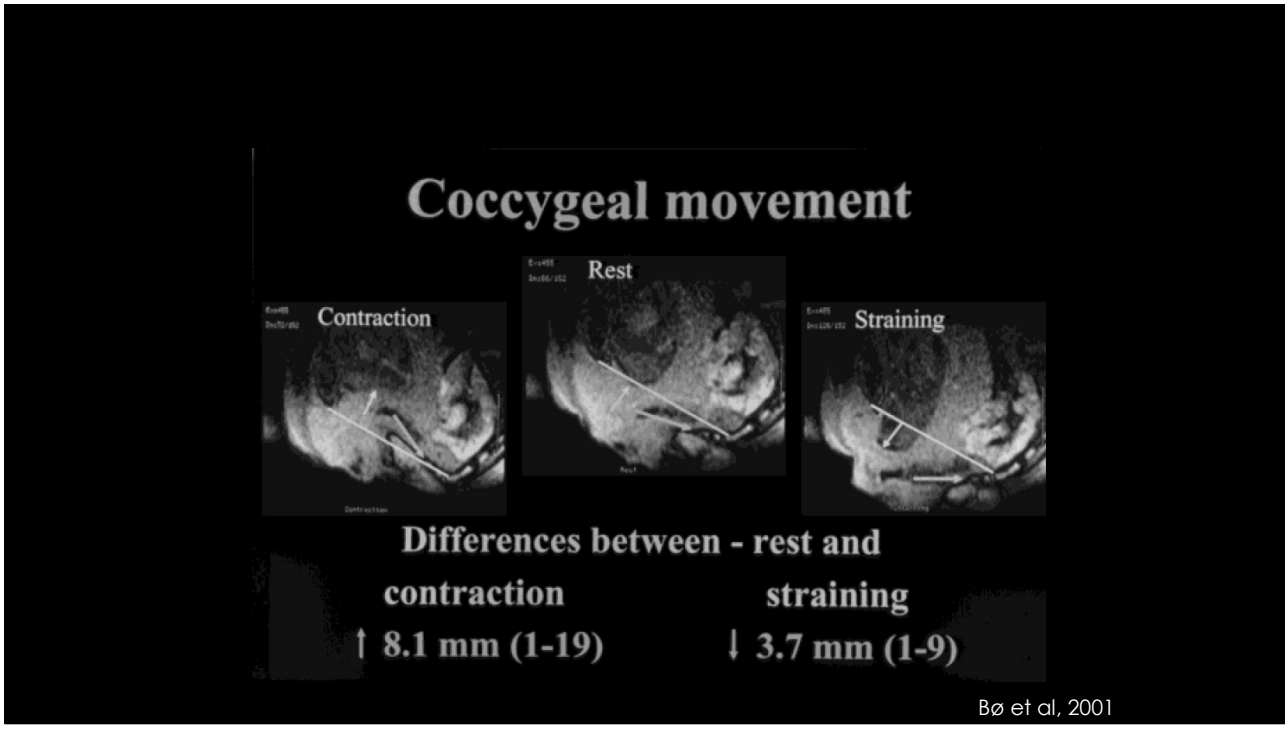
Pelvic floor muscles and trunk control

PFM ↑ stiffness of the sacroiliac joint in women

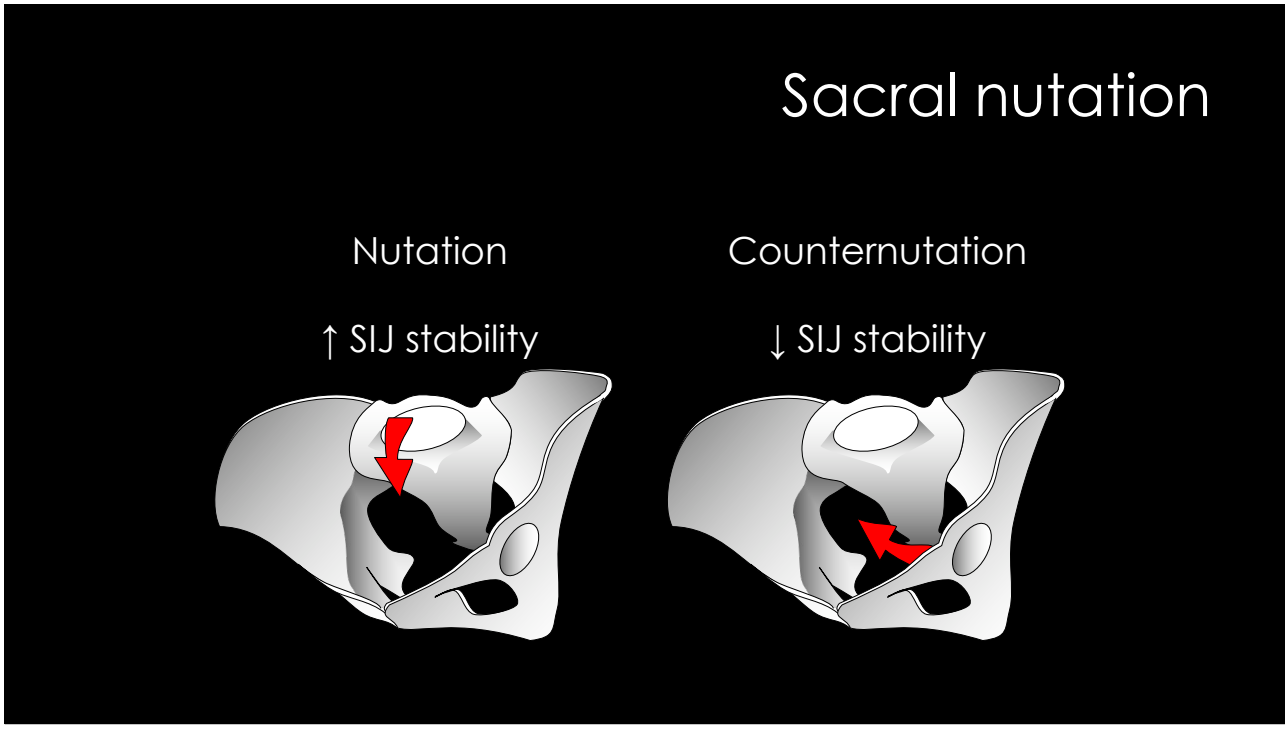


Pool-Goudzwaard et al 2004

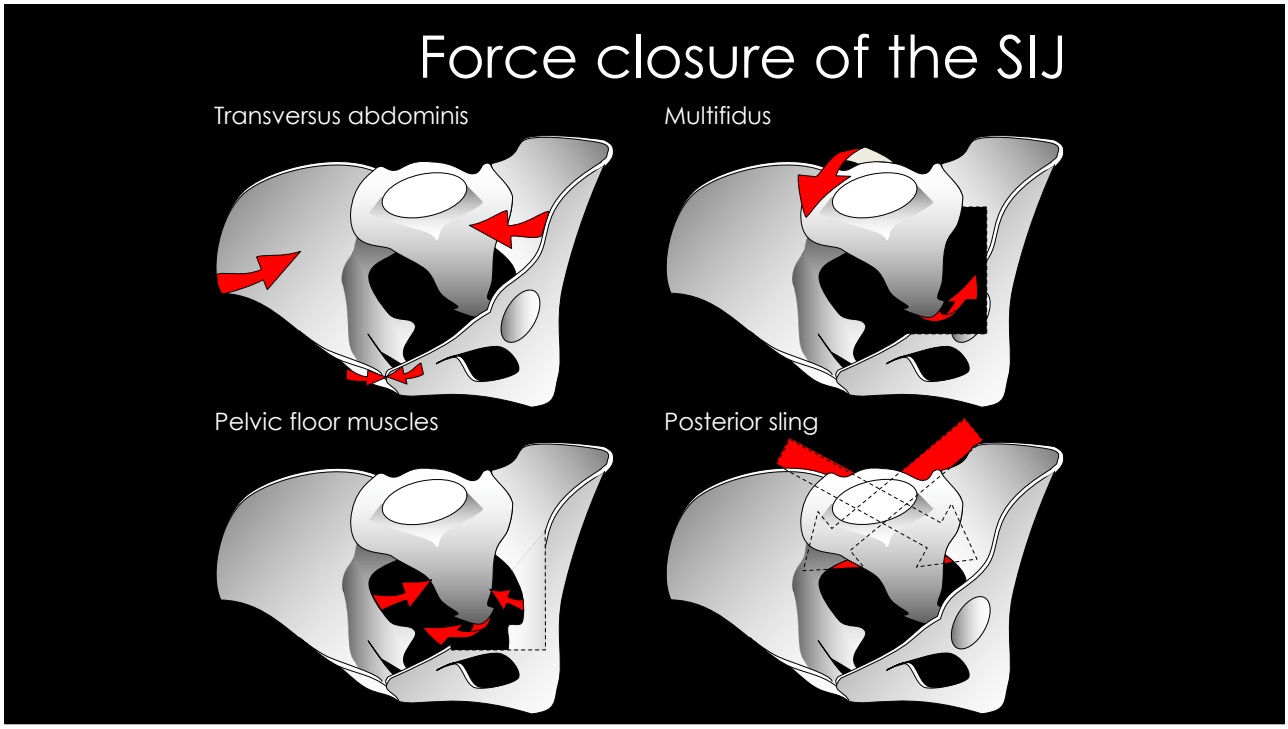
34


Coccygeal movement
Contraction
Rest
Straining
Differences between - rest and
contraction
straining
↑ 8.1 mm (1-19)
↓ 3.7 mm (1-9)
Bø et al, 2001

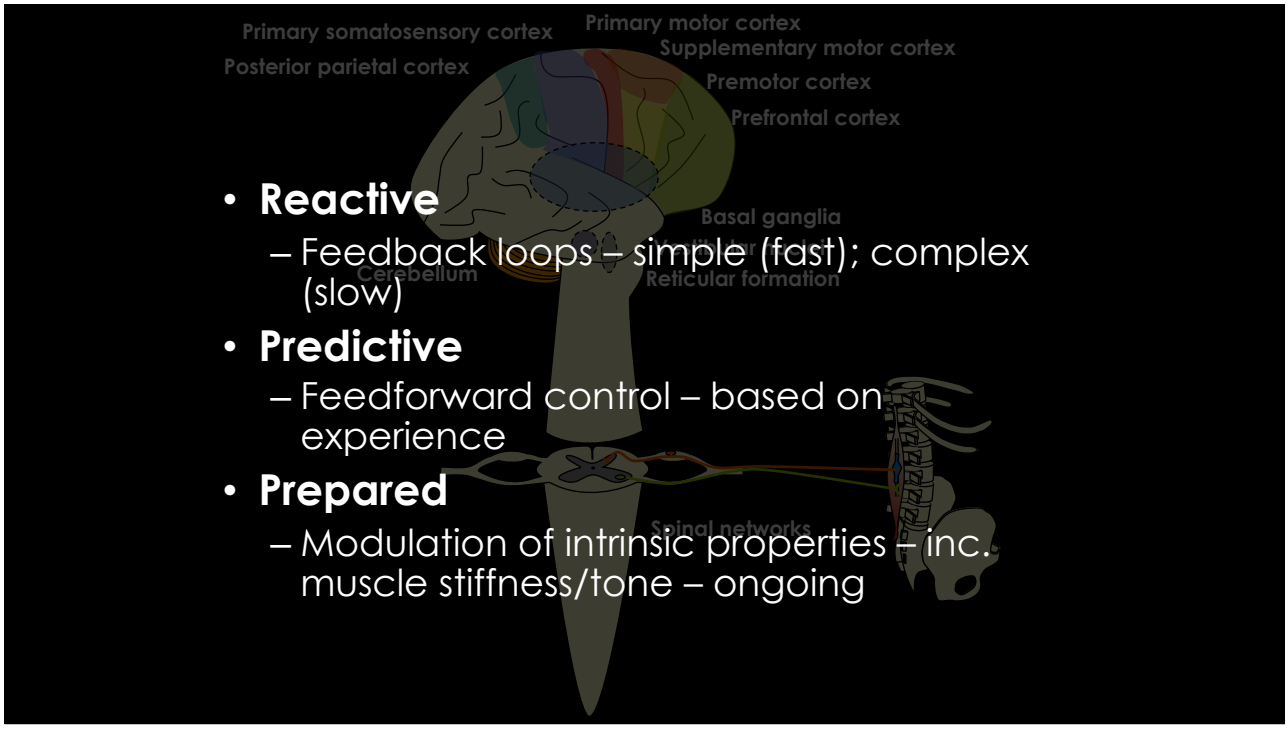
35


Sacral nutation
Nutation
↑ SIJ stability
Counternutation
↓ SIJ stability

36

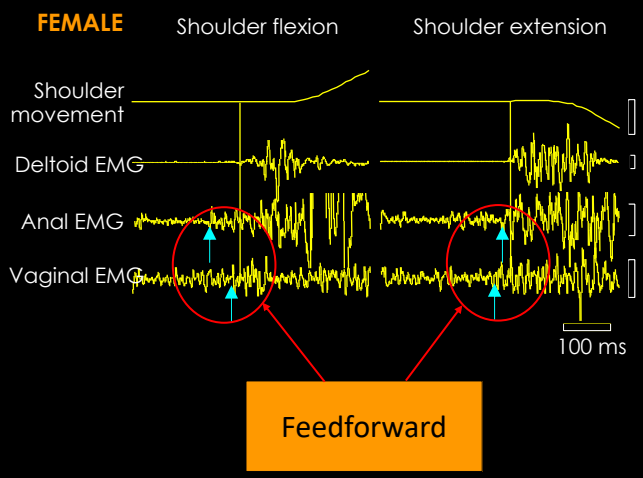

Force closure of the SIJ
Transversus abdominis
Multifidus
Pelvic floor muscles
Posterior sling

37


Primary somatosensory cortex
Primary motor cortex
Supplementary motor cortex
Posterior parietal cortex
Premotor cortex
Prefrontal cortex
Basal ganglia
Cerebellum
Reticular formation
Spinal networks
• Reactive
– Feedback loops – simple (fast); complex (slow)
• Predictive
– Feedforward control – based on experience
• Prepared
– Modulation of intrinsic properties – inc. muscle stiffness/tone – ongoing

38

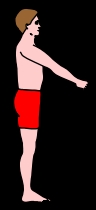
Pelvic floor muscles contribute to **predictive** postural control

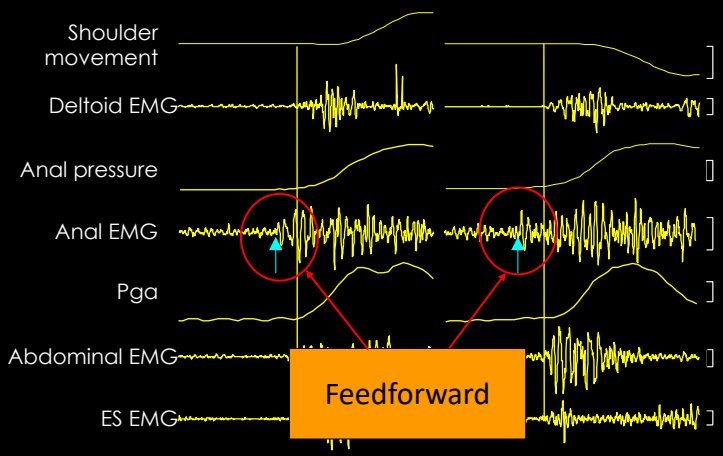


Hodges, Pengel, Sapsford, 2002

39

Pelvic floor muscles contribute to **predictive** postural control

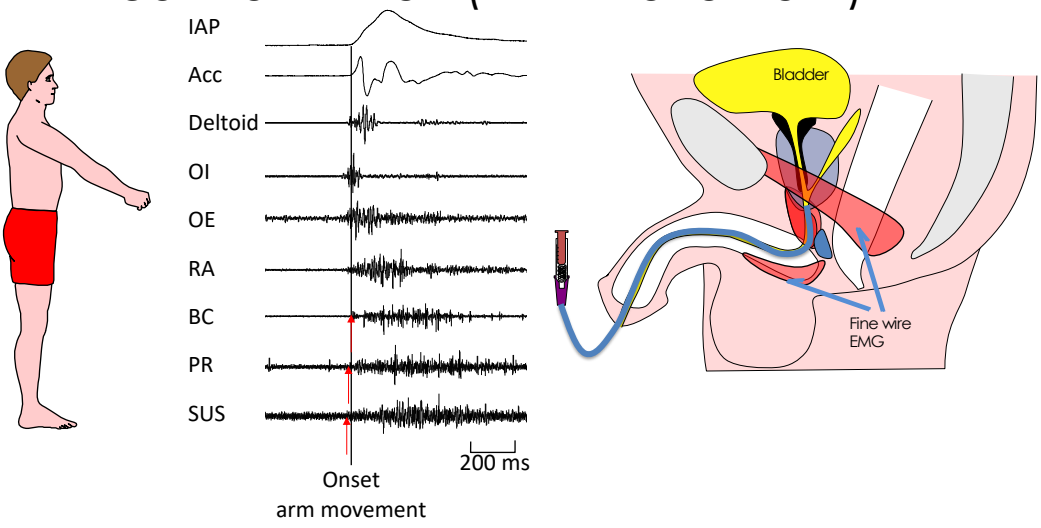




Hodges, Pengel, Sapsford, 2002

40

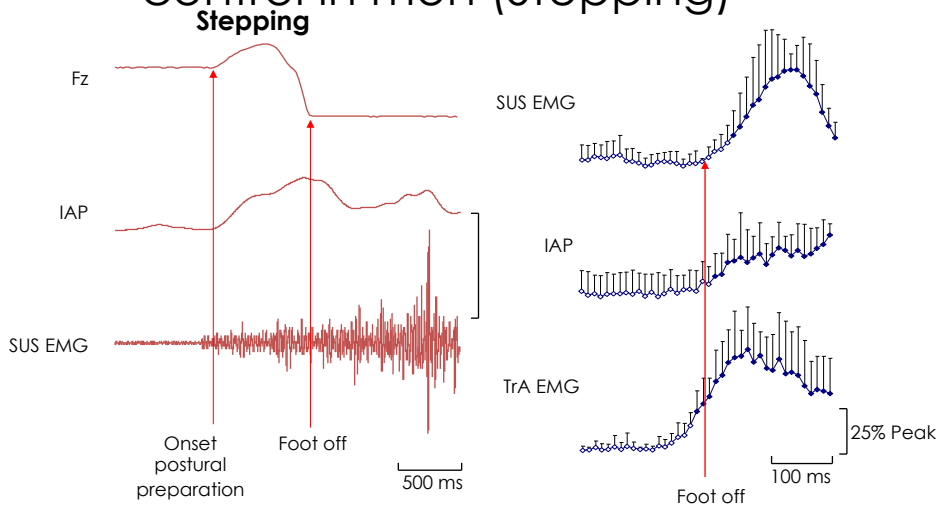
Multiple pelvic floor muscles contribute to **predictive** postural control in men (Arm movement)



Stafford & Hodges (2014), unpublished data

41

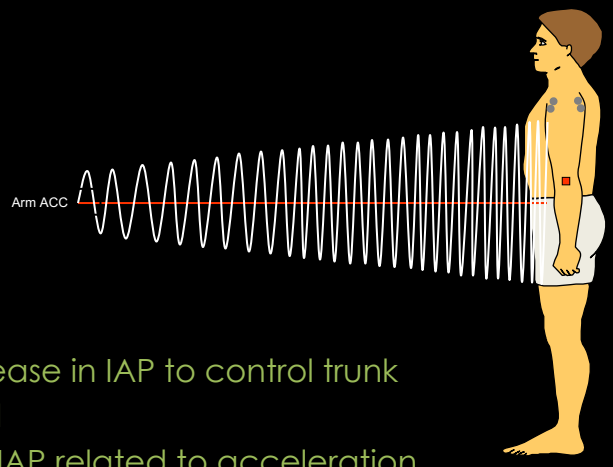
Multiple pelvic floor muscles contribute to **predictive** postural control in men (Stepping)



Stafford, Ashton Miller, Sapsford, Hodges, 2012, *Neurourol Urodyn*

42

Repetitive arm movement



- Transient increase in IAP to control trunk
- Vary demand
- Amplitude of IAP related to acceleration

