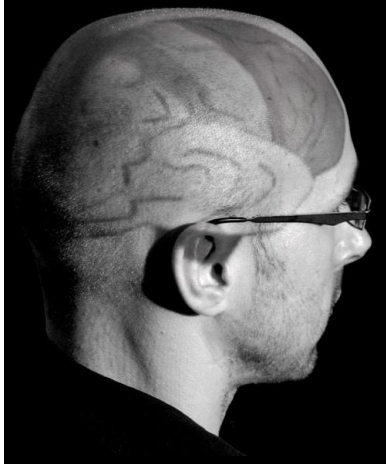


Evaluation and interpretation of changes on muscle function in back pain

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

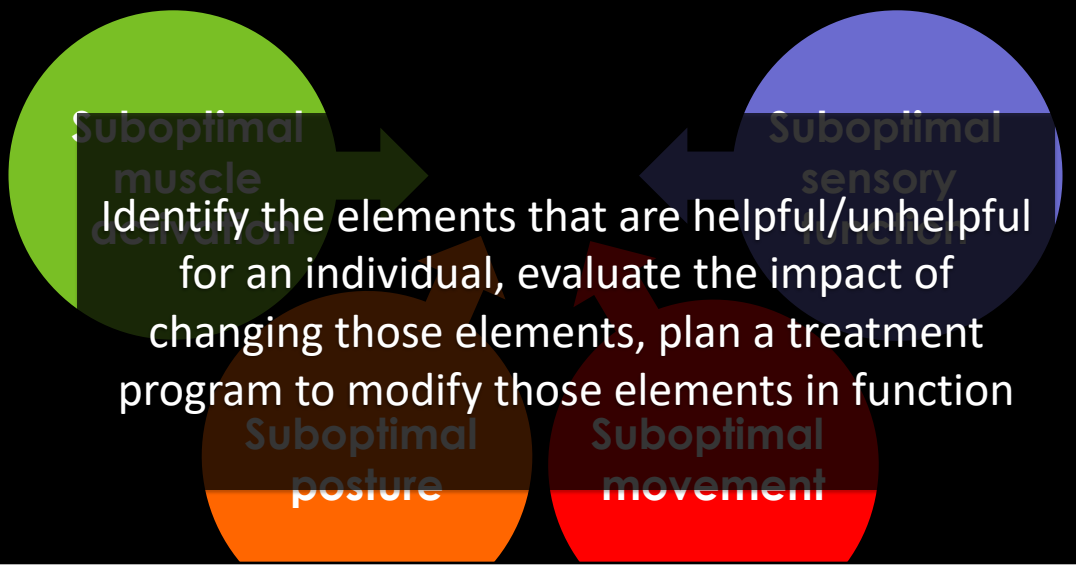
What is motor control training?

Motor control training:

- Aims to restore optimal control of the spine and pelvis
- Considers muscle activation patterns, posture, movement, sensory function and coordination of multiple functions of trunk muscles
- Aims to optimise load on structures of the spine and pelvis to reduce nociceptive input induced by tissue loading
- Encourages "helpful" and discourages "unhelpful" motor control strategies
- Is matched to the individual-specific changes in motor control
- Is matched to the functional demands of the individual patient
- Considers interaction with pain neurobiology and psycho-social aspects of LBP