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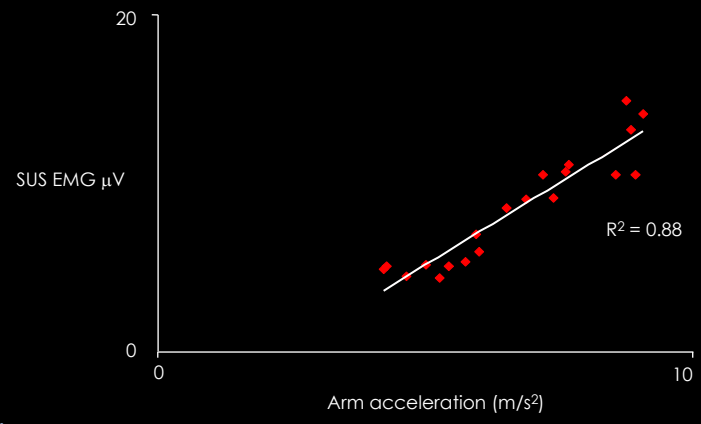
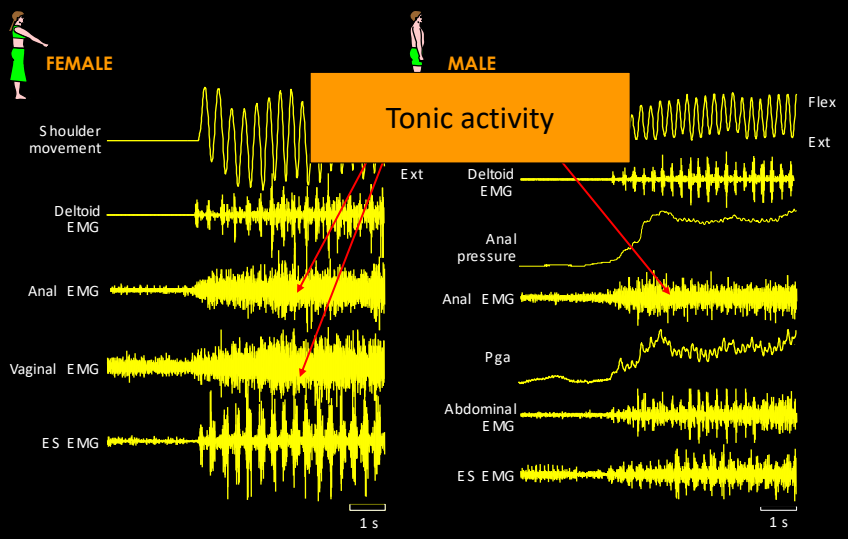
Repetitive arm movement



44

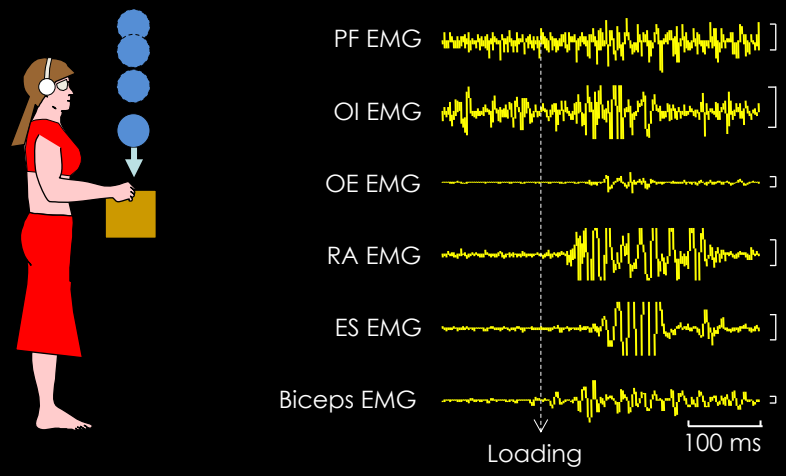
Pelvic floor muscles - **prepared**



Hodges, Pengel, Sapsford, 2002

45

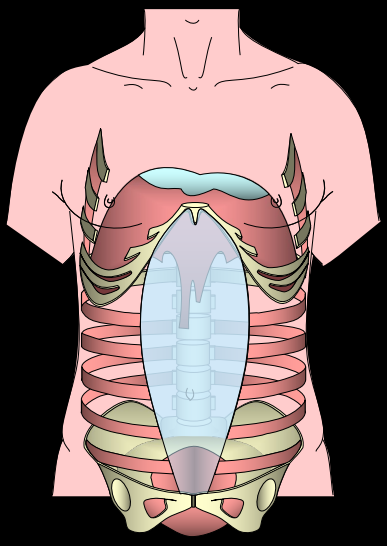
Pelvic floor muscles contribute to **reactive** postural control



Smith, Coppieters & Hodges, 2007 *Exp Brain Res*

46

"Abdominal canister"



- Synergy
  - Coordination between muscles of the abdominal cavity

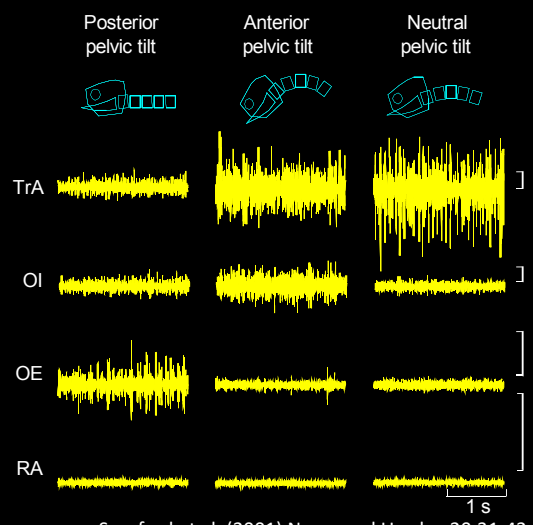
47

2 ways to consider interaction between pelvic floor and abdominal muscles

- Positive
  - Collaboration
    - Optimal control
- Negative
  - Opposition
    - Excessive abdominal muscle activity – increase demand for continence

48

Activation of pelvic floor recruits deep abdominal muscles

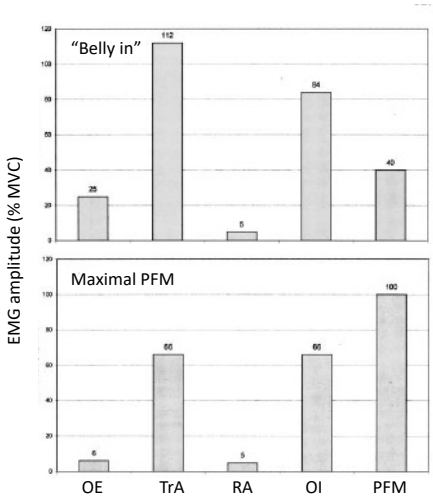


Sapsford et al. (2001) Neurourol Urodyn 20:31-42

- Co-activation during voluntary tasks
  - Sapsford, Hodges, Richardson et al. 2001
- Co-activation with pelvic afferent stimulation
  - Yamamoto et al, 1961
- Neural networks exist to coordinate
  - Holstege et al 2003

49

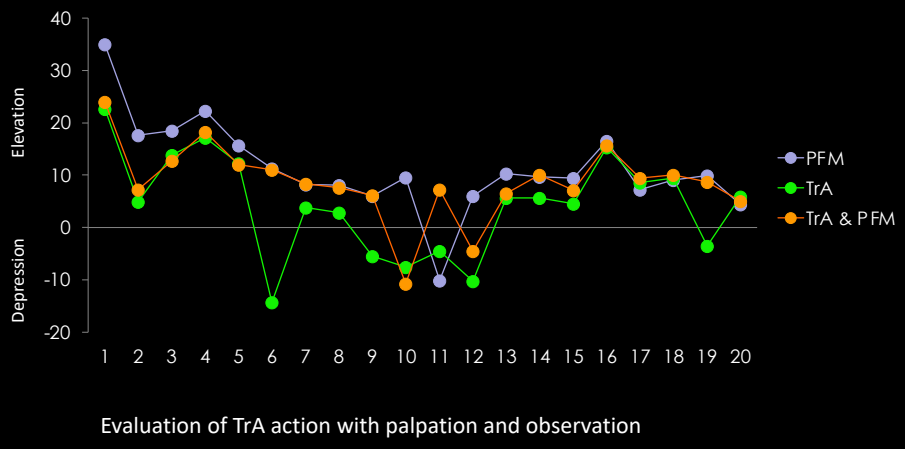
Interaction between abdominal & pelvic floor muscles



Neumann & Gill (2002) Int Urogynecol J 13:125–132

50

Ultrasound imaging: PFM motion



Evaluation of TrA action with palpation and observation

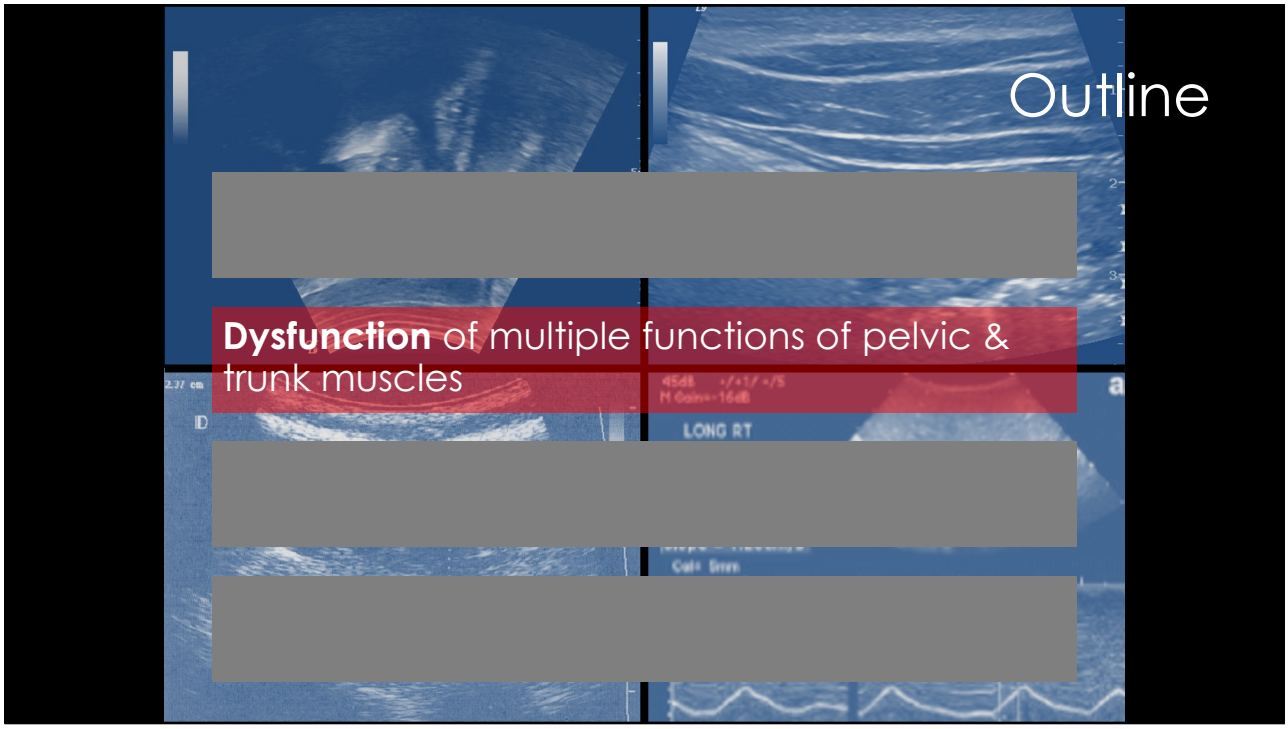
Bo et al (2003) Neurourol Urodynam 22:582-588

51

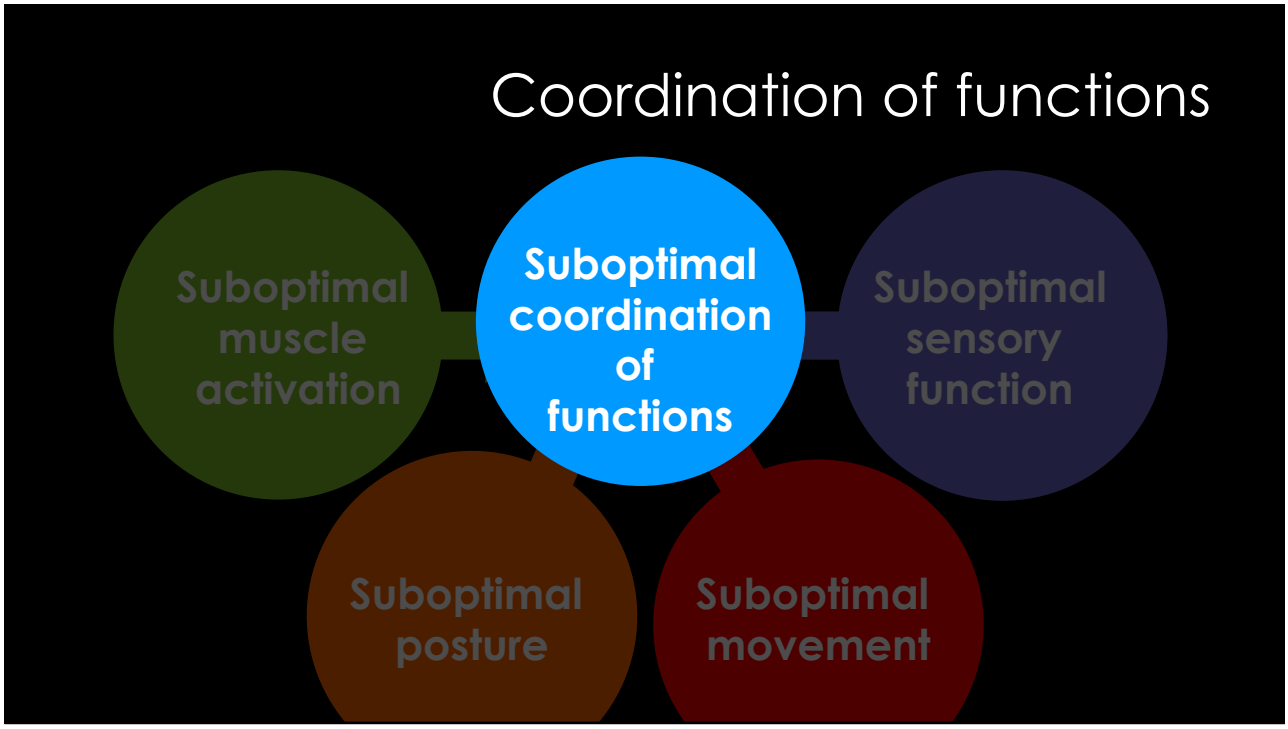
COORDINATION OF SYSTEM

- Abdominal & pelvic floor muscle interaction
  - Sapsford, Hodges et al. 2001
  - Neumann and Gill 2002
  - Critchley et al. 2002
  - Bo, Sherburn, et al. 2003
  - Madill & McLean 2006
  - Thompson, O'Sullivan et al. 2006
  - Junginger et al. 2009
  - Arab & Chehrehrazi 2010
  - Jones & Constantinou 2010
  - Others…

52


Outline
Dysfunction of multiple functions of pelvic & trunk muscles
LONG RT

53

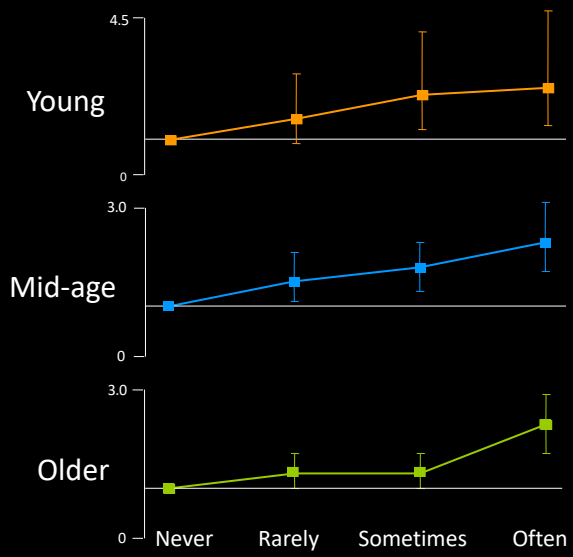

Coordination of functions
Suboptimal muscle activation
Suboptimal coordination of functions
Suboptimal sensory function
Suboptimal posture
Suboptimal movement

54

Are **incontinence**, **respiratory disease**, and **low back pain** related?

55

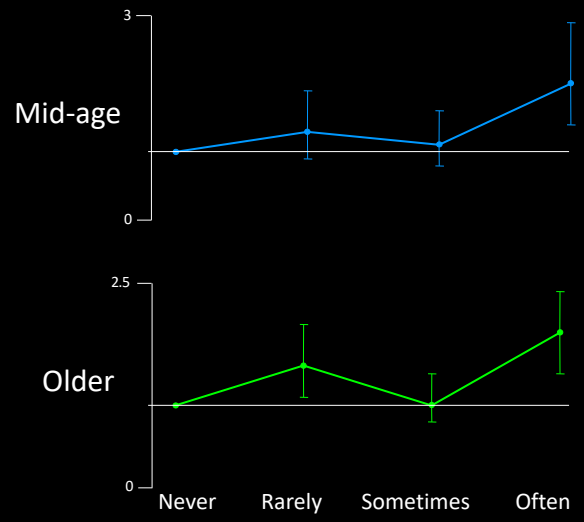
Incontinence & back pain



Smith, Russell, Hodges (2005) *J Physiother*

56

Respiratory disorders & low back pain

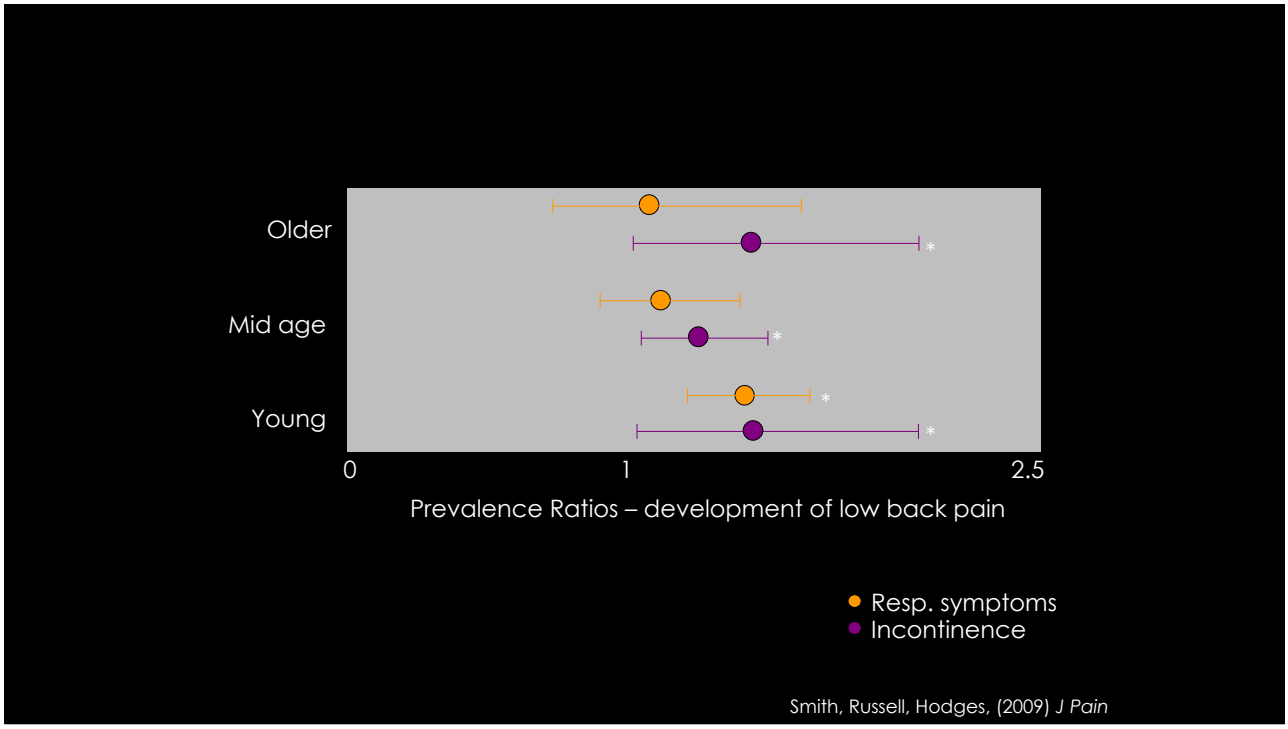


Smith, Russell, Hodges (2005) *J Physiother*

57

Do **incontinence** & **respiratory disease** increase **risk** for low back pain?