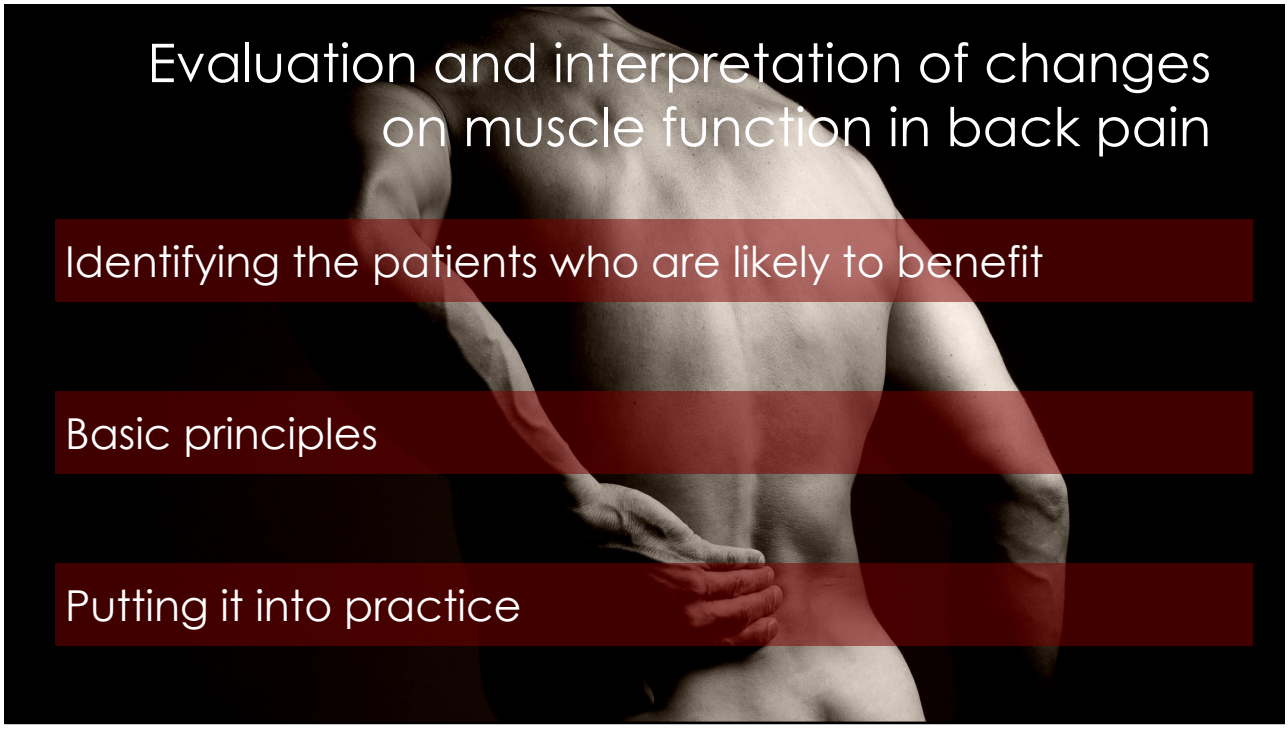
2

Motor control changes in LBP



3

Evaluation and interpretation of changes on muscle function in back pain



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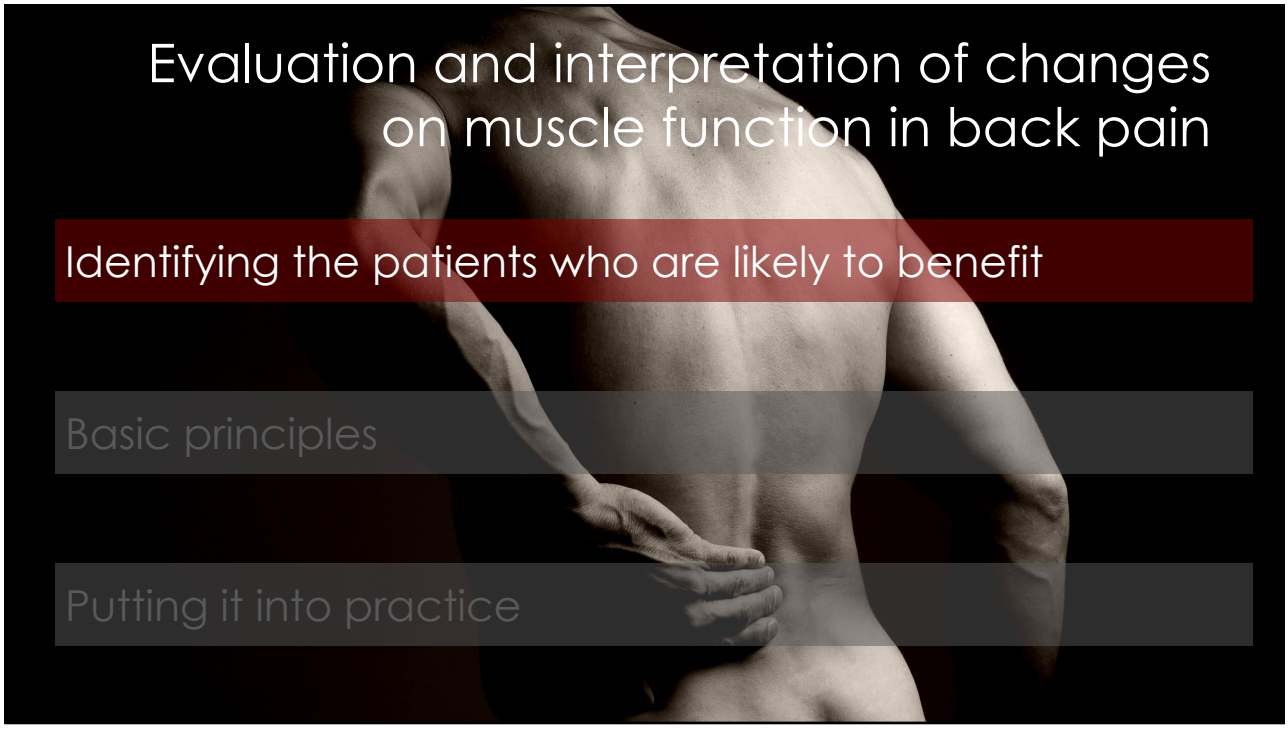
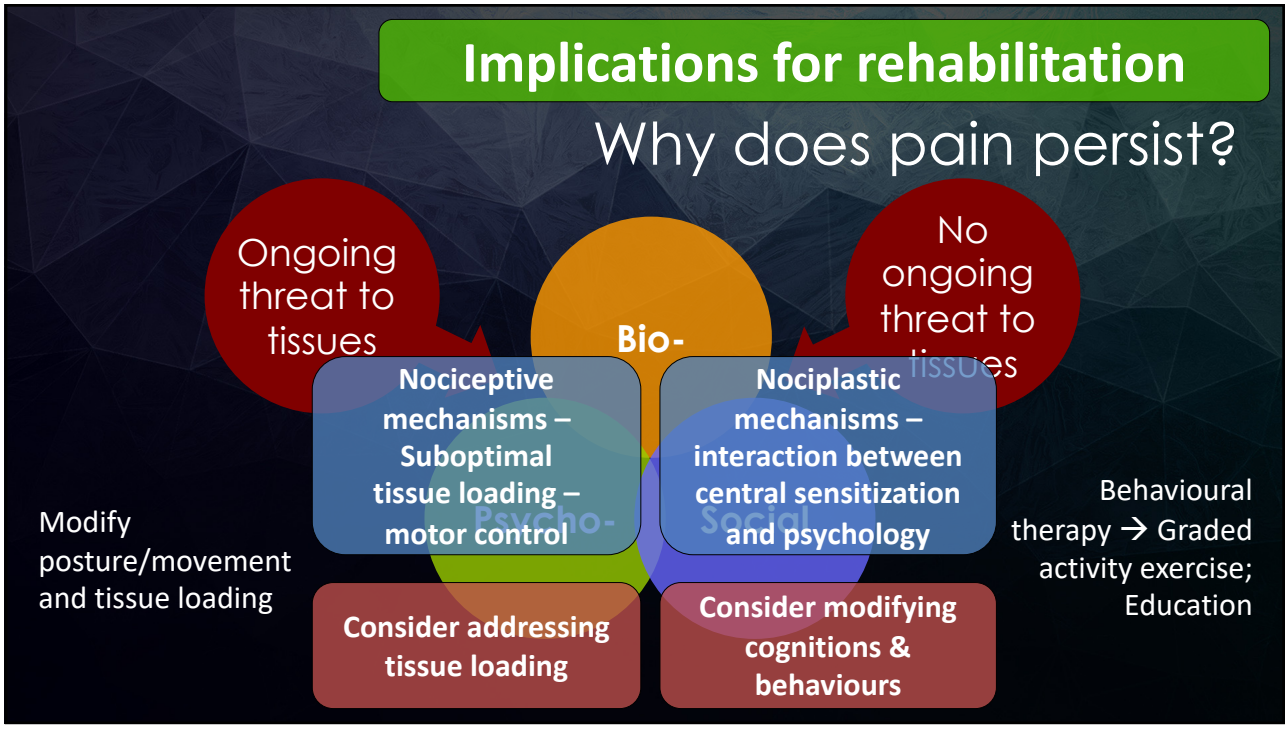

Evaluation and interpretation of changes on muscle function in back pain
Identifying the patients who are likely to benefit
Basic principles
Putting it into practice

5

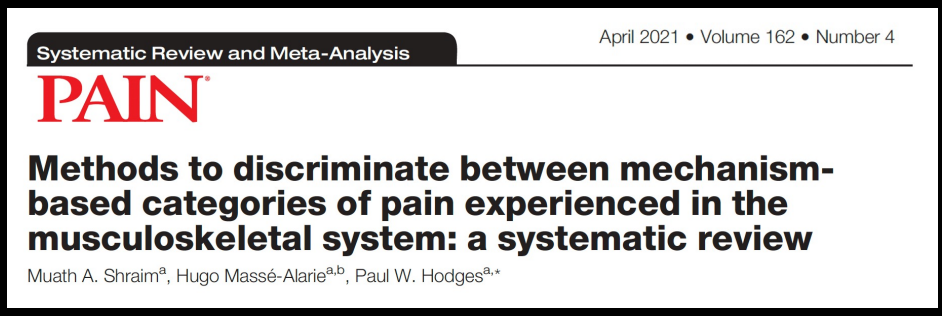

Implications for rehabilitation
Why does pain persist?
Ongoing threat to tissues
No ongoing threat to tissues
Bio-
Psycho-
Social
Nociceptive mechanisms – Suboptimal tissue loading – motor control
Nociplastic mechanisms – interaction between central sensitization and psychology
Consider addressing tissue loading
Consider modifying cognitions & behaviours
Modify posture/movement and tissue loading
Behavioural therapy → Graded activity exercise; Education

6

What does the literature tell us about discrimination between pain mechanisms?

7

Systematic review: Methods



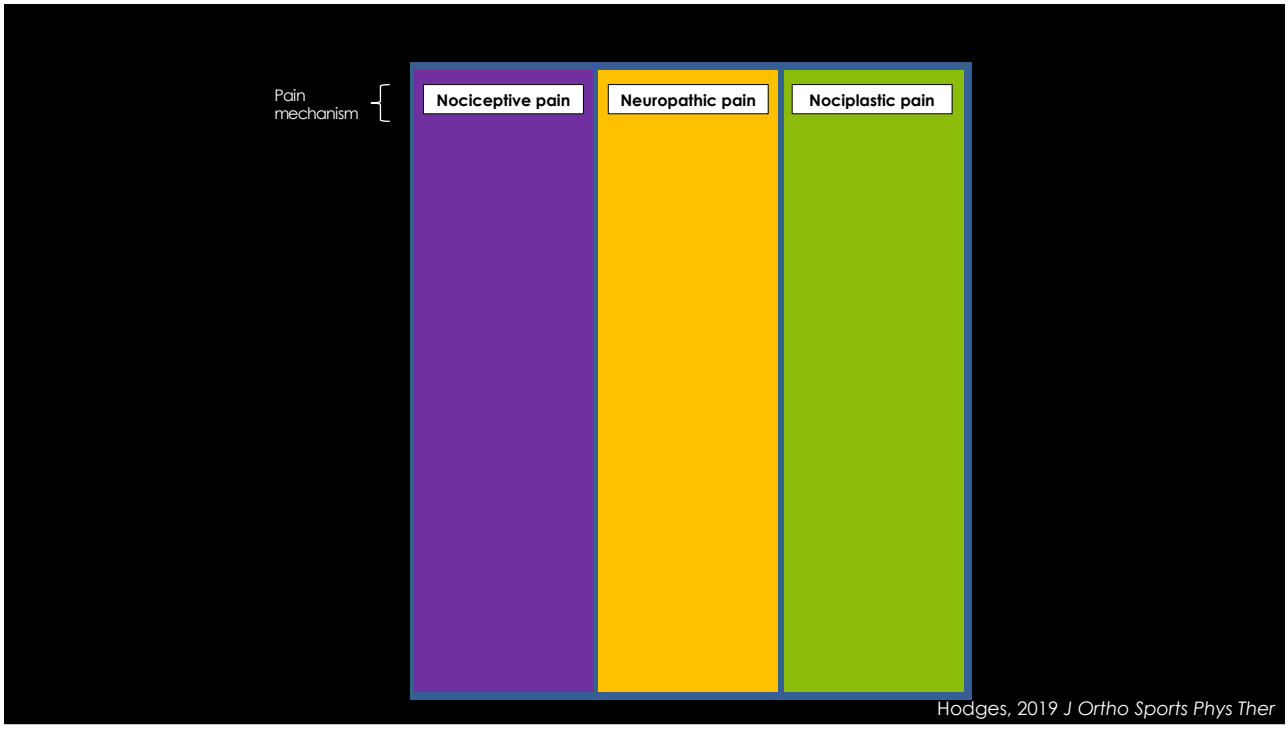
8

How can we identify pain mechanisms in clinical practice?