58



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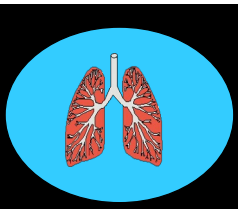
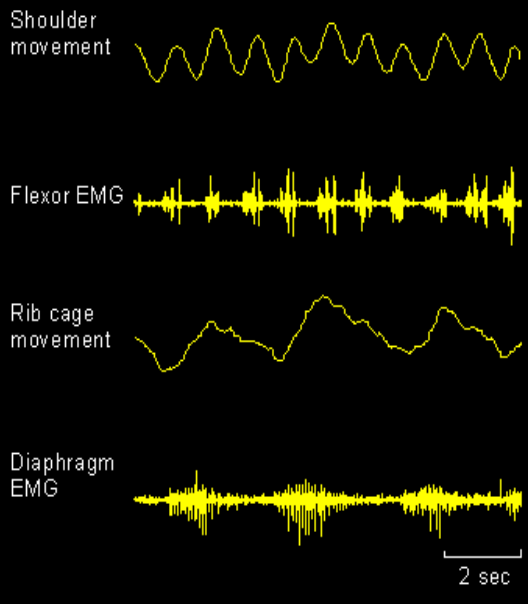


Breathing disorders

60

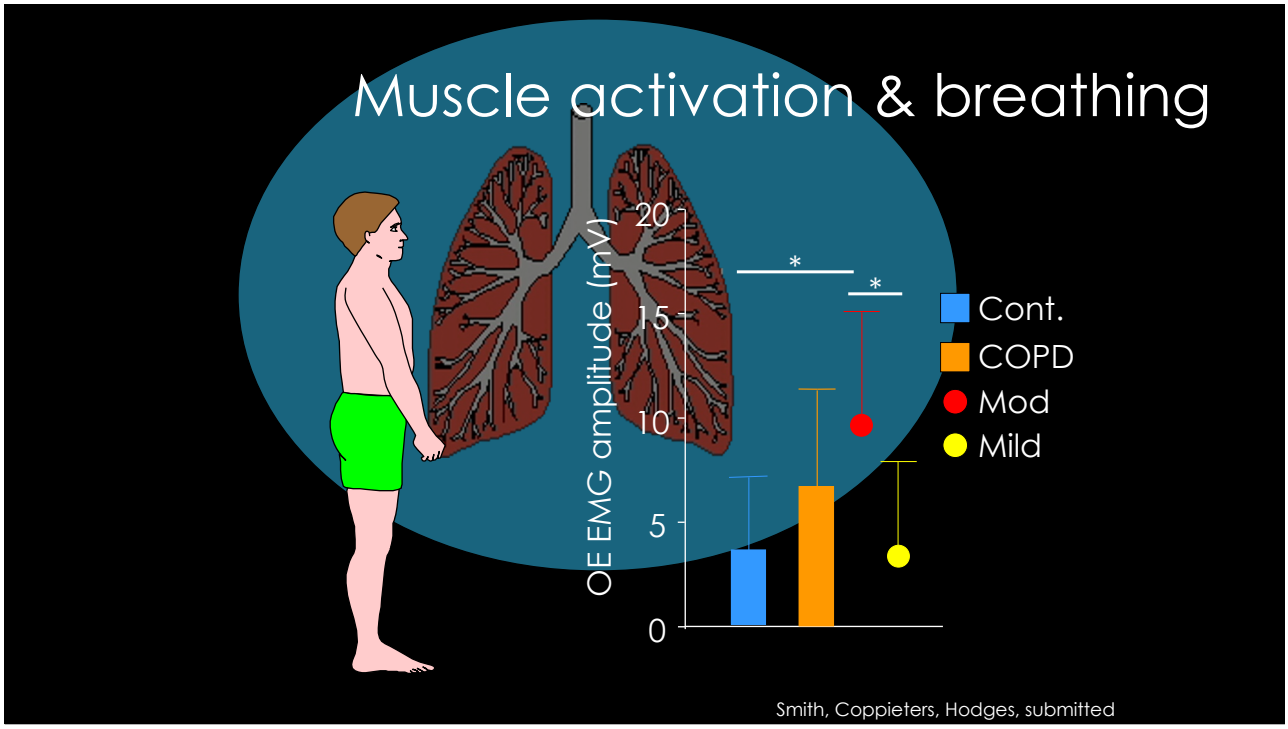
Is postural function of the respiratory muscles disrupted in respiratory disease?

61



Hodges, Heijnen & Gandevia, 2001b

62

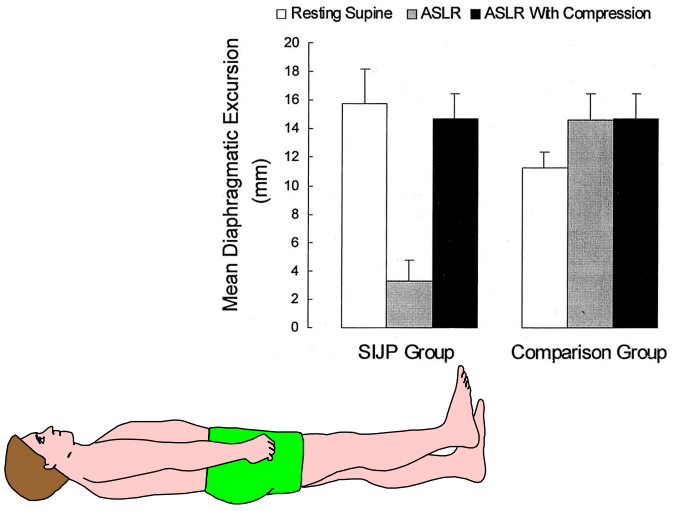


63

Is respiratory muscles function disrupted in low back and pelvic pain?

64

Lumbopelvic pain & diaphragm function



O'Sullivan et al, 2002 Spine 27:E1-8

65

Breathing presentation #1

- Prominent expiratory activity of abdominal muscles in supported positions
  - NORMAL
    - Supported positions – relaxed abdo. muscles
    - Upright positions – Standing +/- respiratory activity of abdo. muscles
  - ABNORMAL
    - Pronounced abdo. Muscle activity in supported postures

66

Breathing Presentation #2

- Tonic activity of abdominal muscles that limits respiratory motion of chest wall
  - Restrict - bibasal expansion/diaphragm motion
  - Enhance - Upper chest breathing

67

Breathing Presentation #3

- Inability to maintain deep muscle contraction with breathing
  1. Loss of deep muscle (including PFM) contraction during inspiration
     - Inability to hold during inspiration
  2. Upper chest breathing
     - Restrict abdominal movement
  3. Shallow breathing
  4. Increase activity of global muscles

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Interpretation

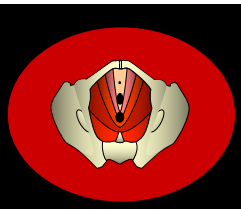
- Inability to hold PFM
  - Unable to ecc. contract PFM
  - Inc. pelvic floor descent due to compromised basal expansion

69

Breathing Presentation #4

- Reliance on abdominal/pelvic floor displacement for breathing
  - Challenge to hold PFM contraction with large change in muscle length

70



Urinary incontinence/pelvic floor muscle dysfunction

71

Dysfunction

- Continence
- Obstructive disorders
- Pelvic organ support
- Postural control
- Pelvic pain disorders

Dysfunction of pelvic floor muscles

- Insufficient pelvic floor muscle activation
- Weakness
- Excessive activation
- Pelvic floor trauma/injury
- Prostatectomy

Role of other mechanisms

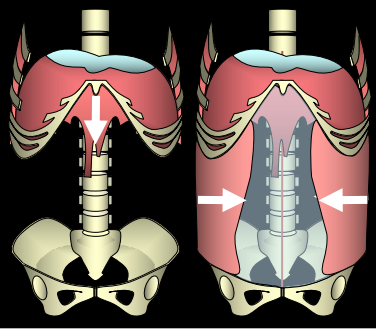
- Insufficient passive support
- Excessive intra-abdominal pressure – abdominal & diaphragm muscles

72

Continence is challenged by multiple factors

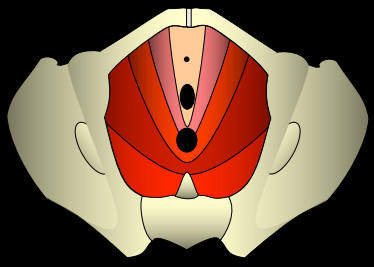
Diaphragm & abdominal muscle

- Inc. IAP/bladder pressure
- Levator plate descent
- Limited inc. urethral pressure



Pelvic floor muscles

- Inc. urethral pressure
- Levator plate elevation

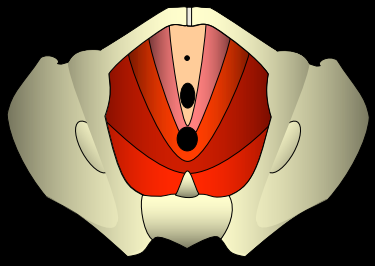


73

Pelvic floor muscles and incontinence

Stress Urinary Incontinence

Bladder pressure
>
Urethral pressure



Hypermobility of bladder neck

↓ PFM strength & endurance
e.g. Morkved et al 2004; Deindl et al 1994

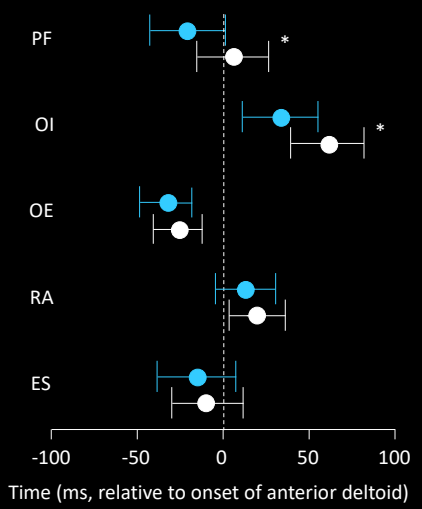
Deficits in PFM activity (amplitude +/- timing)
e.g. Delancey et al 1994; Devreese et al 2004

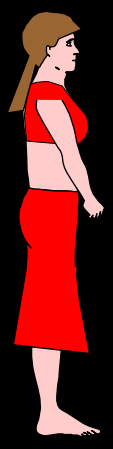
Inc. dorsal motion anorectal angle
Jones et al 2010

74

Is postural function of muscles of continence changed in stress urinary incontinence

75

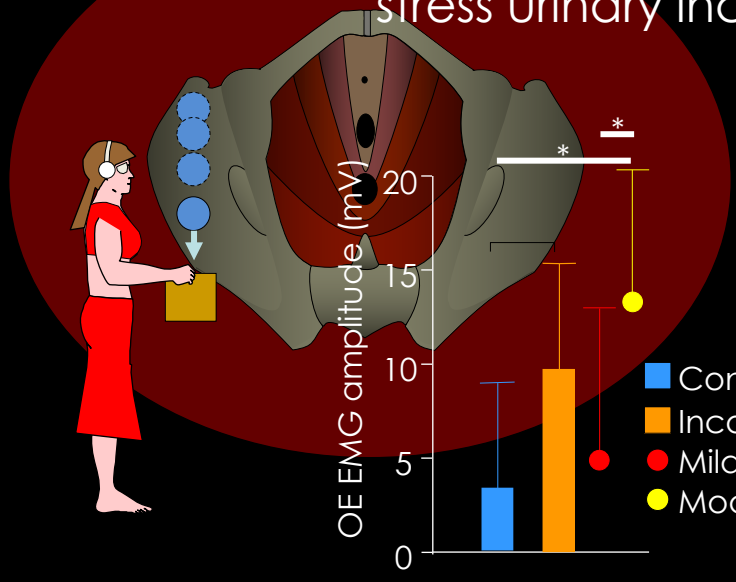




Smith, Coppieters, Hodges, 2008

76

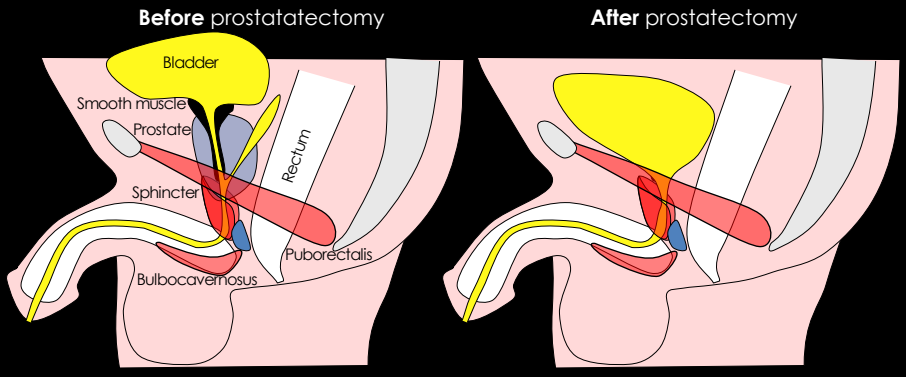
Augmented obliquus externus abd. activity in stress urinary incontinence



Smith, Coppieters, Hodges, (2008) Neurourol Urodyn

77

Impact of radical prostatectomy

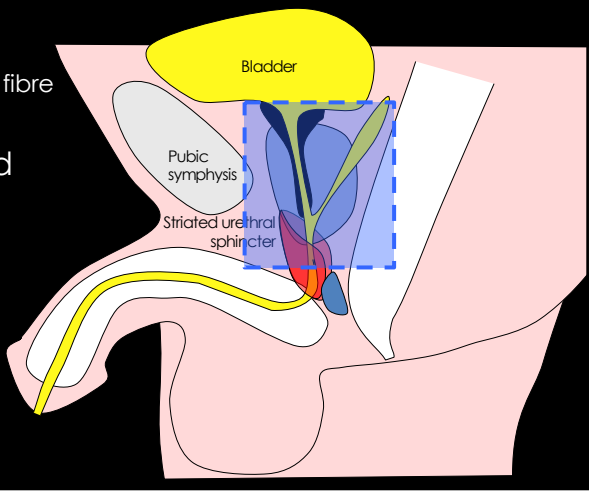


- Removal of prostatic urethra including smooth muscle
- Interference with bladder neck
- +/- Striated urethral sphincter injury
- Exposure/irritation of bladder
- Lower bladder position

78

Recovery of continence after radical prostatectomy

- Compensate for reduced **smooth muscle** contribution to continence
  - → Striated muscles change function
    - → Enhanced tonic activation (neural?)
    - → Enhanced muscle capacity (muscle fibre change?)
- Compensate for compromised **striated urethral sphincter**
  - → Greater reliance on puborectalis & bulbocavernosus
- Restore **bladder** function
  - → Train bladder storage



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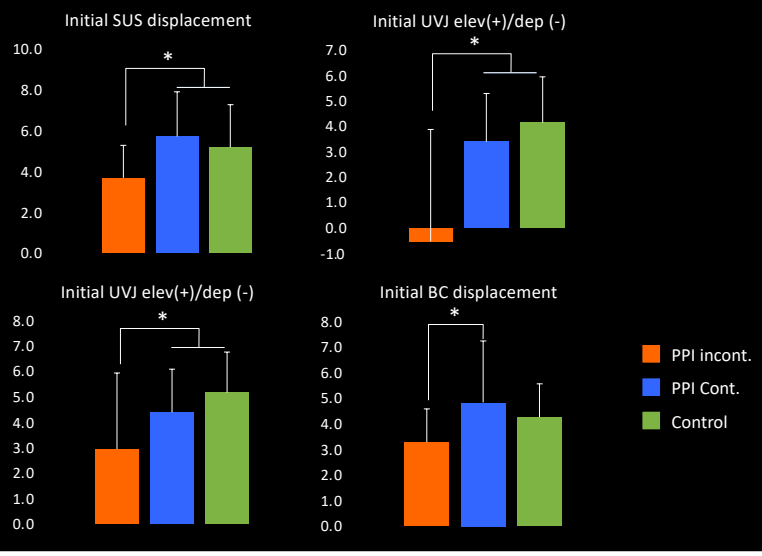
Voluntary contraction of PFM



80

Conclusion

- Differences in activation of individual PFM in men with persistent incontinence after prostatectomy
- Early evidence of subgroups
- Potential to target treatment

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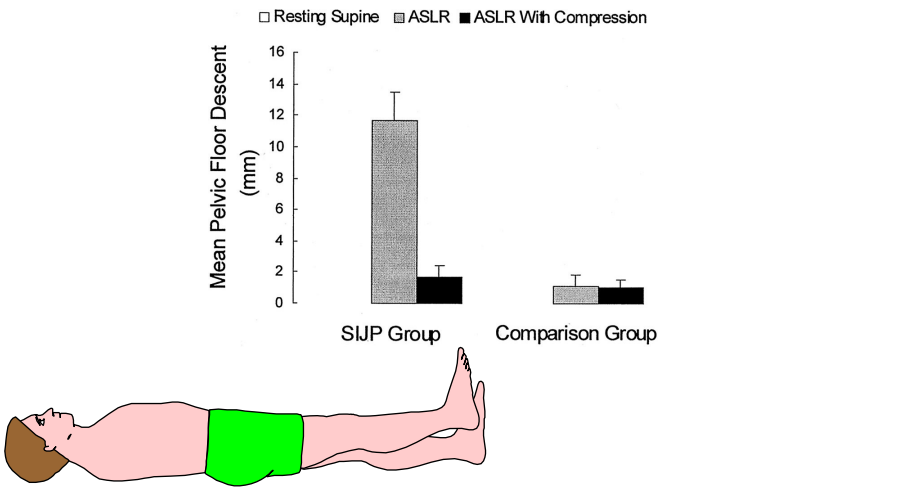
Lumbopelvic pain & pelvic floor muscle function



O'Sullivan et al, 2002 Spine 27:E1-8

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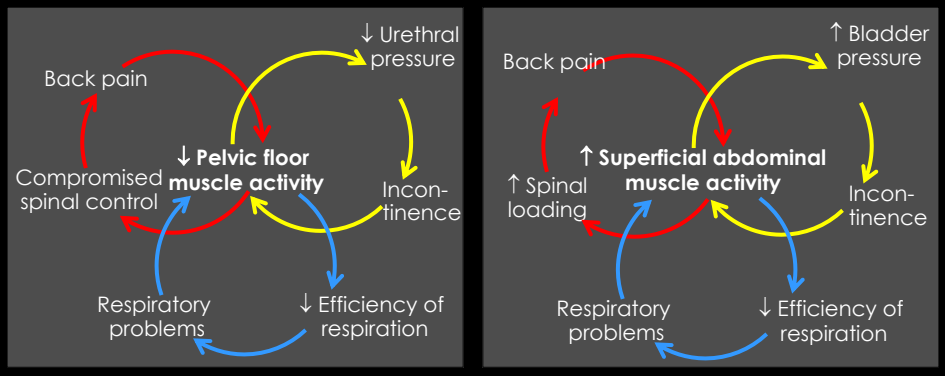
Hypothesised physiological association



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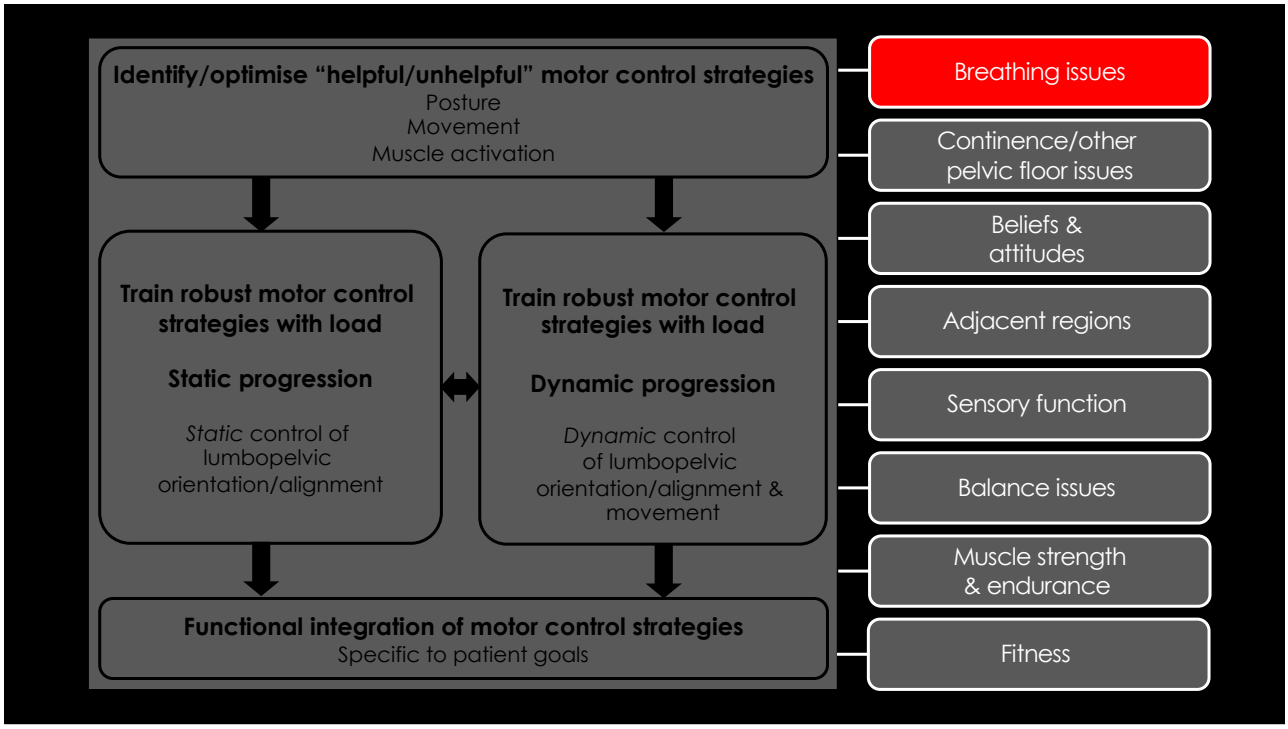

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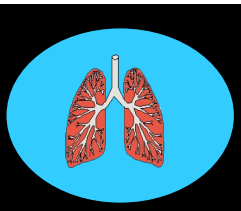


Assessment & Training of respiratory muscles

85

Normal breathing pattern

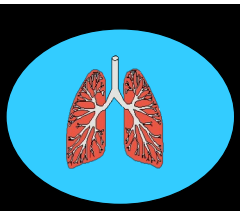
86

87

Breathing and pelvic floor

- Pelvic floor muscle activation is necessary for breathing
- Breathing may drive changes in pelvic floor muscle activation
  - e.g. forced expiration – greater PFM acitvation
- Breathing training may aid modification of pelvic floor muscle activation
  - e.g. relaxed breathing may reduce PFM tone
- Specific challenges from respiratory disease – breathing pattern and coughing

88



Assessment of breathing

89

Breathing pattern: Assessment

- Movement
  - Observation & Palpation of breathing movements
    - 3 components – evenly distributed with no dominance
      - Upper chest
      - Basal chest expansion
      - Abdominal displacement
    - Symmetry
- Muscle activity
  - Observation, Palpation, electromyography, ultrasound imaging
- Effect of posture correction
- Effect of deep/local muscle activation
- Effect of loading

90

Breathing pattern: Assessment

- Respiratory movements
  - Abdominal movement
  - Bibasal rib cage expansion
  - Upper chest breathing

  - Objective
    - Even distribution of movement between regions
    - No region dominating
    - Consider effect of position
      - Reclined – less basal expansion (less abdominal muscle activation)

91

Breathing pattern: Assessment

- Respiratory muscle activity
  - Abdominal muscle activity
    - Palpation
    - Observation
    - EMG biofeedback
    - Ultrasound imaging

92

Breathing pattern: Assessment

- Respiratory muscle activity
  - Abdominal muscle activity
    - Consider
      - Is the muscle activity modulated with breathing?
      - Is there activity that is compromising respiratory movements?