	Nociceptive pain	Neuropathic pain	Nociplastic pain
Pain features	Predictable Inc/dec with movement/posture Proportional Localised	"Electric" Dermatomal distribution/ribbon Pins & needles Numbness +/- positive neurodynamic signs	Unpredictable Inconsistent inc/dec Disproportionate Broad area/multiple area/changing area
QST	Normal sensitivity or local hyperalgesia	Can be sensitized – Hyperalgesia - ↓ pressure/ temp threshold	Hyperalgesia - ↓ pressure/ temp threshold – local & distant areas
Questionnaire	Generally low psychosocial features – multiple questionnaires available to assess specific features	PainDETECT, LANSS (not specific to neuropathic)	Central Sensitization Inventory Various Psychological Qs – Pain Catastrophizing Scale; Fear Avoidance, Pain Self Efficacy, etc
History	Relevant injury	History of nerve damage/ dysfunction	Mismatch between pain & history/mechanism

Smart2012a, b, c Man Ther; Nijs et al. 2015 Pain Physician; Chimenti et al 2018 PhysTher; Shraim, Massé-Alarie & Hodges 2021 Pain.

9



Hodges, 2019 *J Ortho Sports Phys Ther*

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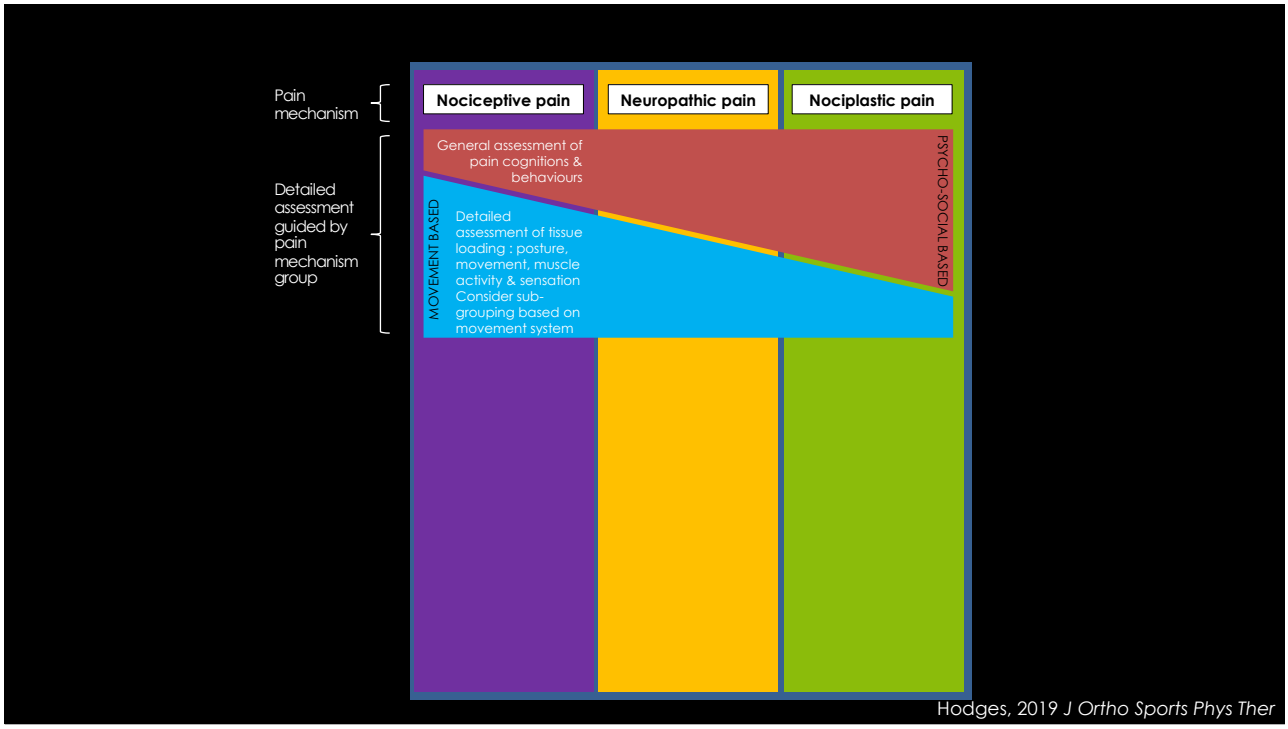
Pain mechanism
Detailed assessment guided by pain mechanism group
Nociceptive pain
Neuropathic pain
Nociplastic pain
General assessment of pain cognitions & behaviours
PSYCHO-SOCIAL BASED
MOVEMENT BASED
Detailed assessment of tissue loading : posture, movement, muscle activity & sensation
Consider sub-grouping based on movement system
Hodges, 2019 J Ortho Sports Phys Ther

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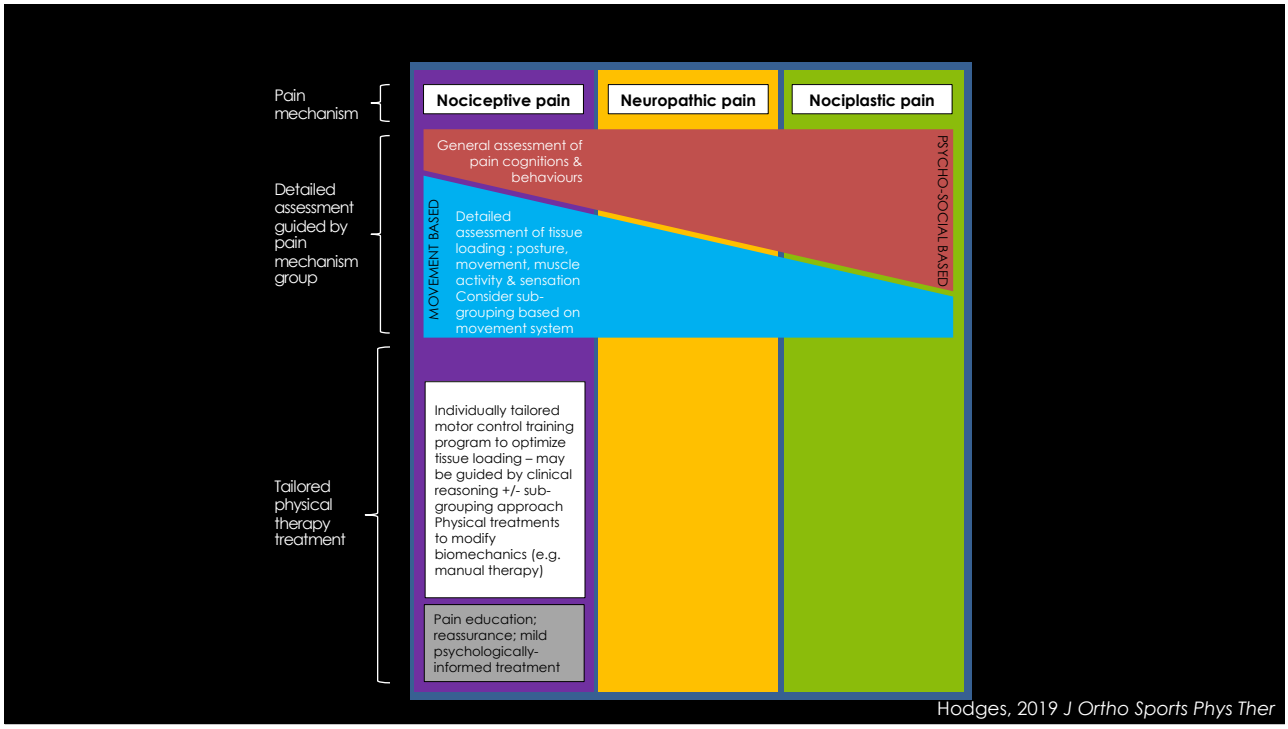
Pain mechanism
Detailed assessment guided by pain mechanism group
Tailored physical therapy treatment
Nociceptive pain
Neuropathic pain
Nociplastic pain
General assessment of pain cognitions & behaviours
PSYCHO-SOCIAL BASED
MOVEMENT BASED
Detailed assessment of tissue loading : posture, movement, muscle activity & sensation
Consider sub-grouping based on movement system
Individually tailored motor control training program to optimize tissue loading – may be guided by clinical reasoning +/- sub-grouping approach
Physical treatments to modify biomechanics (e.g. manual therapy)
Pain education; reassurance; mild psychologically-informed treatment
Hodges, 2019 J Ortho Sports Phys Ther