93

Breathing pattern: Assessment

- Respiratory muscle activity
  - Diaphragm muscle activity
    - Palpation – rib cage and abdominal movement
    - Observation – rib cage and abdominal movement
    - Ultrasound imaging

94

Breathing pattern: Assessment

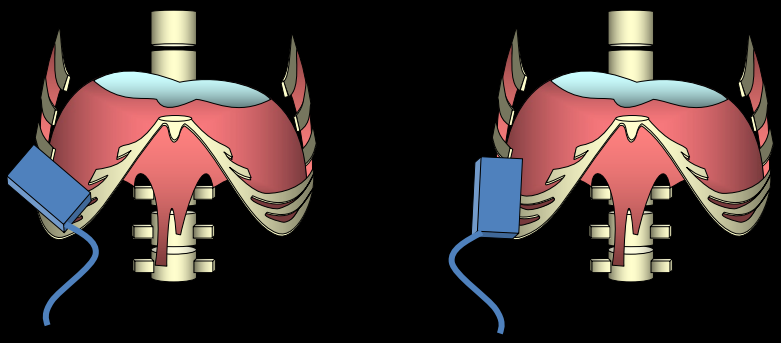
- Respiratory muscle activity
  - Diaphragm muscle activity
    - Consider
      - Does the diaphragm shorten (rib/abdo movement)?
        - » Tight/short/overactive diaphragm
        - » High IAP with abdominal brace - prevent diaphragm descent
      - What is the quality of shortening/thickening – Is it smooth and slow?

95

Ultrasound imaging: **Diaphragm**

96

Diaphragm ultrasound imaging

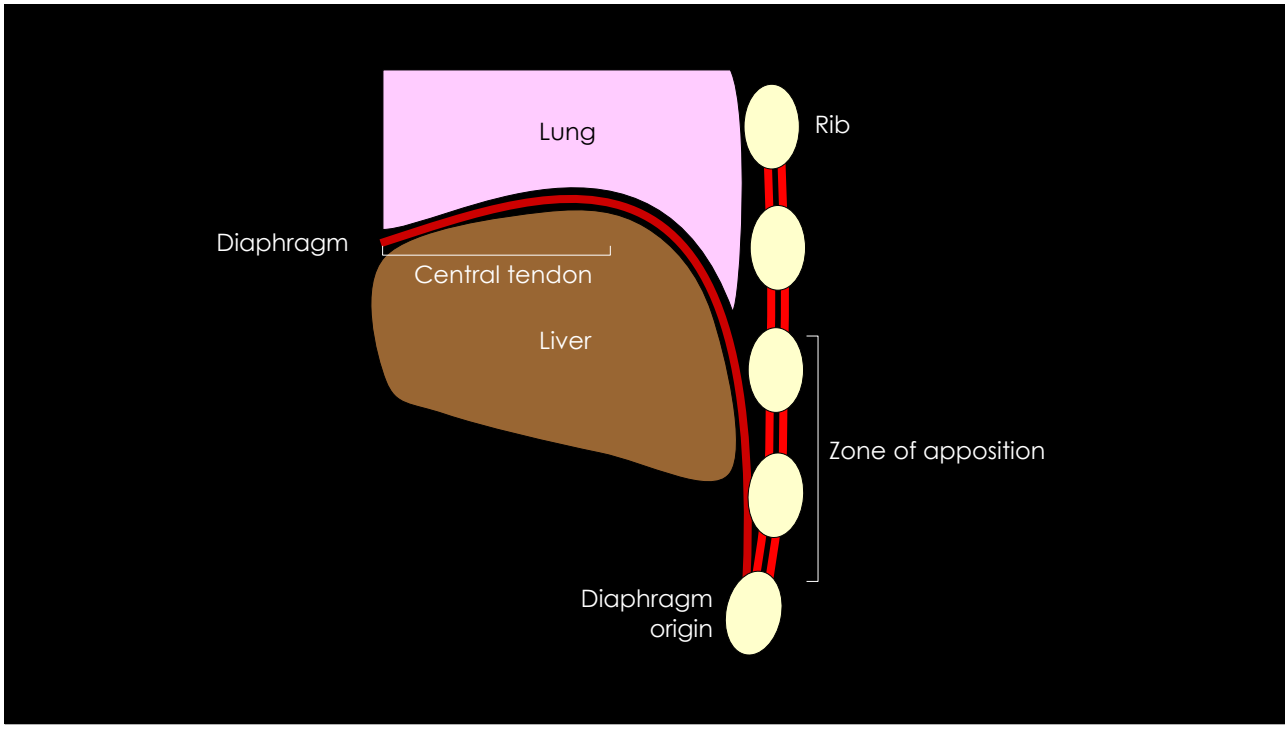


97

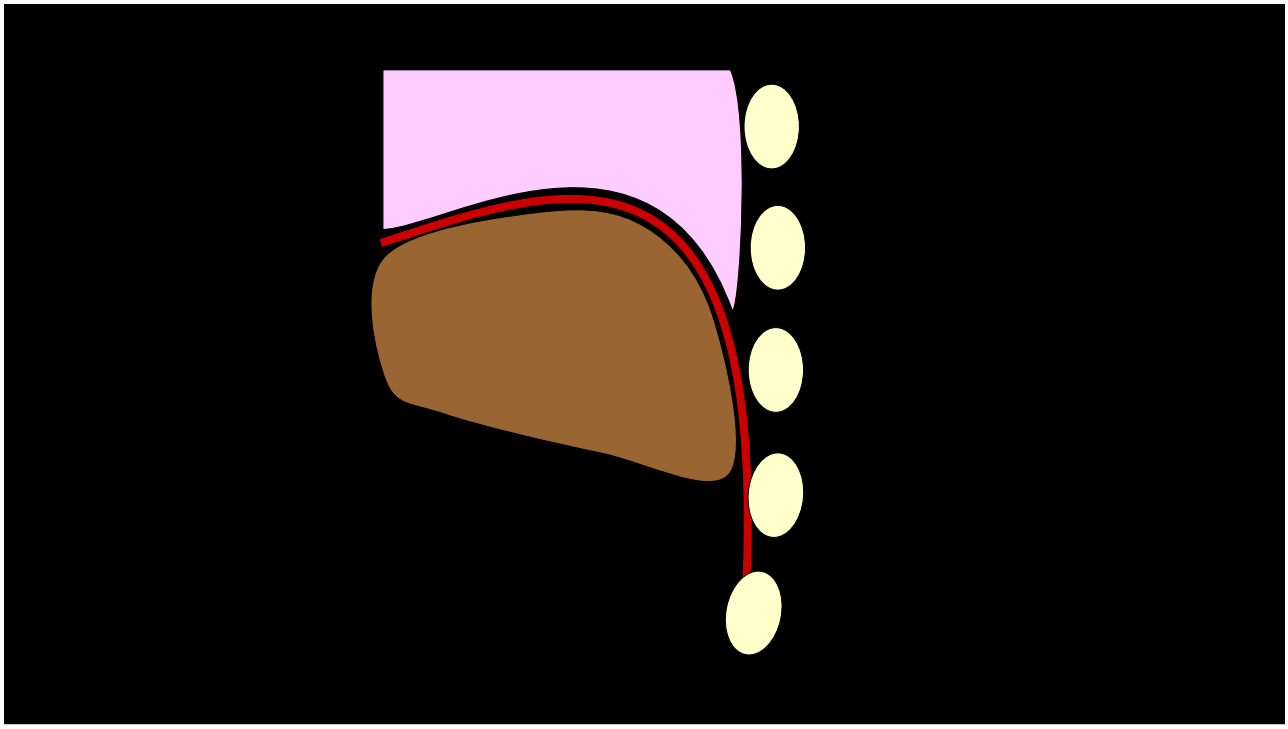
Diaphragm ultrasound imaging

- Thickening of costal diaphragm
- Displacement of central tendon
- Change in length of zone of apposition

98


Lung
Rib
Diaphragm
Central tendon
Liver
Zone of apposition
Diaphragm
origin

99



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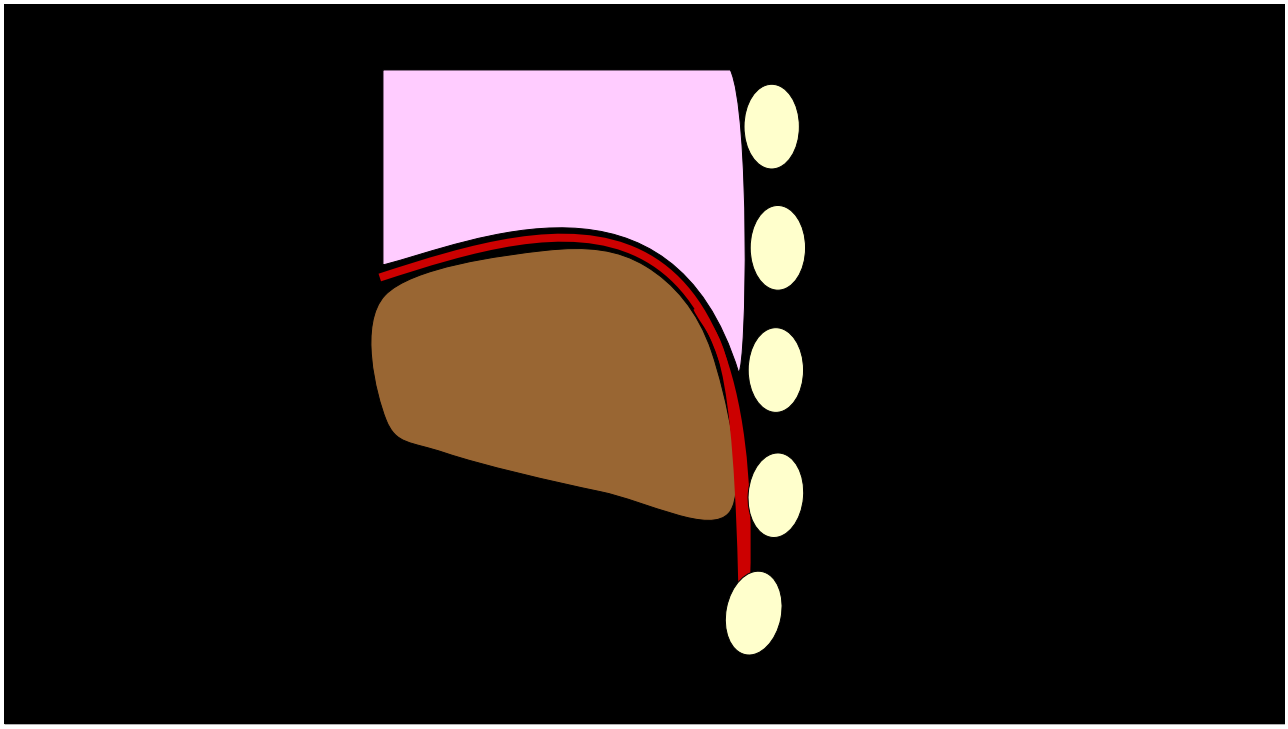

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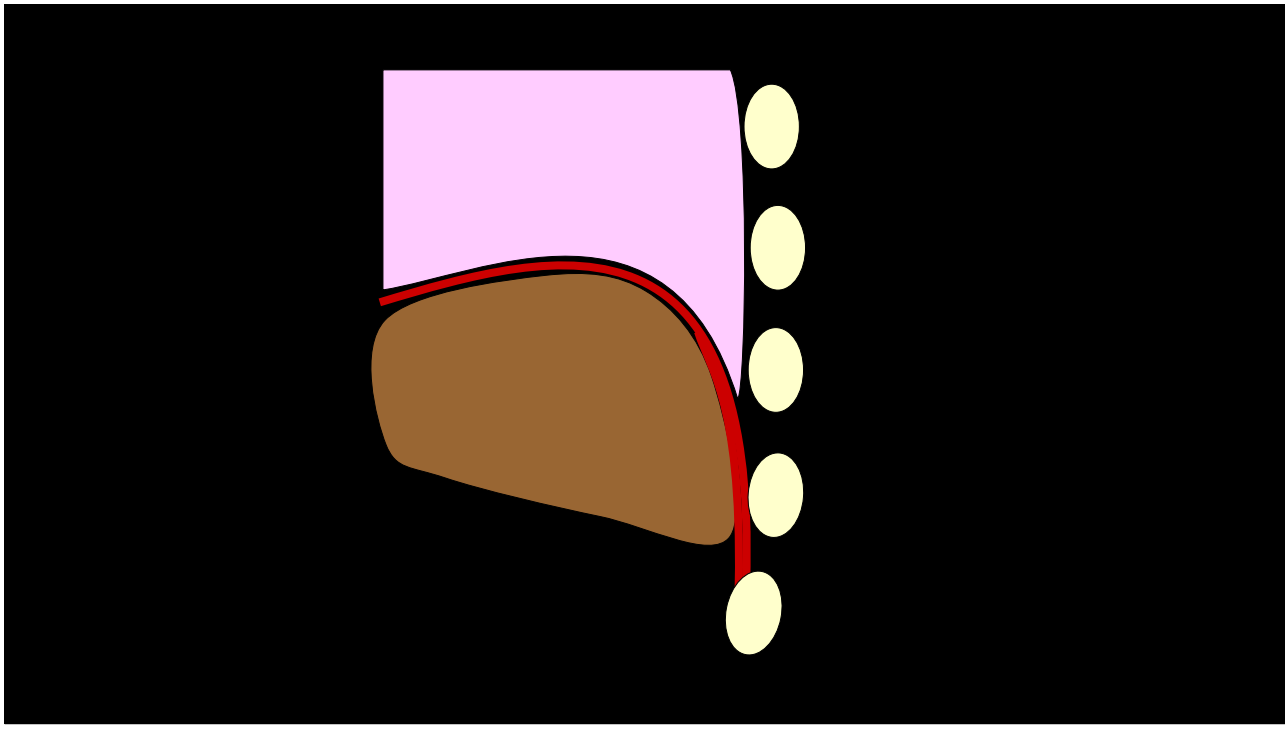

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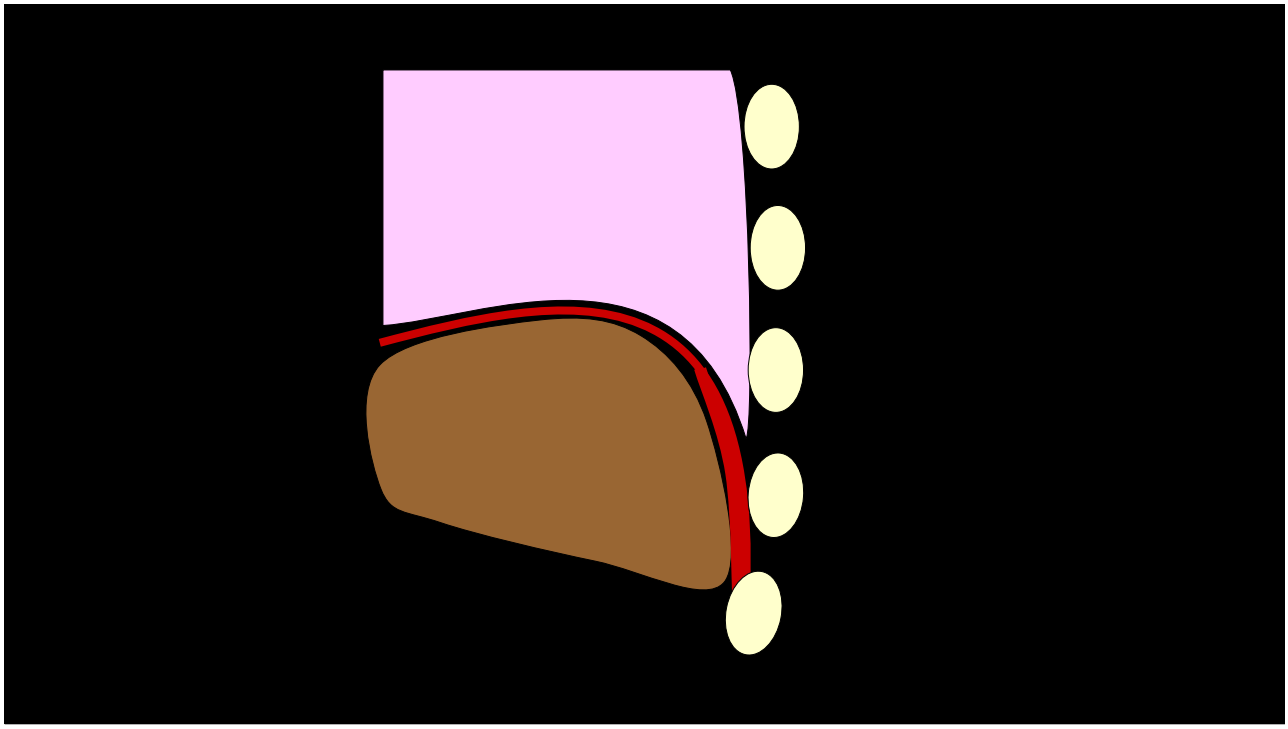

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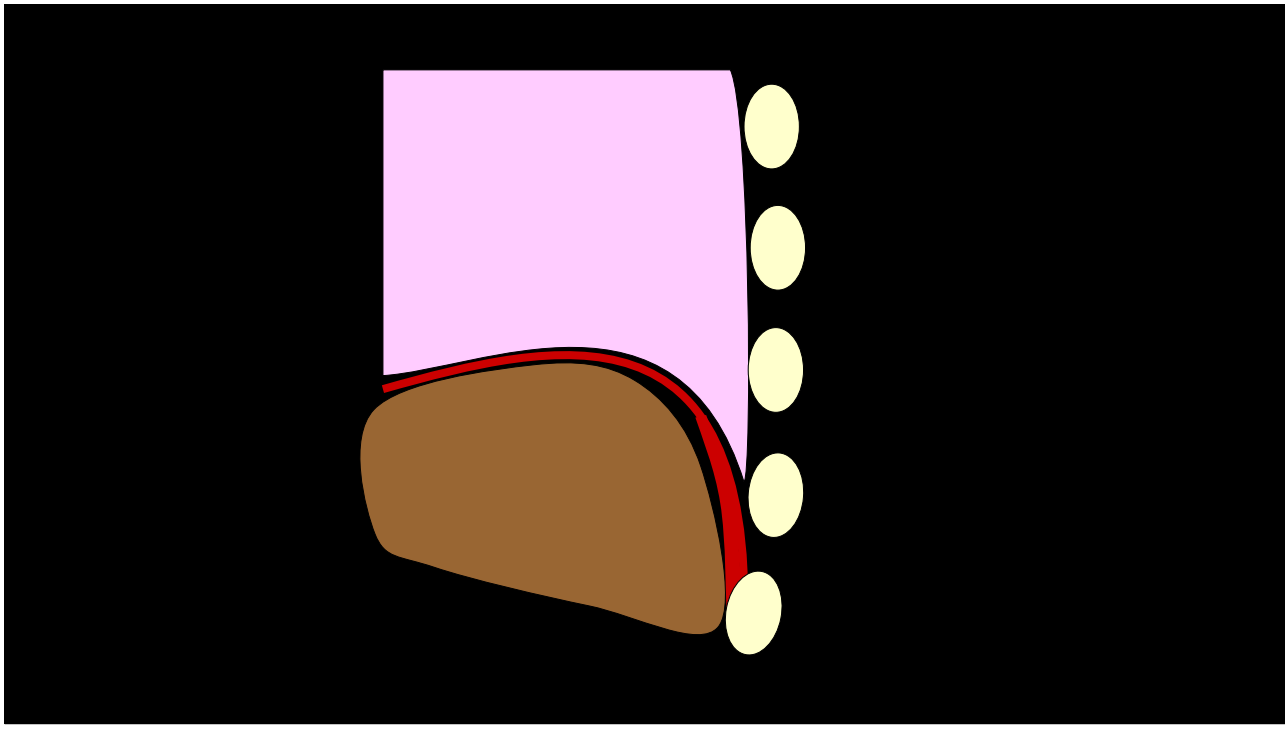

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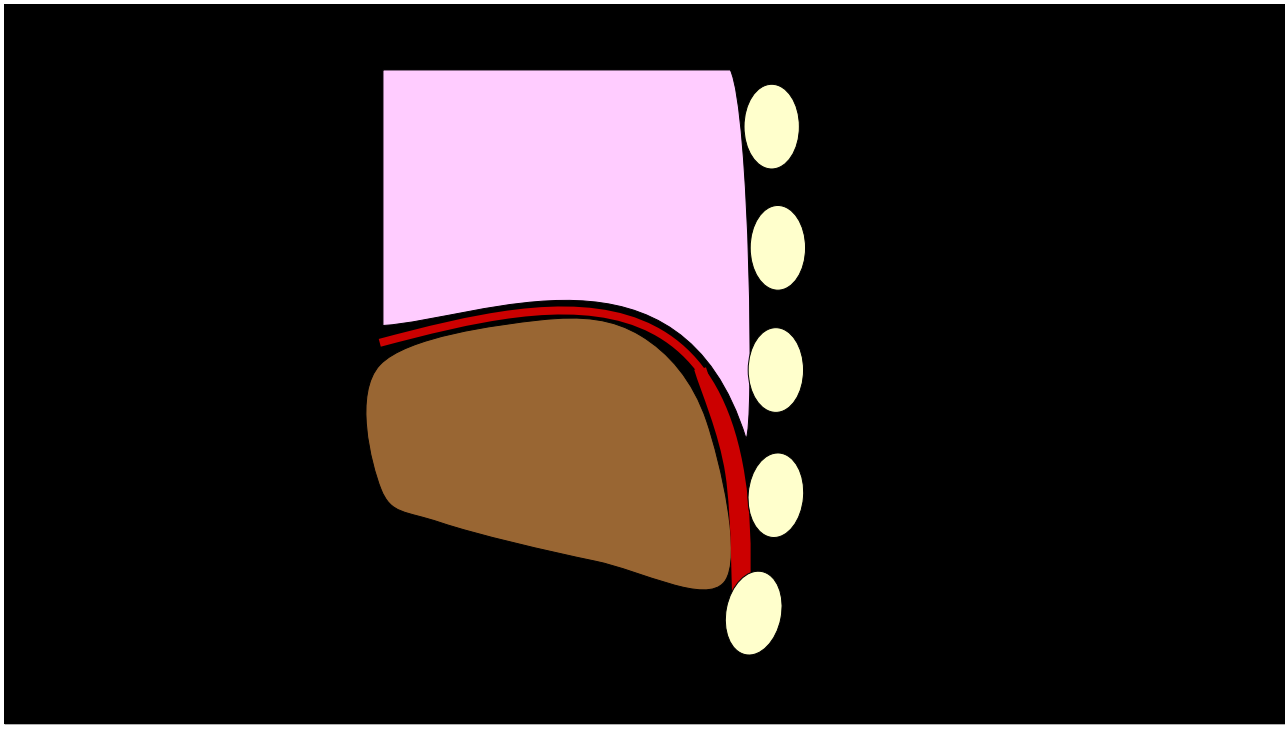

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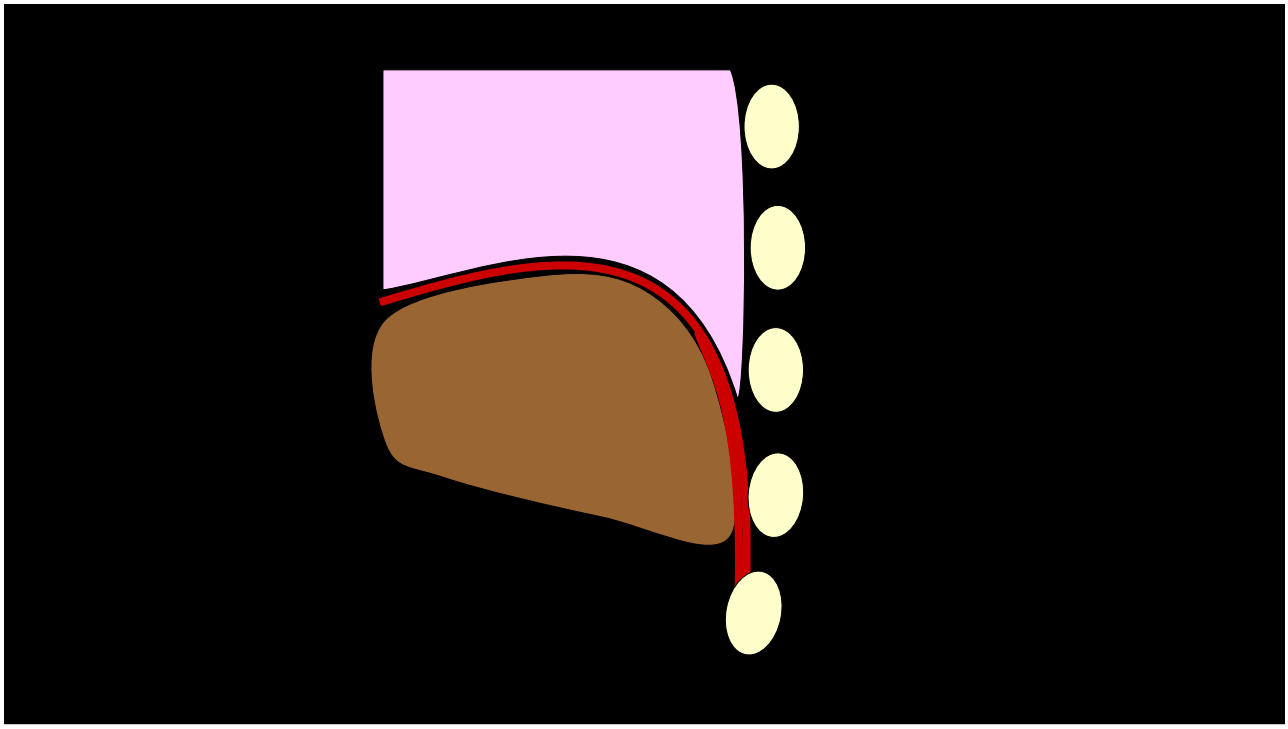

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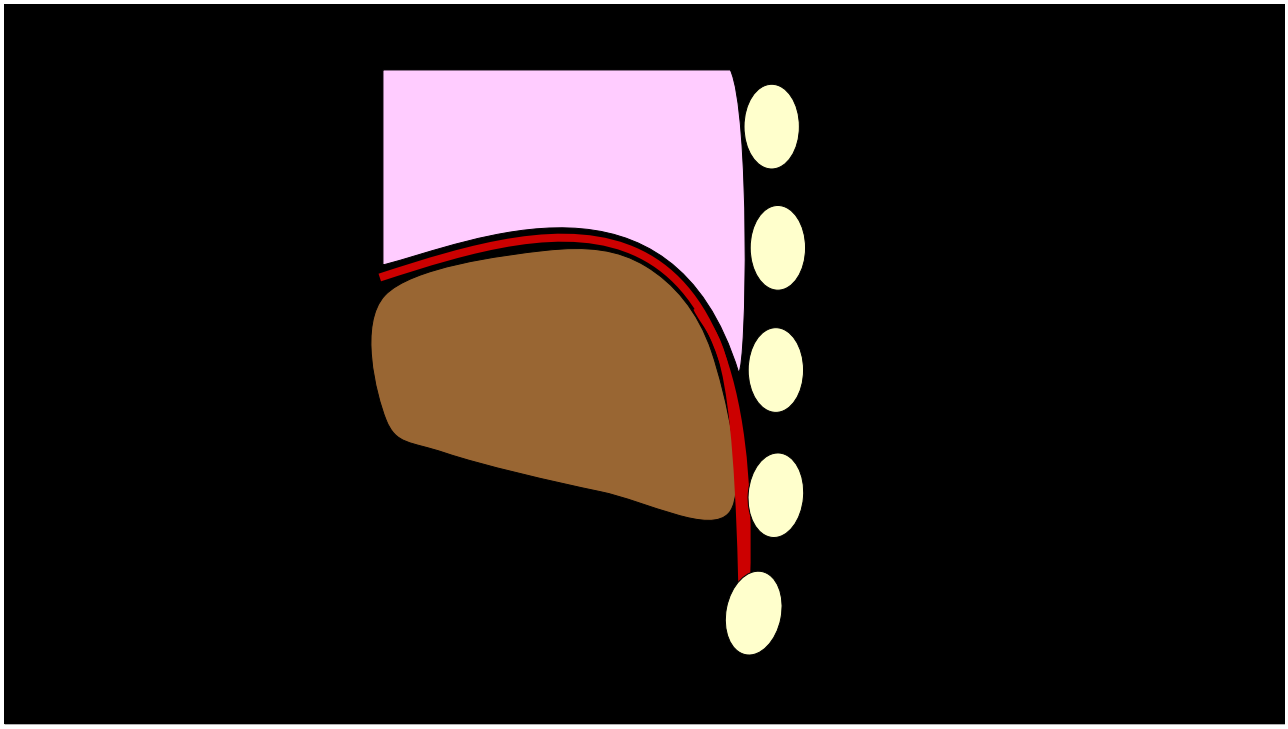

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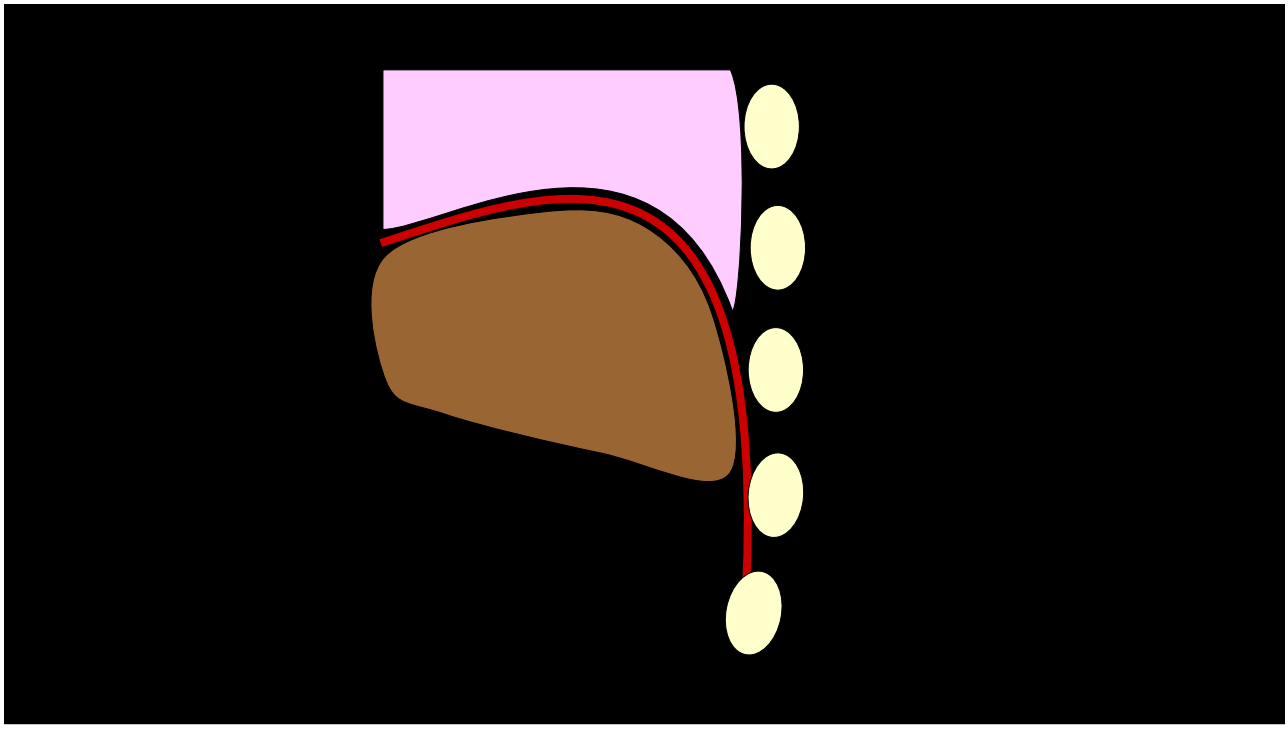

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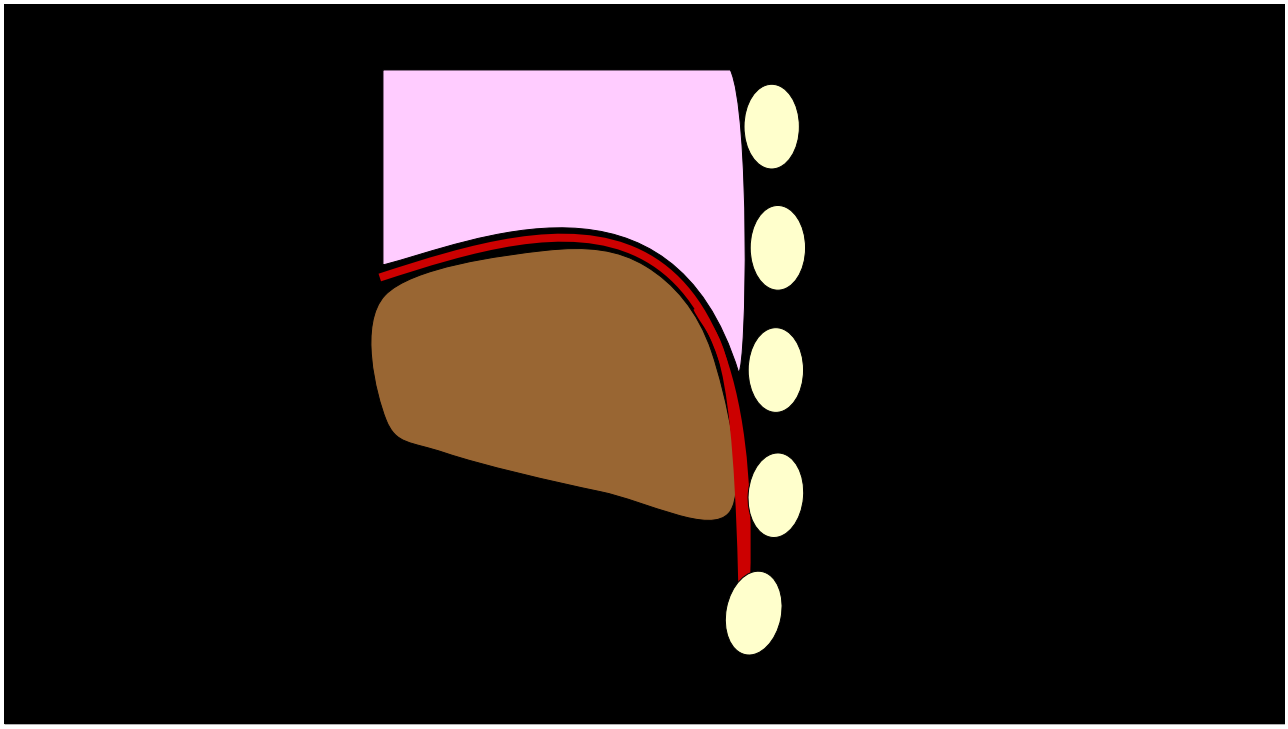

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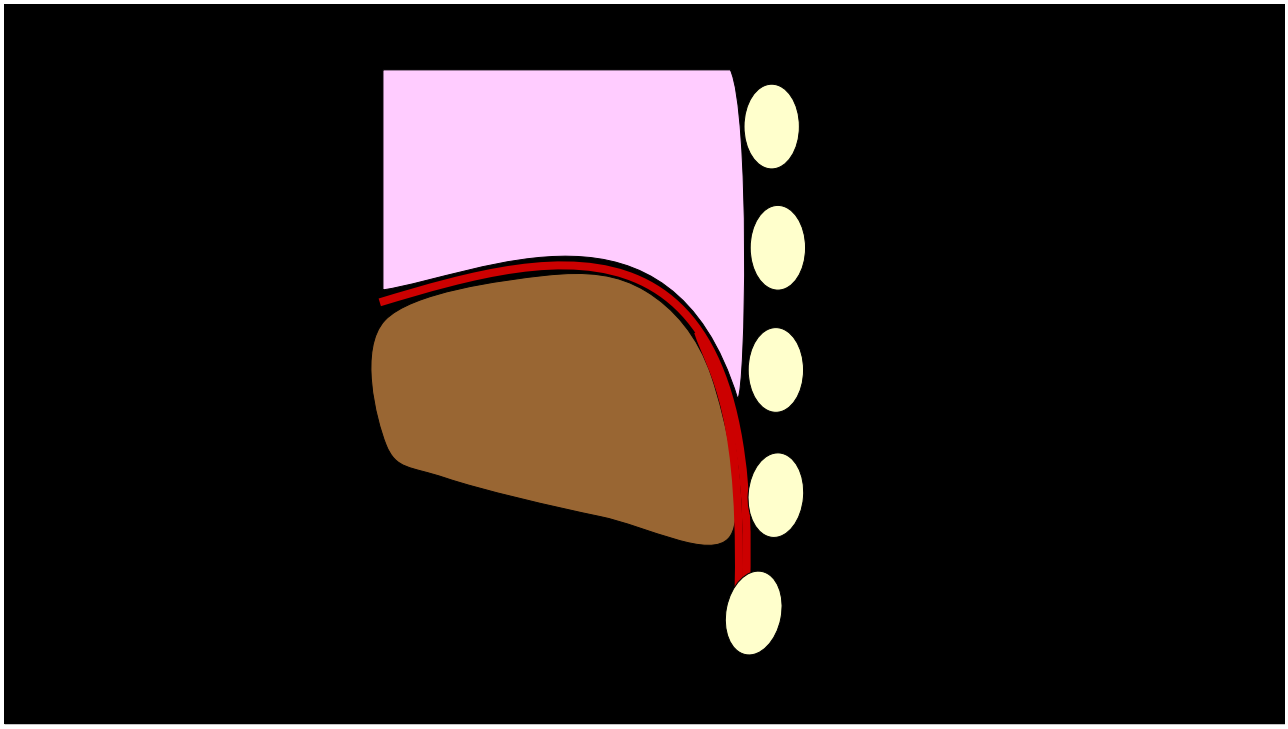

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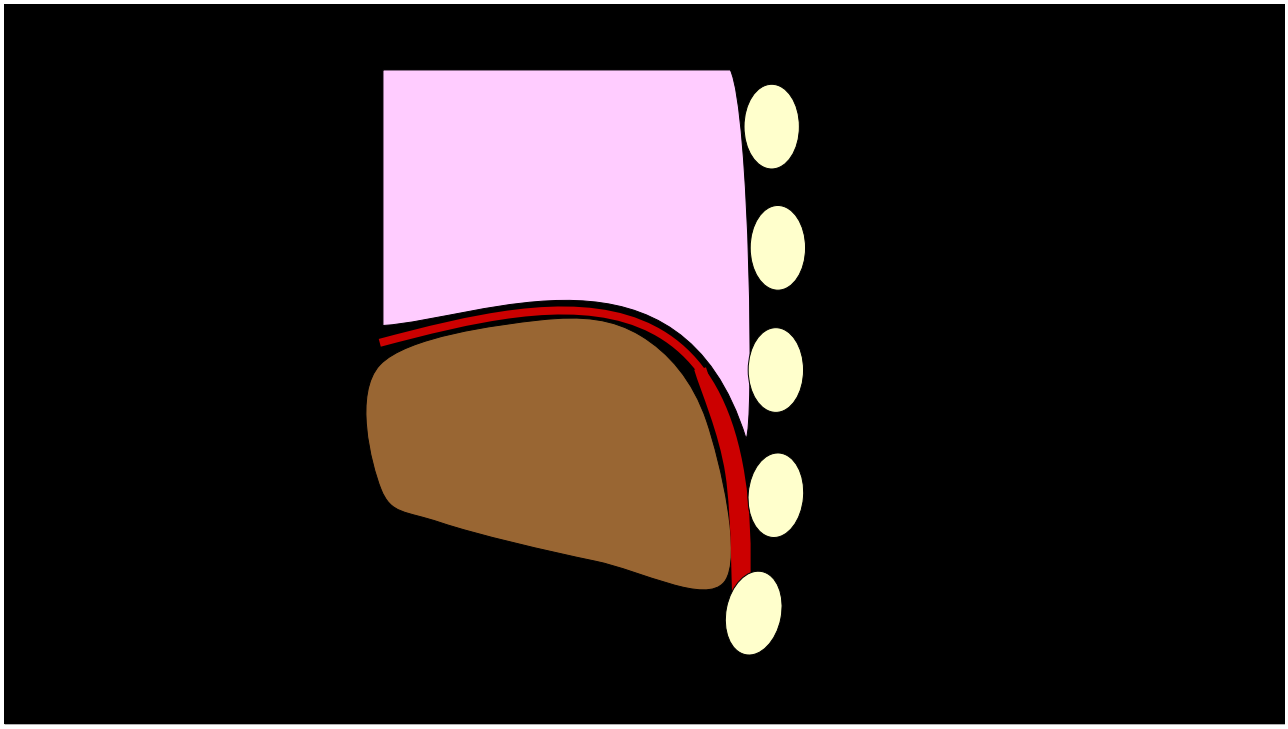