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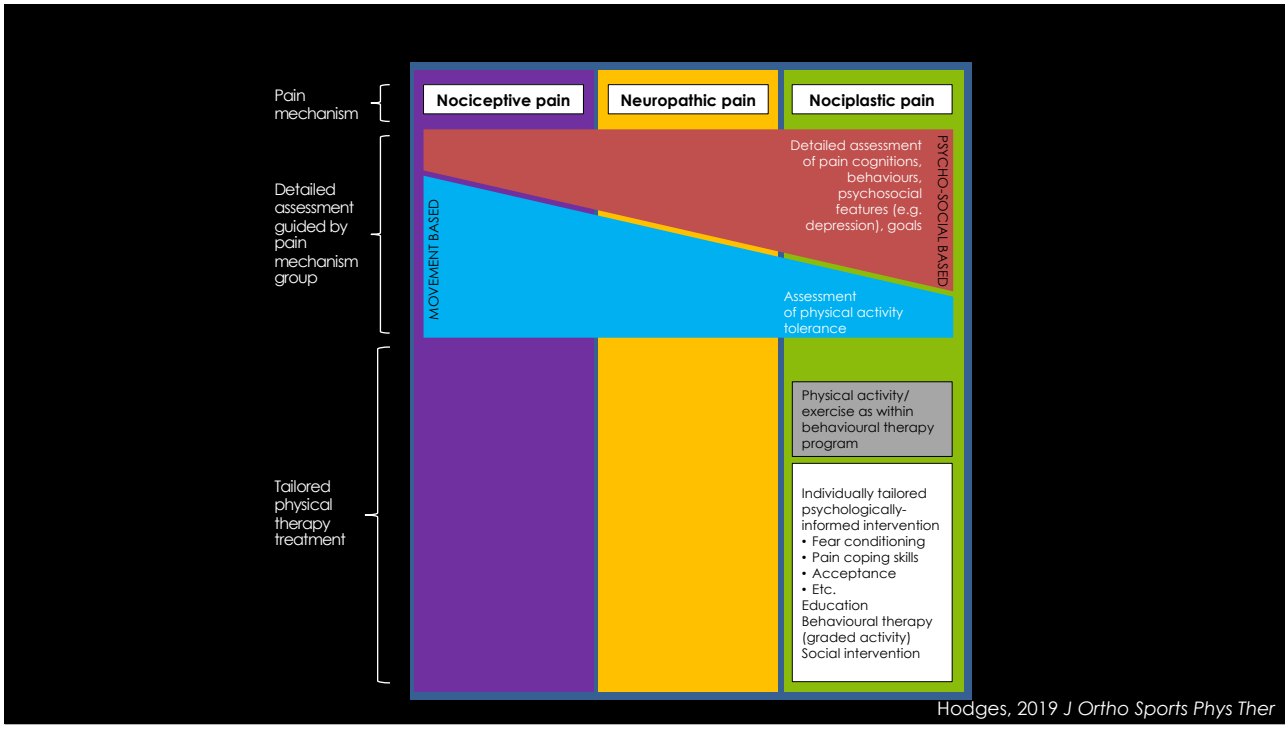
Pain mechanism
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Tailored physical therapy treatment
Nociceptive pain
Neuropathic pain
Nociplastic pain
Detailed assessment of pain cognitions, behaviours, psychosocial features (e.g. depression), goals
PSYCHO-SOCIAL BASED
MOVEMENT BASED
Assessment of physical activity tolerance
Physical activity/ exercise as within behavioural therapy program
Individually tailored psychologically-informed intervention
• Fear conditioning
• Pain coping skills
• Acceptance
• Etc.
Education
Behavioural therapy (graded activity)
Social intervention
Hodges, 2019 J Ortho Sports Phys Ther

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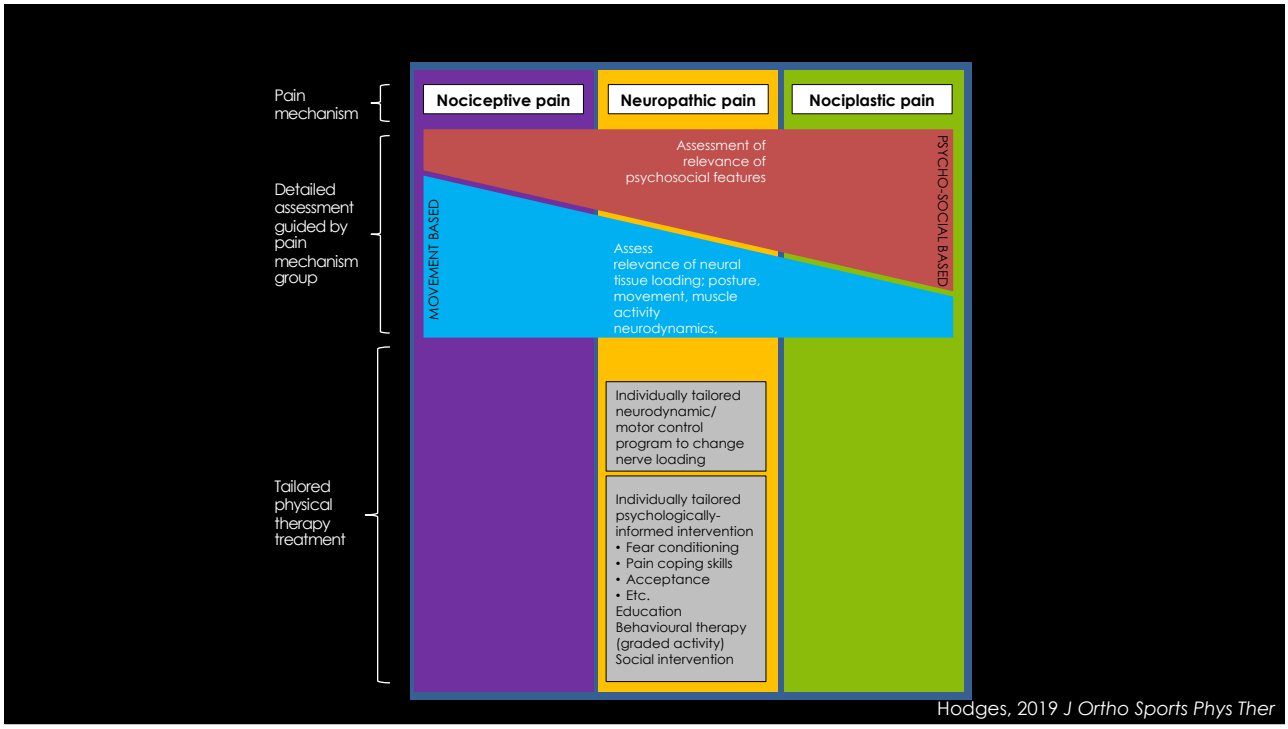
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Neuropathic pain
Nociplastic pain
Assessment of relevance of psychosocial features
PSYCHO-SOCIAL BASED
MOVEMENT BASED
Assess relevance of neural tissue loading; posture, movement, muscle activity neurodynamics,
Individually tailored neurodynamic/ motor control program to change nerve loading
Individually tailored psychologically-informed intervention
• Fear conditioning
• Pain coping skills
• Acceptance
• Etc.
Education
Behavioural therapy (graded activity)
Social intervention
Hodges, 2019 J Ortho Sports Phys Ther