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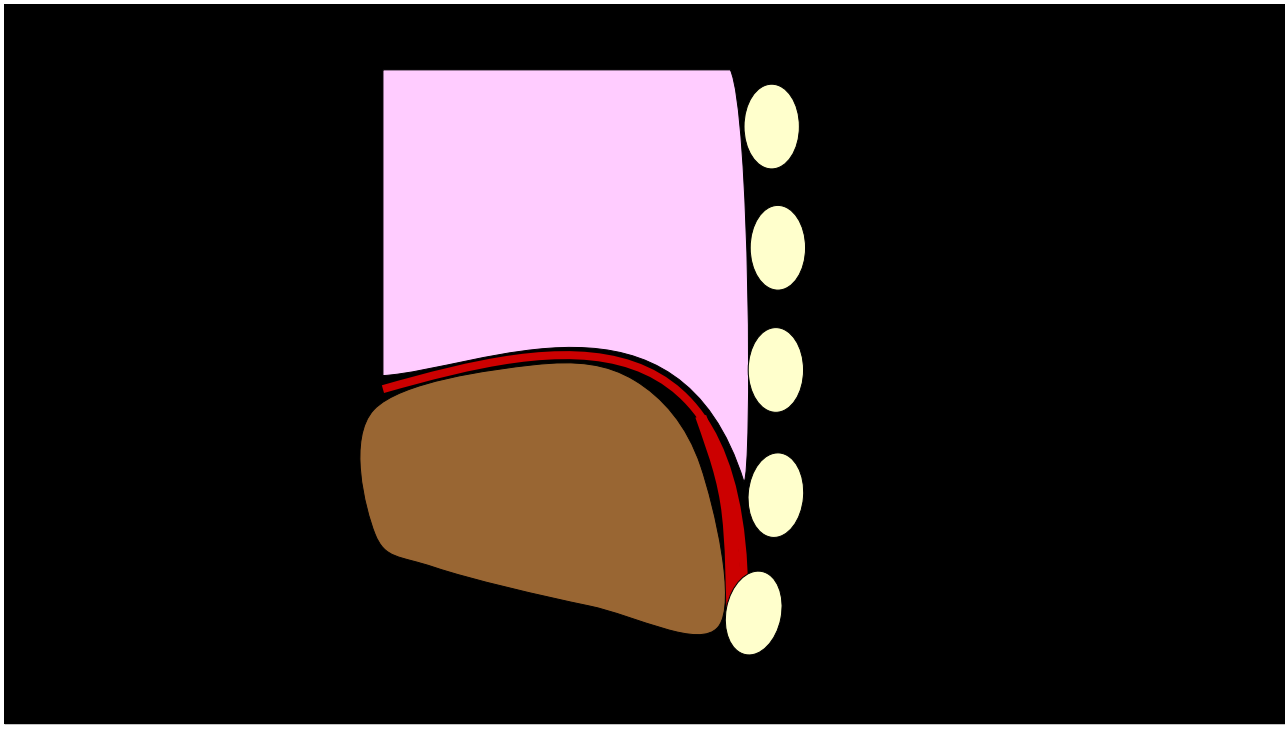

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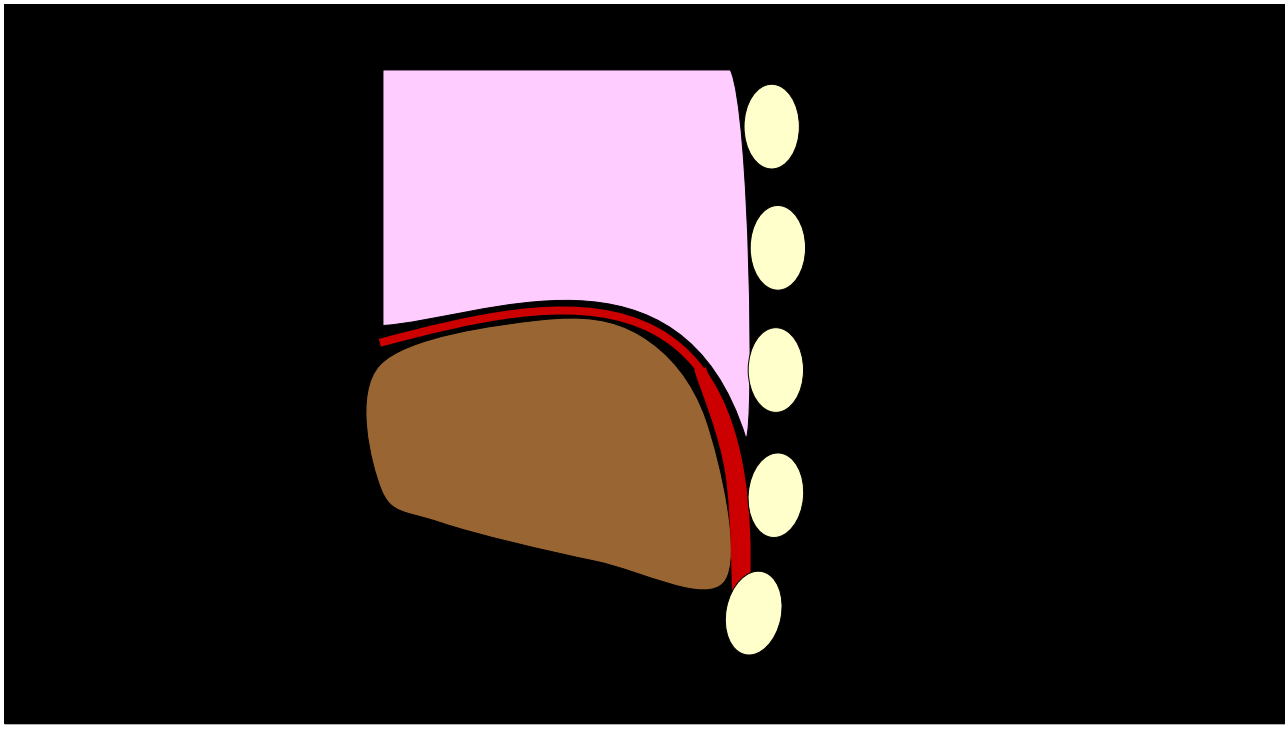

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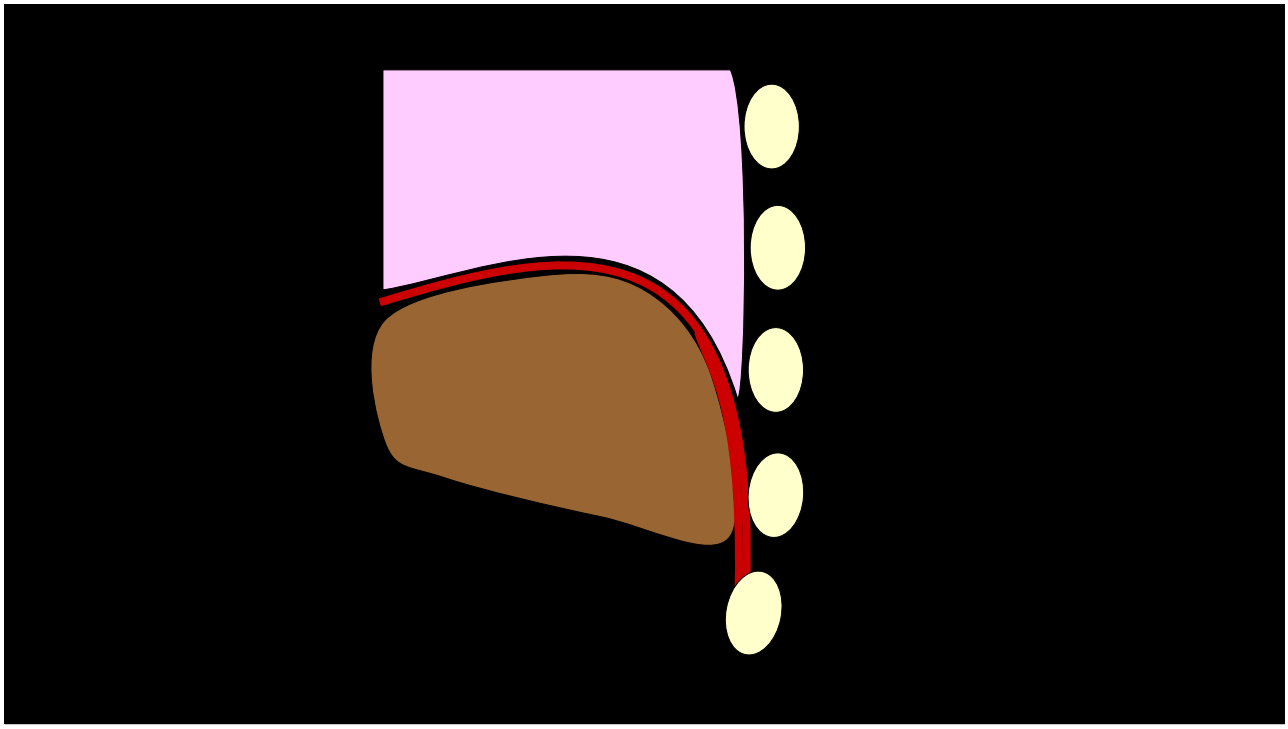

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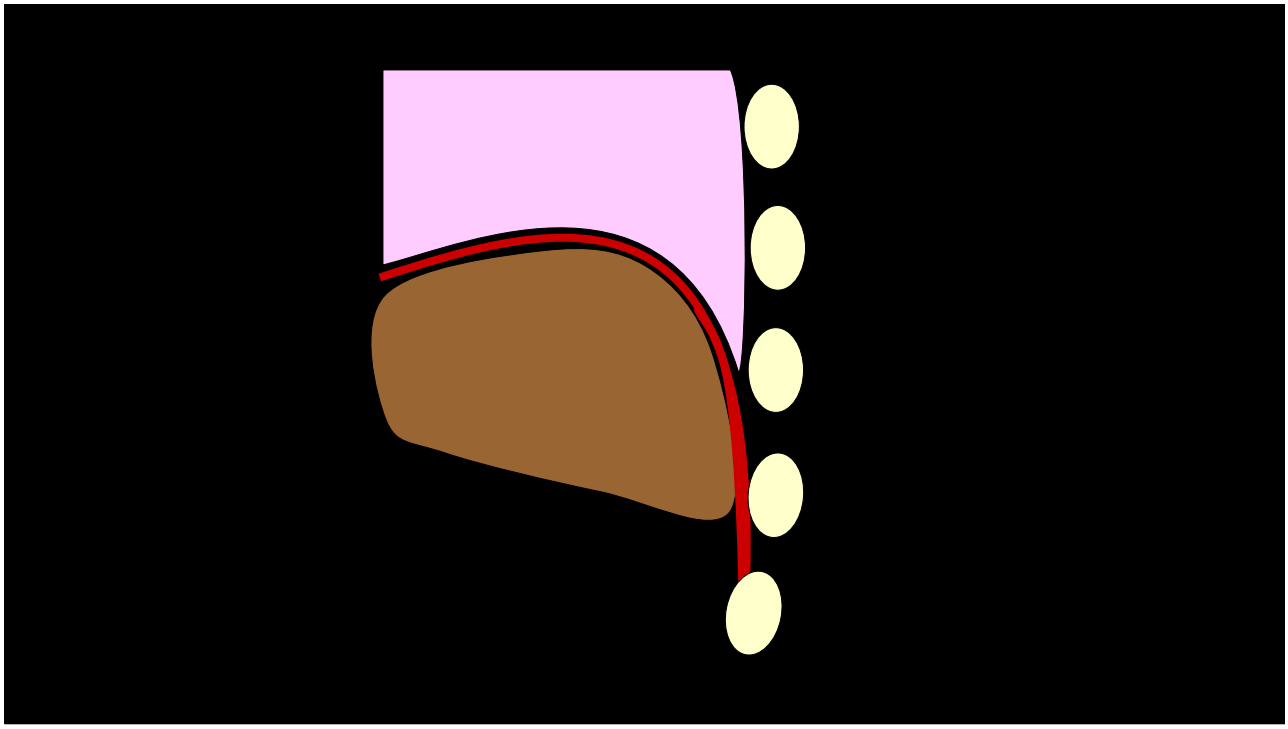

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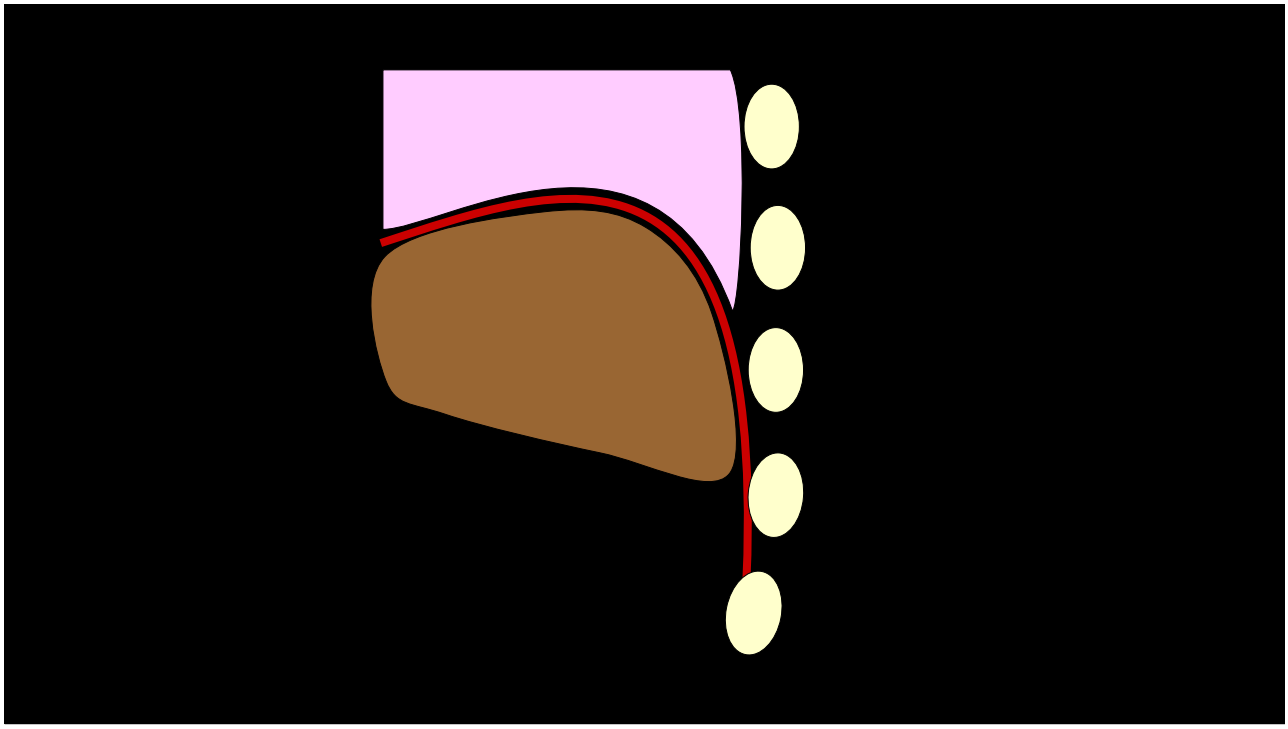

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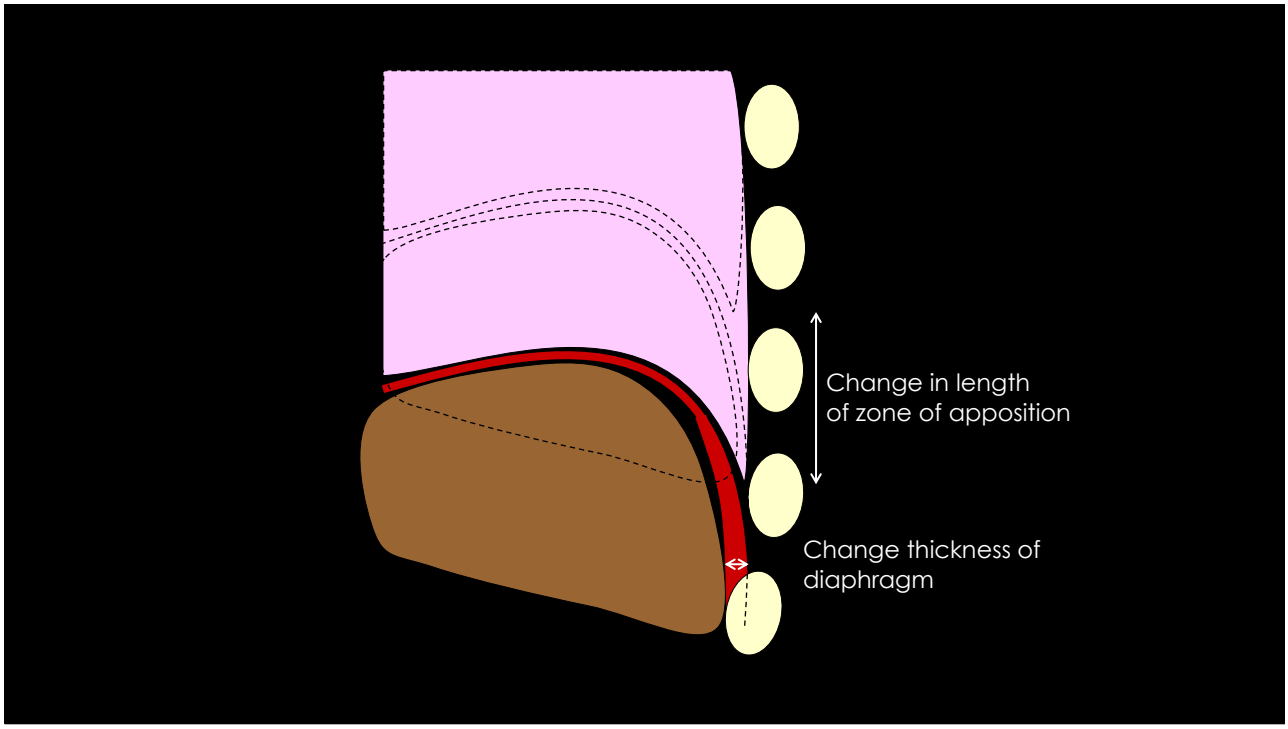
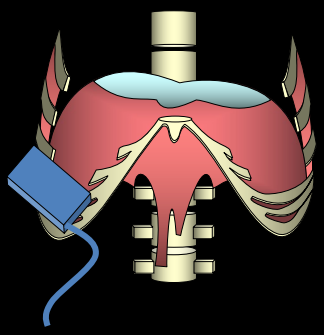


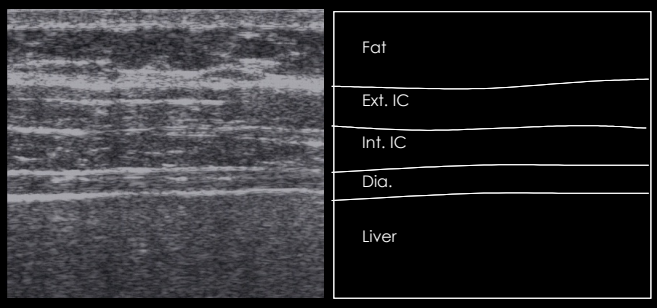
117

Thickening of the diaphragm



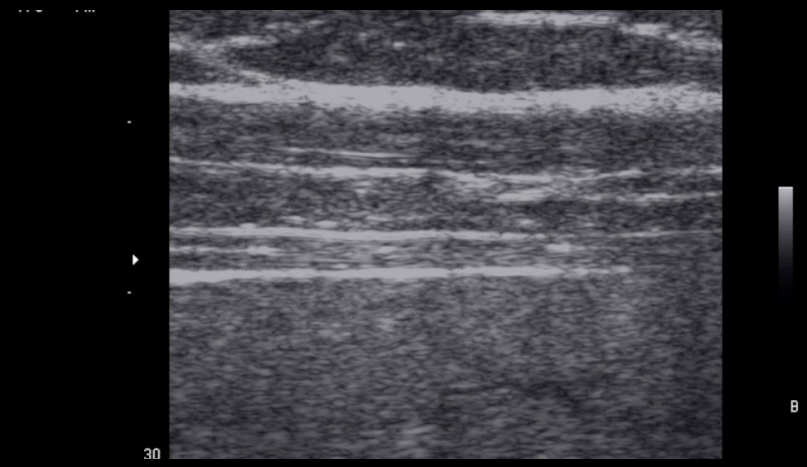
118

Thickening of the diaphragm



119

Diaphragm ultrasound imaging



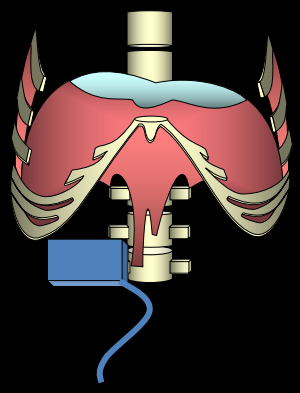
120

Thickening of the diaphragm

- Subject position: Supine with head on pillow
- Transducer: 12 MHz
- Transducer placement:
  - Identify 8th & 9th intercostals space (find 12th rib and count up)
  - Place the transducer along the IC space
  - Place the transducer in the anterior axillary line then optimize
    - Too far back the muscle will peel away and you will loose the image
    - Too far forward the muscle will not thicken much with contraction
  - Check both spaces and pick the one with the best image
  - Optimise the image
    - Select the depth that optimizes the size

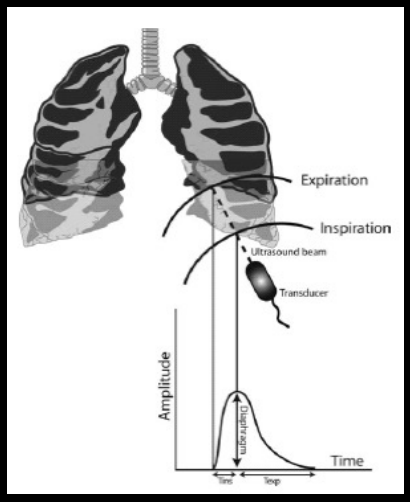
121

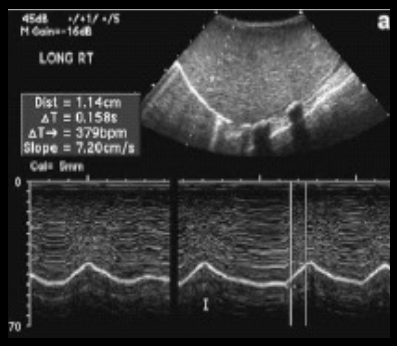
Diaphragm displacement



122

Diaphragm displacement





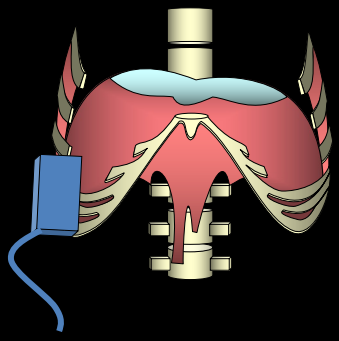
123

Diaphragm displacement

- Subject position: Supine with head on pillow
- Transducer: 3 MHz (set to 4 MHz)
- Transducer placement:
  - Place the transducer in the anterior axillary line, below the rib cage
  - Angle the transducer craniodorsally to image through the liver
  - Identify the posterior aspect of the diaphragm
  - Too horizontal you will not see the diaphragm
  - Too vertical it may be hard to see the edge
  - Optimise the image
    - Select the depth that optimizes the size
  - Use m-mode

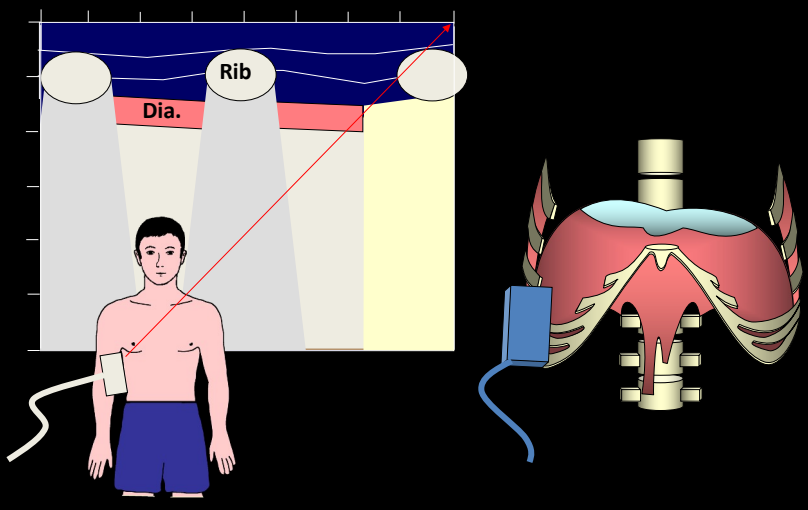
124

Length of zone of apposition



125

Diaphragm ultrasound imaging



126

Length of zone of apposition

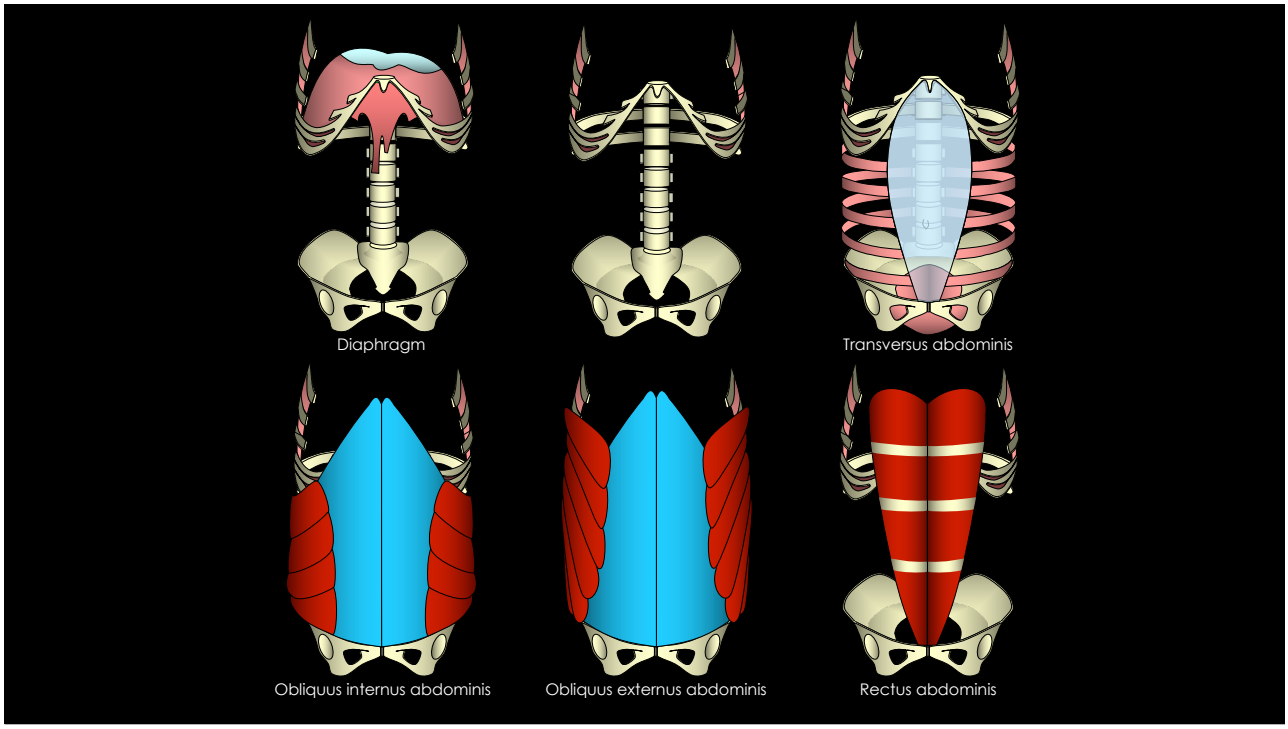
- Subject position: Supine with head on pillow
- Transducer: 12 MHz and 3 MHz
- Transducer placement:
  - Identification of the origin of the diaphragm
    - Place 12 MHz transducer longitudinally in the anterior axilliary line at approx the 8-9th IC space
    - Identify the landmarks (ribs, liver, diaphragm).
    - Ask the subject to breathe and move the transducer caudally until you can see the origin this will be indicated by
      - In rib space below the origin the muscle in the location of the dia will not thicken with inspiration (TrA)
      - Slip of TrA may be noticeable deep to diaphragm
      - Muscle will thin a little and the Dia will not increase in thickness as much with inspiration
      - The rib at which this transition occurs is the origin of the diaphragm
    - Mark the rib with a pen to use as a landmark for the imaging of the zone of apposition (Lzapp)
  - Measurement of the length of the zone of apposition
    - Identify the rib of origin and the superior border of the diaphragm (identified by the white shadow from the lung).
  - Use b-mode and make a cine movie

127

Breathing pattern: Assessment

- Muscle activation & correction
  - Are muscle activation deviations present?
  - Is muscle activation affecting breathing?
  - What is the effect of contraction of transversus abdominis?
  - What effect does muscle activation correction have on breathing pattern?

128



129

Breathing pattern: Assessment

- Pelvic floor muscle activity
  - Activation of PFM during breathing
  - Tonic hold with subtle lengthening (exp) & shortening (insp)

➔Assess breathing pattern and activation of abdominal muscles during breathing

130

Breathing pattern: Assessment

- Postural assessment
  - Neutral spine
    - Optimal breathing pattern
    - Slump – upper chest
    - Thoracolumbar ext – basal expansion
    - Rotated – decreased basal, increased abdo.

Lee & Hodges 2006

  - Assess impact of posture correction

131

Breathing presentation #1

- Prominent expiratory activity of abdominal muscles in supported positions
  - NORMAL
    - Supported positions – relaxed abdo. muscles
    - Upright positions – Standing +/- respiratory activity of abdo. muscles
  - ABNORMAL
    - Pronounced abdo. Muscle activity in supported postures

132

Breathing Presentation #2

- Tonic activity of abdominal muscles that limits respiratory motion of chest wall
  - Restrict - bibasal expansion/diaphragm motion
  - Enhance - Upper chest breathing

133

Interpretation

- Increased OE activity
  - Consequence of pain?
  - Increased resistance to expiration (COPD/Asthma)
- Decreased upper chest movement
  - OE holding rib cage down – decreased basal expansion & abdominal wall displacement
  - Vertical motion only strategy left
  - Posture – thoracolumbar extension – change rib motion

134

Breathing Presentation #3

- Inability to maintain deep muscle contraction with breathing
  1. Loss of deep muscle (including PFM) contraction during inspiration
     - Inability to hold during inspiration
  2. Upper chest breathing
     - Restrict abdominal movement
  3. Shallow breathing
  4. Increase activity of global muscles

135

Interpretation

- Inability to hold PFM
  - Unable to ecc. contract PFM
  - Inc. pelvic floor descent due to compromised basal expansion

136

Breathing Presentation #4

- Reliance on abdominal/pelvic floor displacement for breathing
  - Challenge to hold PFM contraction with large change in muscle length

137

Breathing pattern: Assessment

Basic assessment - sequence

- Observe breathing pattern
  - 3 components
- Palpate movements
- Assess muscle activity
  - Palpation
  - EMG
  - US imaging – abdominal wall, diaphragm
- Consider posture and muscle activation strategy
- Assess affect of correction of posture and muscle activation
- Assess affect of loading
- Assess chest wall flexibility

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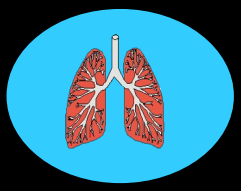


Training of breathing

139

Breathing: Training goals

- Optimise respiratory movements
  - Encourage even distribution of movement between regions
  - Change breathing pattern to simplify spine control
  - Train symmetry
- Optimise respiratory activity of trunk muscles
  - Reduce tonic muscle activity compromising respiratory motion
  - Reduce excessive respiratory activity of trunk muscles
- Optimise posture to optimise breathing
- Optimise thorax dynamic control (thoracic spine & rib cage) to optimise breathing
- Optimise efficiency of breathing pattern in disease
- Train breathing pattern with motor control progressions

140

Breathing pattern: Techniques

- Optimise respiratory movements
  - Respiratory training techniques
    - Manual facilitation
    - Quick stretch
    - Positioning
    - Feedback – manual, elastic
  - Need motion of upper chest, basal rib cage and abdomen
    - If high abdominal movement – difficult to sustain TrA contraction
    - If low bibasal – often large OE to compress
    - If high upper chest – OE prevent other motion

141

Breathing pattern: Techniques

- Optimise respiratory activity of trunk muscles
  - Reduce tonic/excessive activity
  - Maintain deep muscle activity during respiration
    - Feedback
    - Gradually increase inspiratory volume to threshold
    - Optimise breathing pattern
    - Commence with expiration

142

Muscle activation: Techniques

- Increase activity of TrA/ MF/ PFM
  - Whole body posture (stretch on muscle)
  - Spinal posture (greater activity in neutral)
  - Instruction
  - Co-contraction with other muscles
  - Manual facilitation
  - Imagery
  - Feedback (Observation, palpation, US)
  - Taping

143

Muscle activation: Techniques

- Reduce activity of OE/OI/RA/TL ES
  - Whole body posture (more activity, more support
  - Spinal posture (less activity of global in neutral)
  - Instruction
  - Breathing techniques
  - Feedback (EMG, palpation)
  - Decrease effort
  - Connective tissue techniques, trigger point, dry needling
  - Inhibitory taping
  - imagery

144

Breathing pattern: Techniques

- Optimise posture to optimise breathing
  - Retrain neutral posture

145

Breathing pattern: Techniques

- Optimise thorax dynamic control (thoracic spine & rib cage) to optimise breathing
  - Thoracic spine mobility/motor control – exercise, manual therapy
  - Rib cage mobility/motor control – exercise, manual therapy

146

Breathing pattern: Techniques

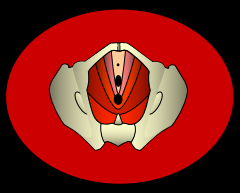
- Optimise efficiency of breathing pattern in disease
  - Optimise breathing movements & muscle activity
  - Increase fitness – pulmonary rehabilitation
  - Flexibility – muscle length & thorax dynamics

147

Breathing pattern: Techniques

- Train breathing pattern with motor control progressions

148



Assessment & training of pelvic floor muscle dysfunction

149

Pelvic floor muscles

- Train activation of pelvic floor muscles
  - Train elevation
  - Restore symmetry
  - Train timing
  - Increase holding time (endurance)
  - Increase strength
  - Reduce over activity (hypertonicity)
- Retrain coordination between pelvic floor and trunk muscles
  - Reduce over-activity of superficial trunk muscles
  - Retrain co-activation with deep trunk muscles
- Retrain control with breathing

150

Assessment: Pelvic floor muscles

- Assessment Goal – assessment items you use depend on your training & tools
  - Evaluate symptoms of incontinence and type
  - Identify whether hypo-/hyper-activity
  - Evaluate ability to contract
  - Evaluate quality of contraction
  - Evaluate symmetry of contraction
  - Evaluate strength and endurance
  - Evaluate co-activation of other muscle of abdominal cavity
  - Evaluate posture
  - Evaluate breathing

151

Pelvic floor muscles: Assessment

- Subjective assessment
- Self palpation
- Ultrasound imaging
- Specialised techniques
  - Manual palpation
  - Vaginal/anal EMG
  - Vaginal/anal pressure

152

Assessment: Pelvic floor muscles

- Subjective assessment - Incontinence
  - Symptoms & type of incontinence
    - Do you have any urine loss on exertion, coughing, etc?
      - Could suggest stress urinary incontinence
    - Do you often experience symptoms of urge to urinate?
      - Could suggest urge incontinence
    - Do you have any pain/discomfort?

153

Assessment: Pelvic floor muscles

- Subjective assessment - Activation
  - Can you stop the flow of urine midstream?
    - Assess ability to contract
    - Avoid doing this regularly – interfere with autonomic control of micturition?
    - Avoid first void in morning – infection risk?
  - Do you have difficulty initiating micturition?
    - May suggest hyper-activity
  - Do you have any pain/discomfort?

154

Assessment: Pelvic floor muscles

- Voluntary activation of PFM (1)
  - Purpose of assessment
    - Identify whether hypo-/hyper-activity
    - Evaluate ability to contract
    - Evaluate quality of contraction
    - Evaluate symmetry of contraction
    - Evaluate strength and endurance
    - Evaluate structural deficits

155

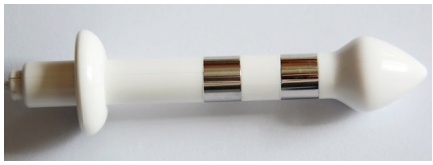
Assessment: Pelvic floor muscles

- Voluntary activation of PFM (2)
  - Methods for assessment
    - Self-assessment
      - External palpation of peineal body (female – elevation; male tightening)
      - Voluntary stop flow of urine – avoid for training
    - Ultrasound imaging
      - Trans-abdominal (Transverse [R-L symmetry] & sagittal) or Trans-perineal - additional training
      - Ability, quality, symmetry, direction,
    - Specialised techniques – additional training
      - Manual palpation
      - Vaginal/anal EMG
      - Vaginal/anal pressure

156

Electromyography recordings: Anal electrodes

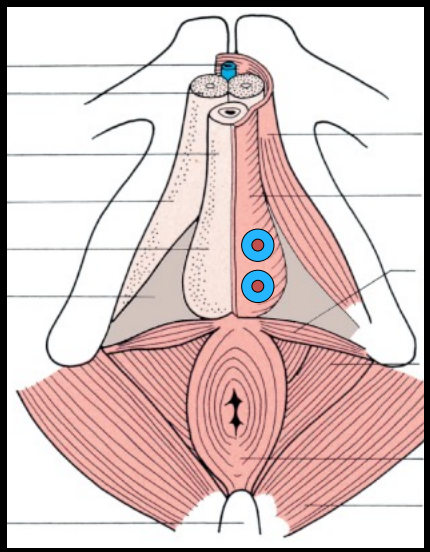
- Primarily record from external anal sphincter
- Often suboptimal design
  - Wrong orientation of electrodes
- Does not provide information of urethral control



157

Electromyography recordings: Perineal electrodes

- Primarily record from bulbocavernosus
- Some information of urethral control



158

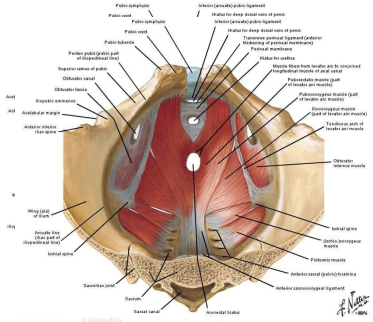
Conclusion

- Electromyography
  - Anal EMG - clinically viable, but potentially of limited value
  - Perineal EMG - clinically viable, some clinical value for continence control,
  - Urethral muscle EMG - limited to laboratory

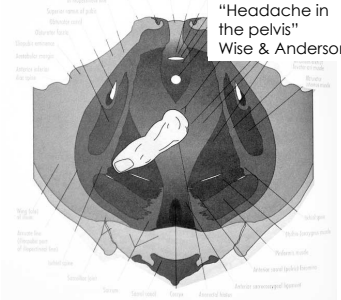
160

Digital rectal examination

- Evaluation of;
  - Contraction of external anal sphincter and puborectalis
    - Strength
    - Endurance
    - Coordination
  - Muscle tone
  - Identification of areas of tenderness



"Headache in the pelvis" Wise & Anderson



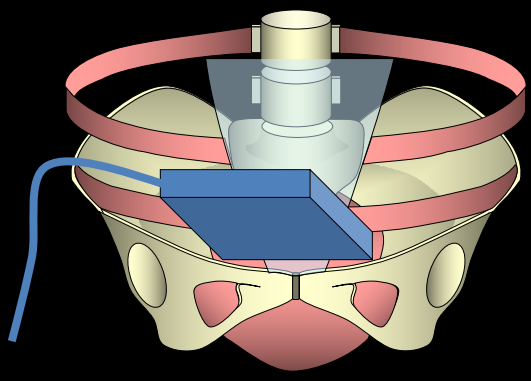
161

Conclusion

- Digital rectal examination
  - When
    - If information will influence management
  - Issues
    - Requires training
    - Requires consent

162

Transabdominal US imaging



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Assessment: Pelvic floor muscles

- Ultrasound imaging
  - Transabdominal & transperineal approaches
  - Provides information regarding the position and movement of the pelvic floor
- Assessment features
  - Activation of multiple components of continence mechanism
  - Relative timing and relative amplitude
  - Quality of contraction
  - Right/left symmetry – relaxed and contracted

164

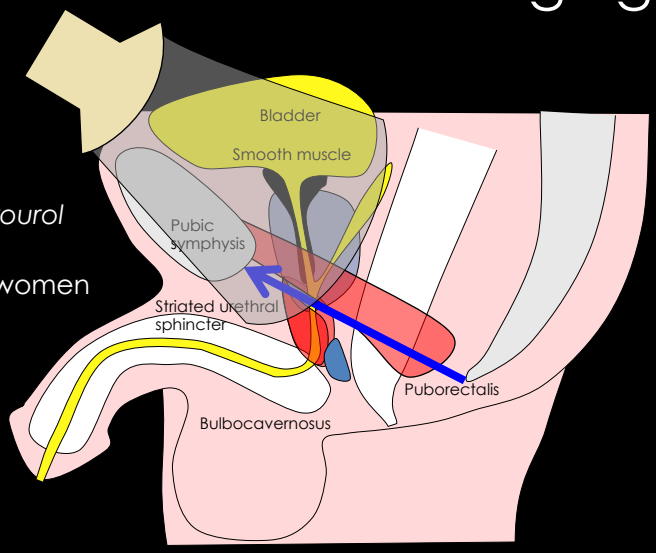
Ultrasound imaging

- Measurement of;
  - **Position of pelvic floor muscles/structures**
    - Depends on;
      - Muscle tone,
      - Structural/fascial integrity,
      - Intra-abdominal pressure
  - **Movement (activation) of pelvic floor muscles**
    - Position
    - Change in position
    - Multiple muscles of pelvic floor

165

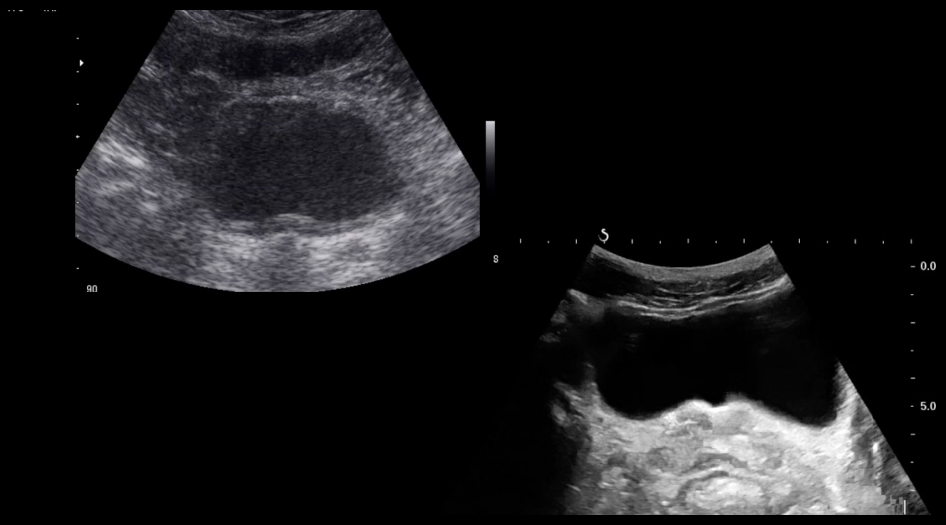
Transabdominal ultrasound imaging

- Levator ani/Puborectalis
  - Nahon I, et. al. *Neurourol Urodyn*, 2011
  - Commonly used in women