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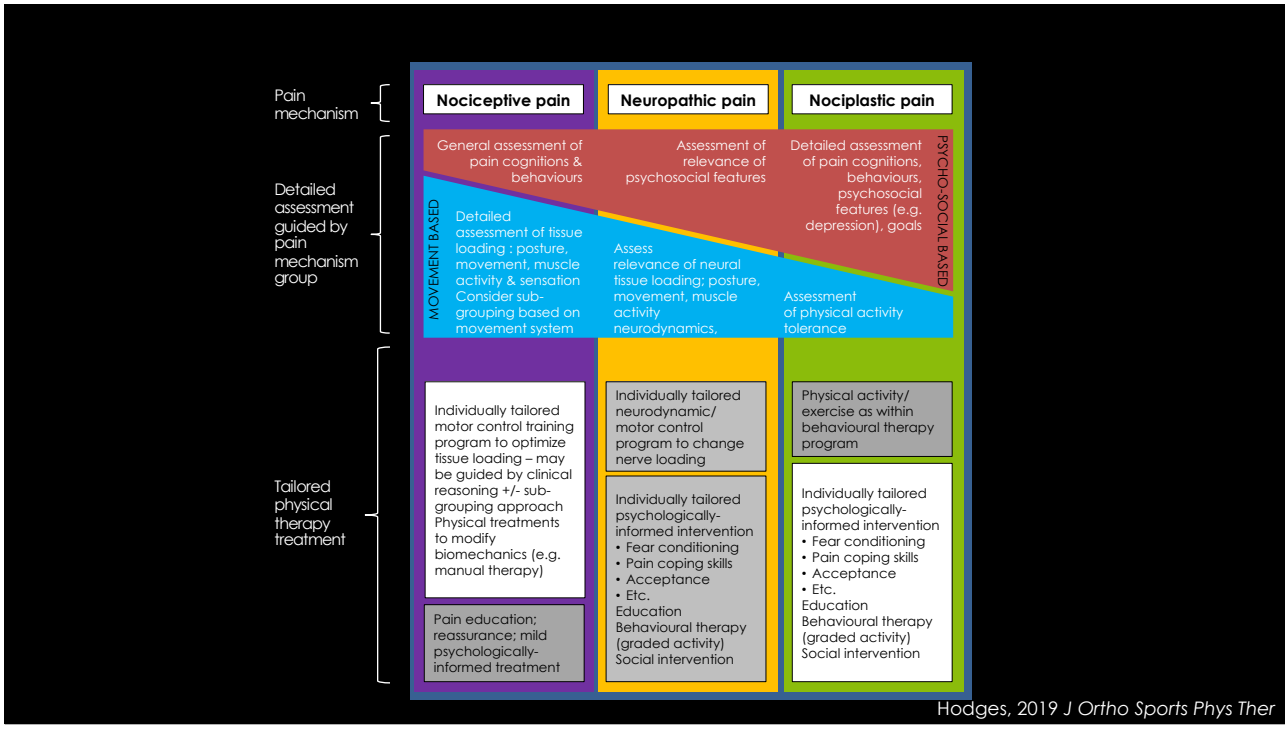
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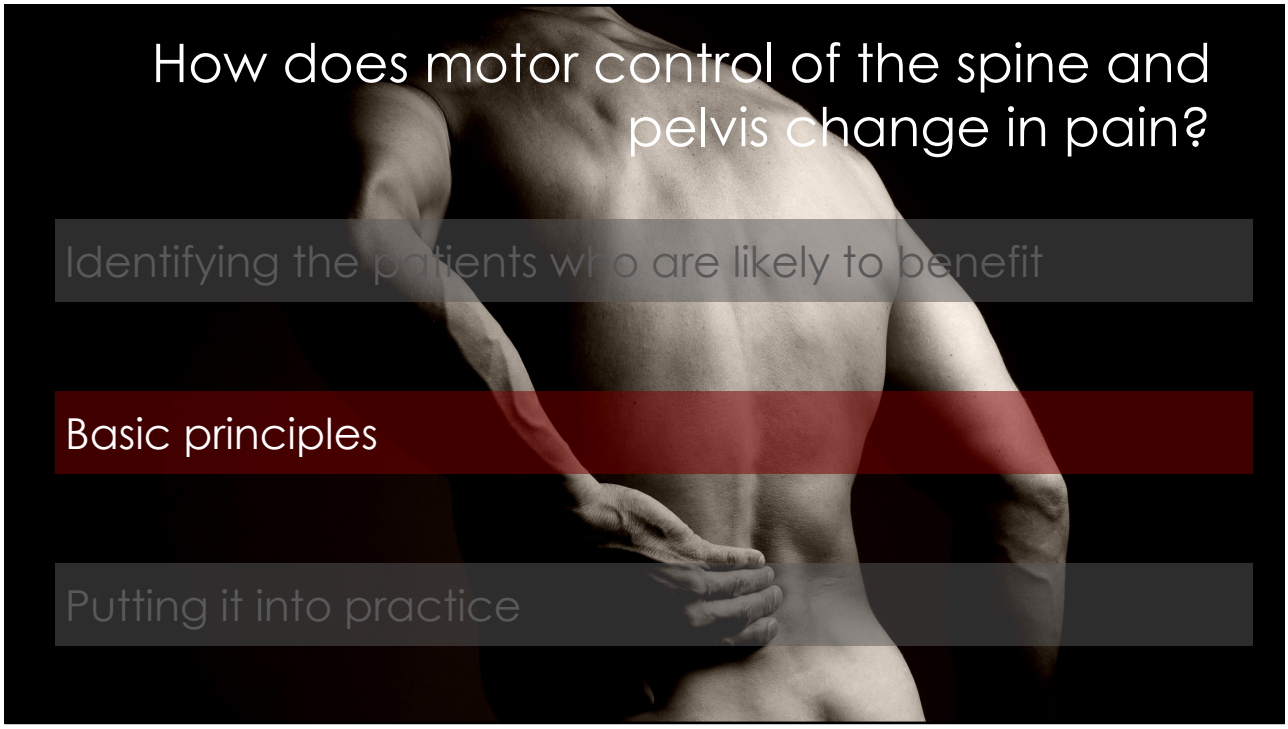
Hodges, 2019 J Ortho Sports Phys Ther

15


How does motor control of the spine and pelvis change in pain?
Identifying the patients who are likely to benefit
Basic principles
Putting it into practice

16

What is optimal lumbopelvic control?