166

Transabdominal US imaging



167

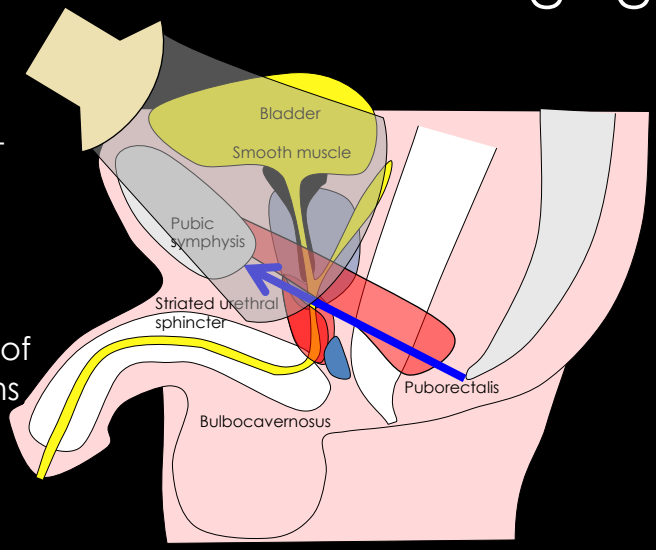
Transabdominal US imaging

- Assessment
  - Position and motion (elevation/depression)
  - Transverse
    - Right left symmetry
    - Location of most motion
      - Problem – AP motion
  - Sagittal
    - Midline (urethrovesicle junction) and sides
  - Measurement
    - Displacement direction and amplitude

168

Transabdominal ultrasound imaging

- Problems
  - Difficult to quantify - no bony landmark
  - Affected by abdominal displacement
  - Limited information of multiple mechanisms



169

Ultrasound imaging: Transabdominal Imaging technique

- Preparation
  - Bladder volume controlled – empty bladder and drink 100 ml 20 min before imaging
  - Place paper towel in waist-band to keep gel from
- Transducer
  - 3-5 MHz curved transducer
- Transducer position
  - Transverse image
    - Place transducer transversely across abdominal wall superior to pubic symphysis
    - Direct transducer inferior towards perineum to visualise bladder
    - Optimise image depth to just beyond bladder base
    - Adjust angle to observe urethro-vesical junction (protrusion in bladder base)
  - Sagittal image
    - Place transducer in midline superior to pubic symphysis
    - Angle transducer sharply inferior towards perineum to visualise bladder
    - Optimise image depth to just beyond bladder base
    - Adjust angle to observe pubic symphysis
    - Move right and left to align to midline

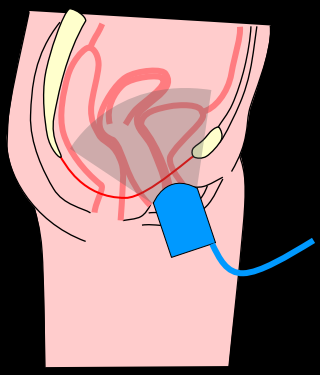
170

Transabdominal US imaging

- Pros
  - Non-invasive
  - Assessment of symmetry
- Cons
  - No bony landmark
  - Difficult to control/interpret with abdominal brace

171

Transperineal US imaging



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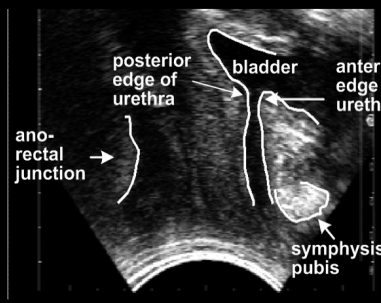
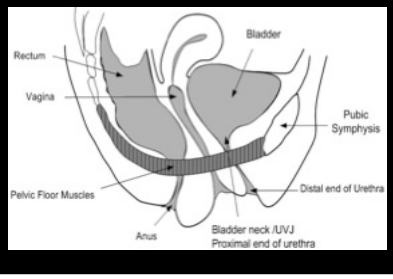
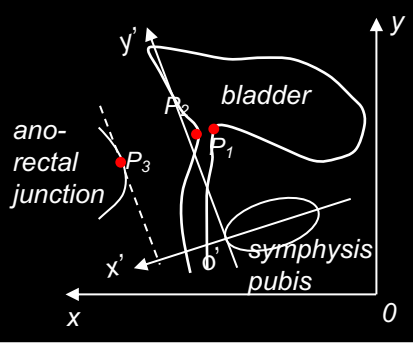
Transperineal US imaging - **women**





- Commonly used in women (Dietz HP, *Int Urogynecol J*, 2011)
- Validated measurement of displacement (Peng et al., *Annals Biomed Engineering*, 2006)



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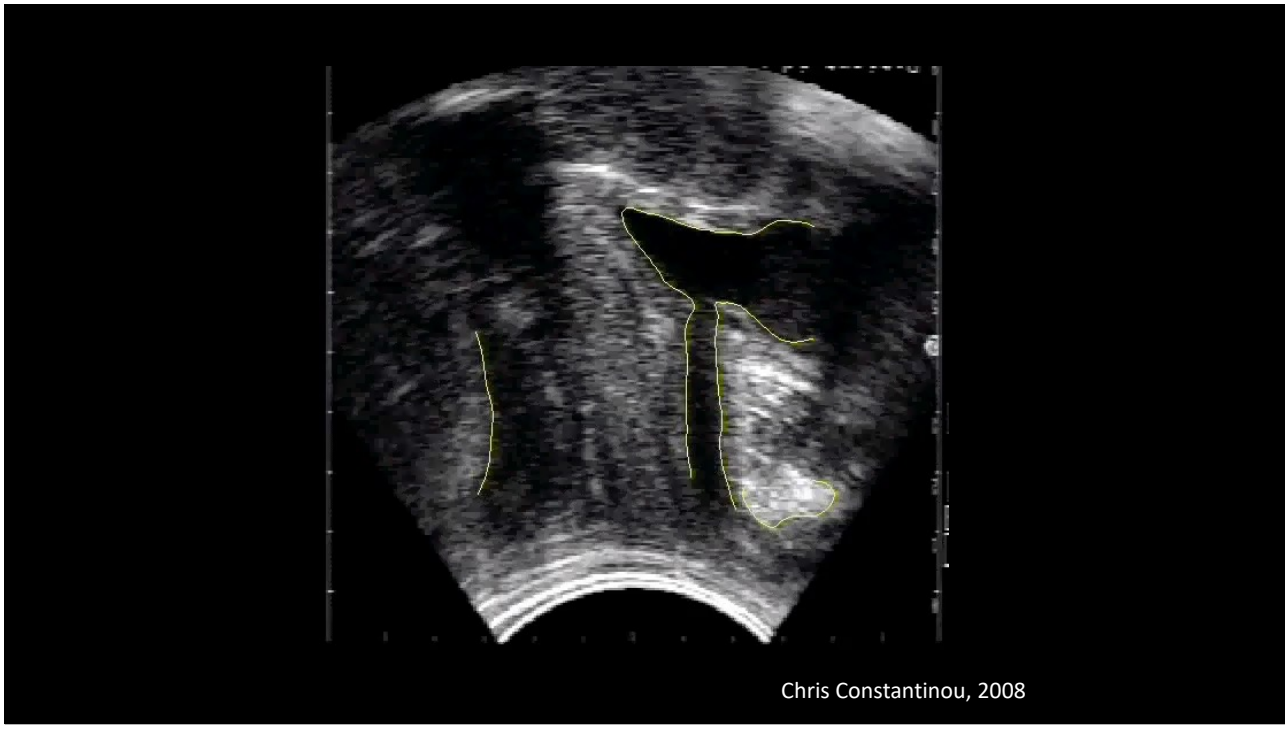
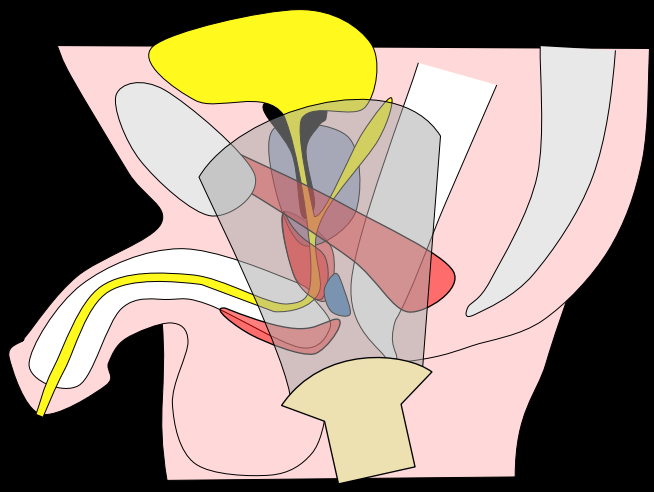


174

Transperineal US imaging – **men**

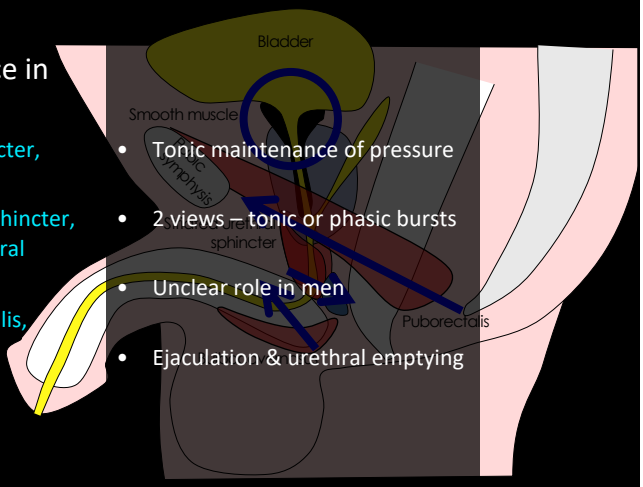


175

Smooth & striated muscles of continence

- Continence
  - Urethral pressure>Bladder pressure
- Major contributors to continence in males:
  - **Smooth muscle sphincter** (Lissosphincter, internal urethral sphincter)
  - **Striated urethral sphincter** (Rhabdosphincter, external urethral sphincter, peri-urethral striated muscle)
  - **Levator ani** (Puborectalis, pubovisceralis, pubococcygeus)
  - **Bulbocavernosus**

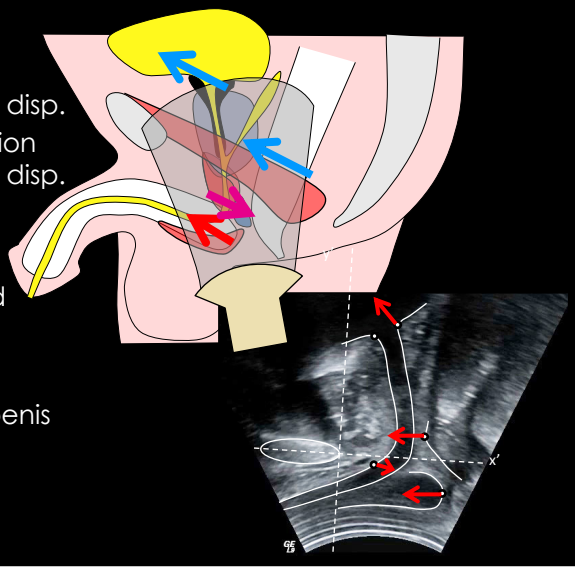
Traditional view



176

Transperineal ultrasound imaging

- Puborectalis
  - Ano-rectal angle elevation & anterior disp.
  - Urethrovesical junction elevation & anterior disp.
- Striated urethral sphincter
  - Posterior motion mid urethra
- Bulbocavernosus
  - Compression bulb penis



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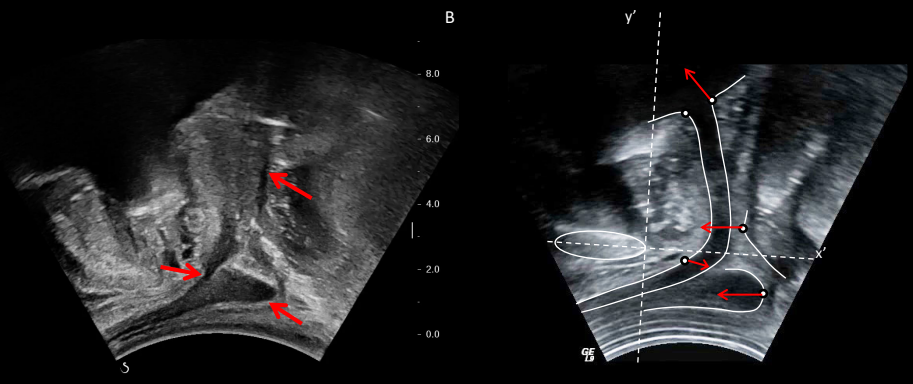
Transperineal ultrasound imaging: Voluntary contraction



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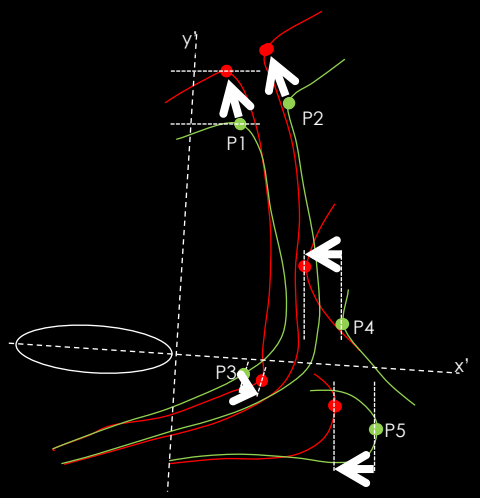
Ultrasound imaging: Transperineal Measurement

- Relaxed state
- Contracted state



Stafford, Ashton-Miller, Constantinou, Hodges (2013) *Urology*

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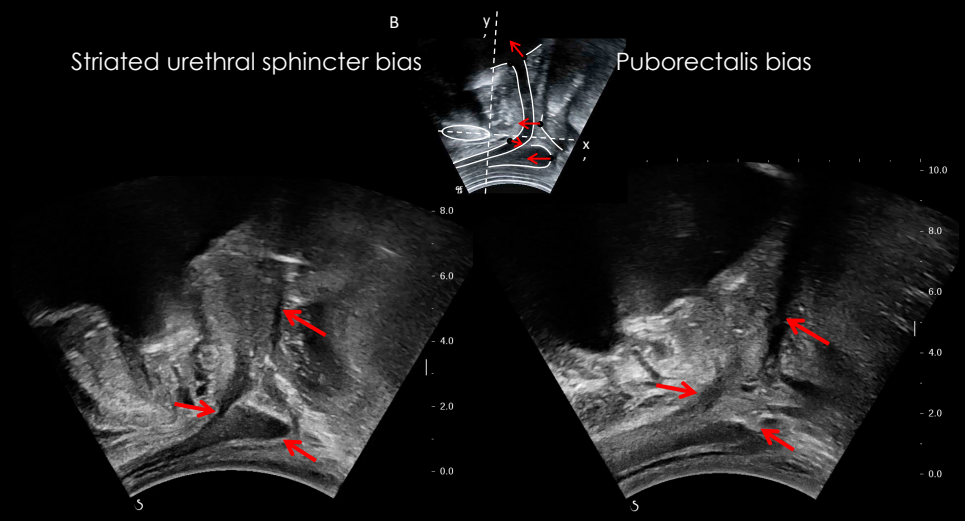
Individual strategies of striated urethral muscle control



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Male Transperineal Ultrasound: Imaging technique

- Preparation
  - Bladder volume controlled – empty bladder and drink 100 ml 20 min before imaging
  - Remove underwear and place towel around waist
- Transducer
  - 7 MHz curved transducer
  - Apply gel to transducer and cover with glove/clear film ensuring no bubbles are present. Apply gel to glove/film.
- Transducer position
  - Place on perineum between anus and scrotum
  - Move anteroposterior and left-right to identify urethra, bulb of penis and pubic symphysis
  - Align transducer to optimise image of urethra
  - Ensure pubic symphysis is visible at anterior edge of image
  - Adjust frequency and focus points to optimise view of mid urethra and bladder neck
  - Observe for ano-rectal junction

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Assessment: Pelvic floor muscles

- Basic assessment - sequence
  - Subjective
  - Voluntary activation of PFM
    - Self assessment – external palpation, stop flow
    - US imaging
      - Transverse and sagittal imaging
  - Breathing
  - Posture
  - Voluntary activation of TrA and MF

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Assessment: Pelvic floor muscles

- Breathing
  - Activation of PFM during breathing
  - Tonic hold with subtle lengthening (exp) & shortening (insp)

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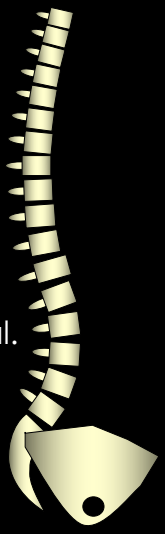
Posture and the pelvic floor muscles

- Impact of postural alignment
  - Slump – decrease PFM
  - Neutral – increase PFM
  - Activation of PFM appears best with lumbar lordosis

Sapsford et al.



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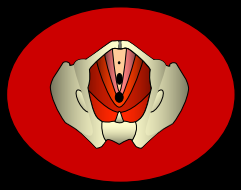

Training of pelvic floor muscle dysfunction

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Pelvic floor muscles: Training goals

- Goals
  - Train activation with elevation
  - Increase strength and endurance
  - Restore symmetry
  - Reduce over-activity of superficial abdominal muscles
  - Reduce over-activity of PFM
  - Restore control with breathing

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Pelvic floor muscles: Training goals Train activation with elevation

- Education and instruction
  - Anatomy and function
    - Sling of muscle
    - Controls flow of urine
  - Instructions
    - Feeling of stopping flow of urine
    - Lift of floor (elevator analogy)
    - Pull ischial tuberosities together (posterior)
    - Male – stop flow of urine, shorten penis, lift testes

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Question

- Can coordination between muscles be affected by instructions?

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Voluntary activation: Instructions

- "**Shorten the penis**" - greatest dorsal displacement of the mid-urethra and **SUS** muscle activity
- "**Elevate the bladder**" - greatest increase in **abdominal EMG** and **IAP**
- "**Tighten around the anus**" - greatest **anal sphincter** muscle activity

Stafford, Ashton-Miller, Constantinou, Hodges (2015) *Neurourol Urodyn*

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Pelvic floor muscles: Training goals
Train activation with elevation

- Submaximal contraction of TrA activates the PFM
  - NB. SUI has not been tested experimentally
- Feedback
  - Transabdominal ultrasound imaging
  - Self palpation of perineal body
  - Movement of "pole" on Periform EMG electrode
- Postural correction
  - Lordosis is associated with improved contraction

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Pelvic floor muscles: Training goals
Restore symmetry

- Feedback
  - Transverse ultrasound imaging
- Positioning
- Specialist intervention

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Pelvic floor muscles: Training goals
Increase strength & endurance

- Repeated contraction
- Weights
- Pressure feedback

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Pelvic floor muscles: Training goals
Reduce activity of superficial muscles

- Feedback
  - EMG
  - Palpation
- Positioning
  - Whole body
  - Spinal curvature

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Pelvic floor muscles: Training goals
Reduce over-activity of PFM

- Specialist intervention
- Palpation
- Relaxation

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Pelvic floor muscles: Training goals
Restore control with breathing

- US feedback
- Feedback of muscle activity with breathing – avoid OE/RA
  - EMG biofeedback
- Feedback of breathing pattern
  - Aim for 3 components
    - Manual feedback
    - Chest strap
    - Mirror

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Incontinence & obstructive disorders

- PFM training is only one part
- Requires specialised skills
- Voiding strategies
  - Toilet posture
  - Abdominal and PFM coordination
- Diet and fluid intake
- Voiding behaviour - frequency

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Contribution to management of pelvic floor muscle disorders

- Look beyond the pelvic floor
- Requires specialised assessment
- Rehabilitation of pelvic floor control
  - Over/under active
  - Symmetry/strength/endurance
  - Consider other structural changes
- Rehabilitation of coordination with abdominal muscles
  - Consider abdominal muscle function
  - Consider posture
  - Consider breathing

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Diastasis rectus abdominis

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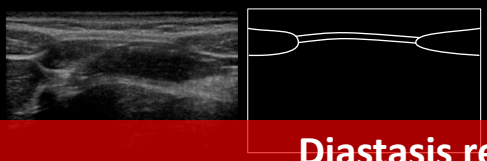
Load transfer & fascia

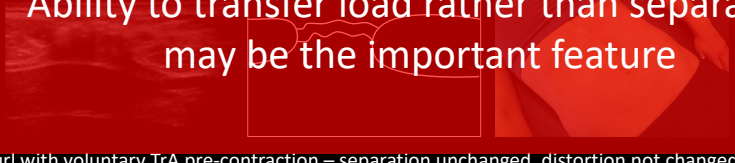
Rest



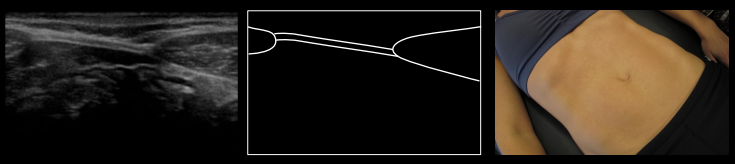
Diastasis recti

Curl without spontaneous TrA contraction - separation reduced, distortion increased

Ability to transfer load rather than separation may be the important feature



Curl with voluntary TrA pre-contraction – separation unchanged, distortion not changed



Lee & Hodges (2016) JOSPT

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