5 key principles

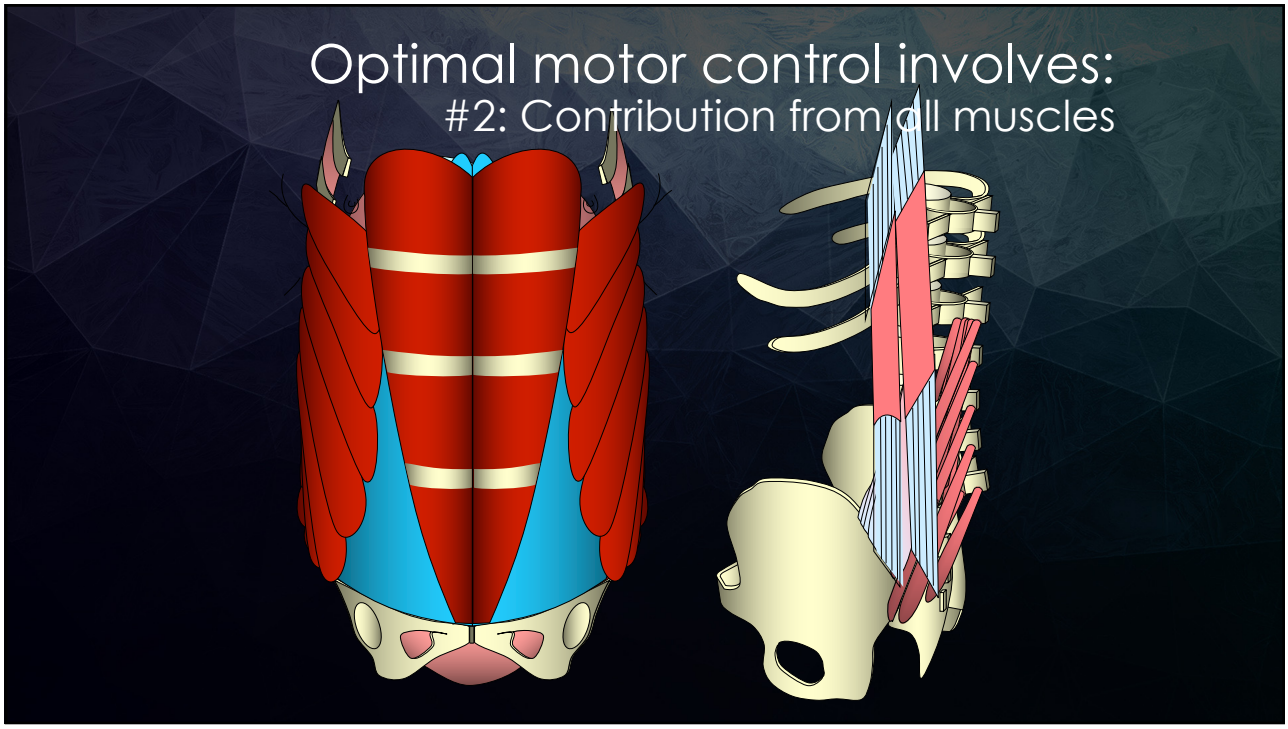
17

Optimal motor control involves:
#1: Balance between movement & stiffness

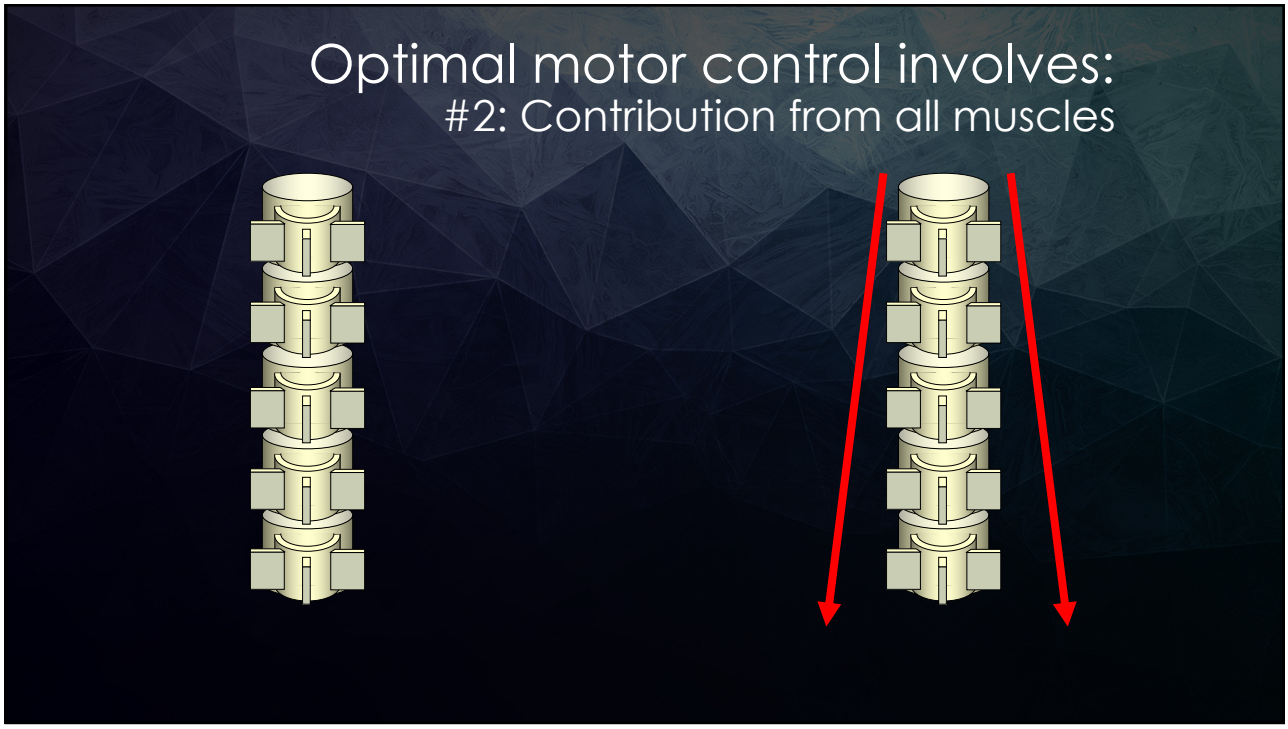
STIFFNESS
- Maintain alignment
- Control translations

MOVEMENT
- Motion for function
- Motion for shock absorption
- Motion for load transfer
- Variation for load sharing

18


Optimal motor control involves:
#2: Contribution from all muscles

19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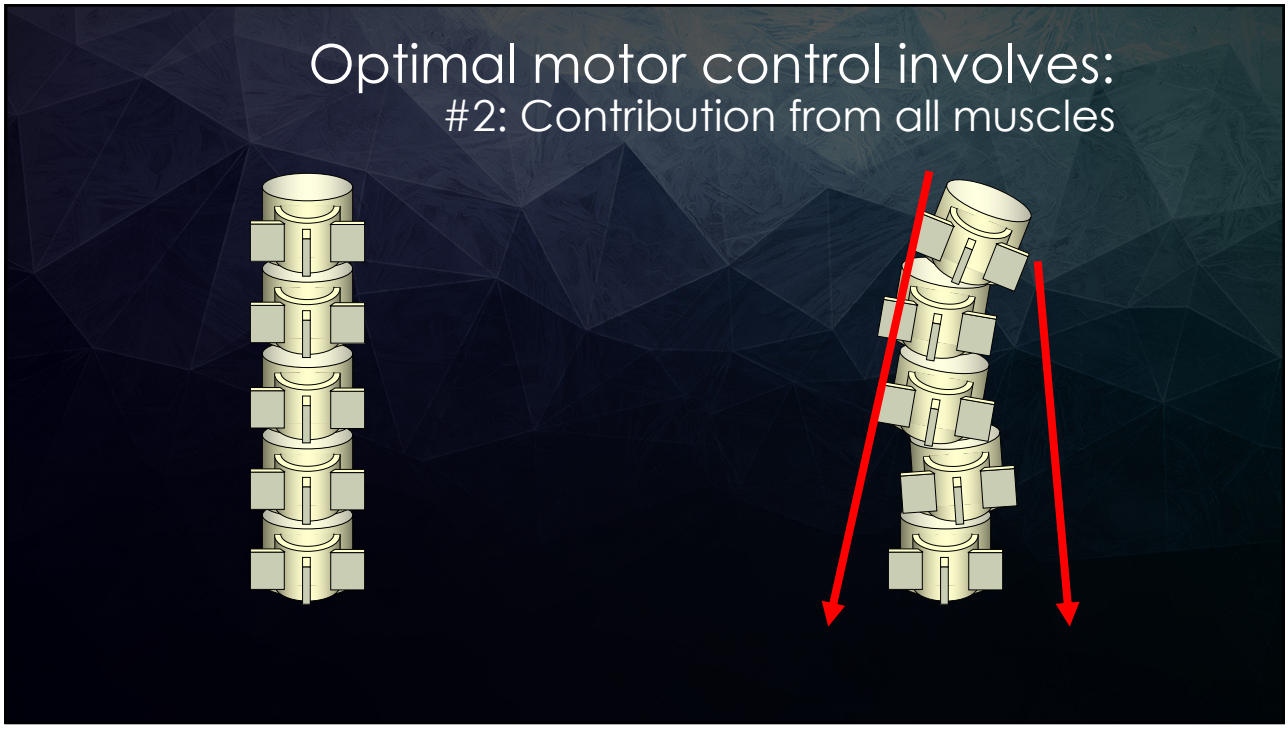
20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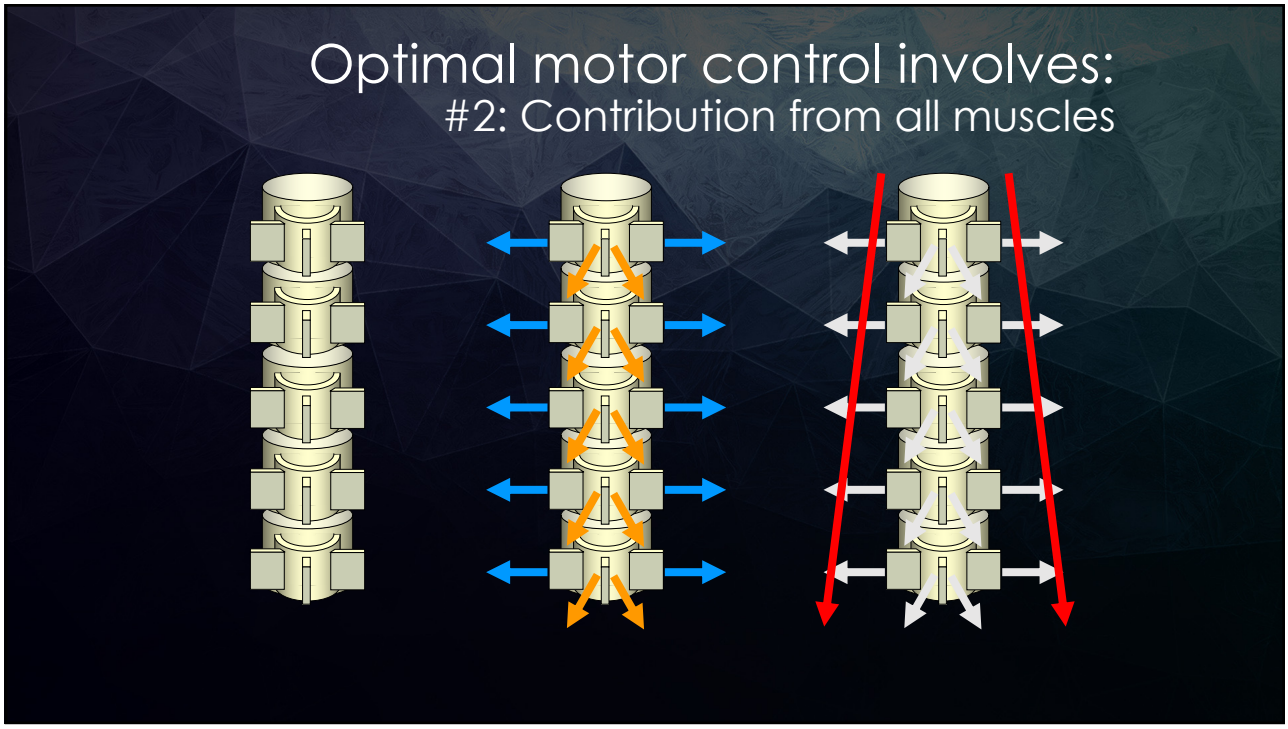
21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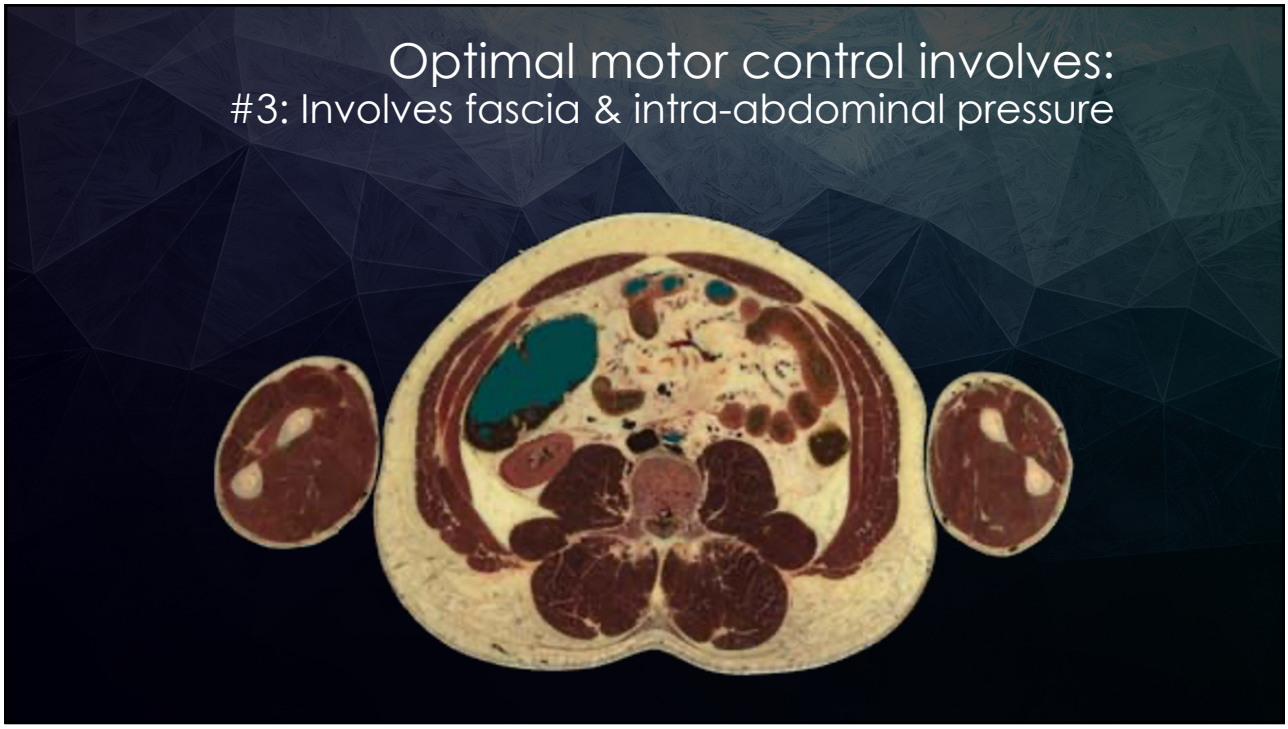
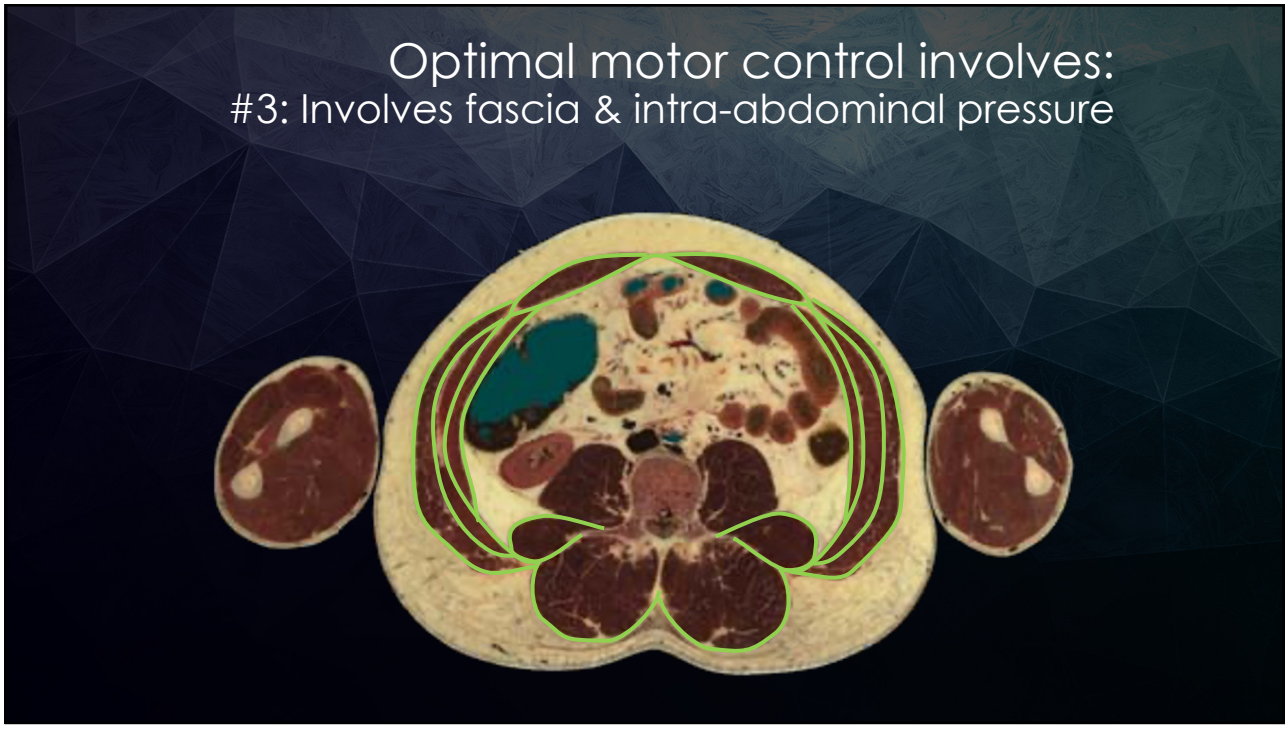
22

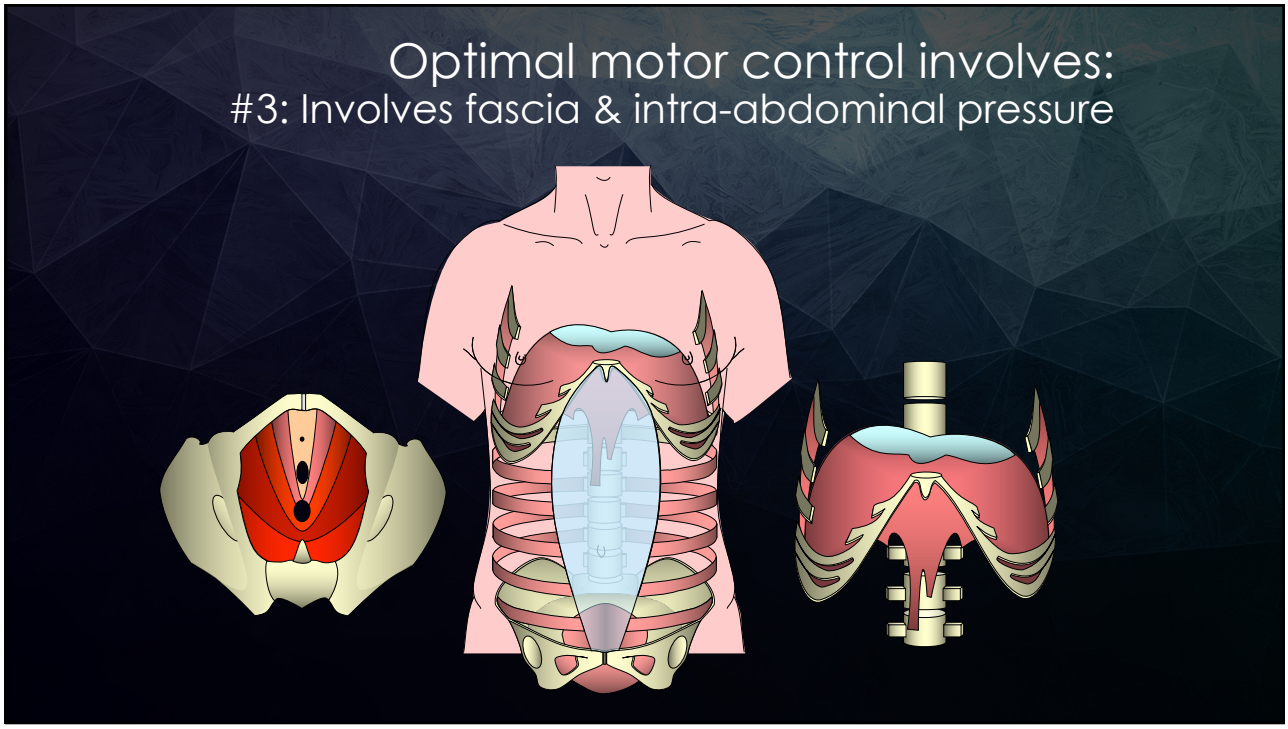

Optimal motor control involves:
#3: Involves fascia & intra-abdominal pressure

23


Optimal motor control involves:
#3: Involves fascia & intra-abdominal pressure

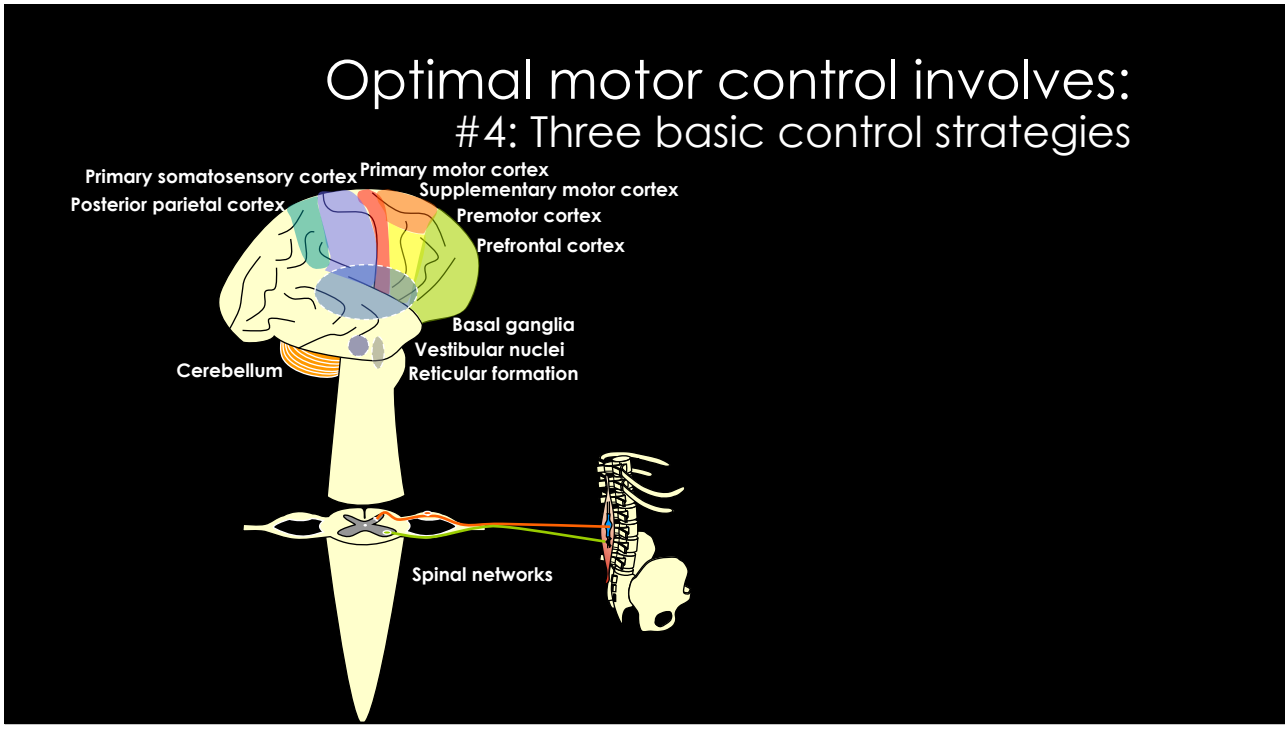
24

Optimal motor control involves:
#3: Involves fascia & intra-abdominal pressure



25

Optimal motor control involves:
#4: Three basic control strategies



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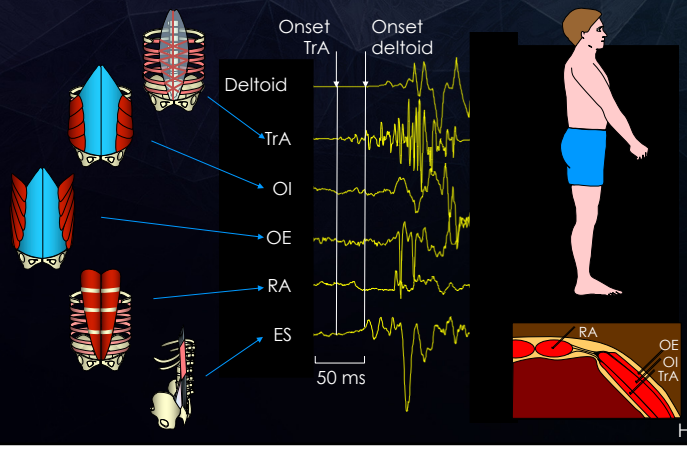
Optimal motor control involves:
#4: Three basic control strategies

- **Predictive**
  - Feedforward control – based on experience
- **Reactive**
  - Feedback loops – simple (fast); complex (slow)
- **Tonic**
  - Modulation of intrinsic properties – inc. muscle stiffness/tone – ongoing

27

Optimal motor control involves:
#4: Three basic control strategies

- **Predictive**
  – Feedforward control – based on experience

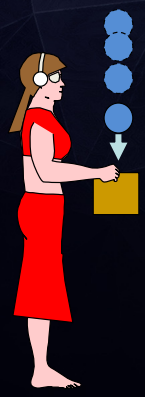


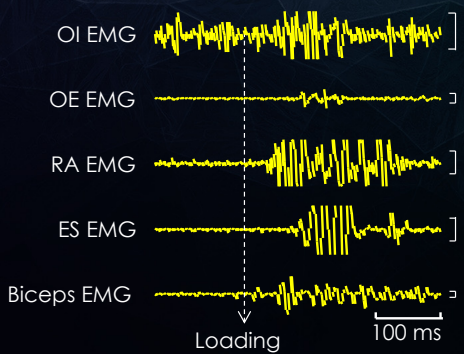
Hodges & Richardson, 1997 Exp Brain Res

28

Optimal motor control involves: #4: Three basic control strategies

- **Predictive**
  - Feedback – simple (fast); complex (slow)



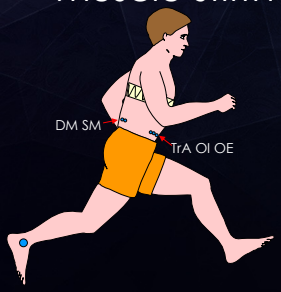


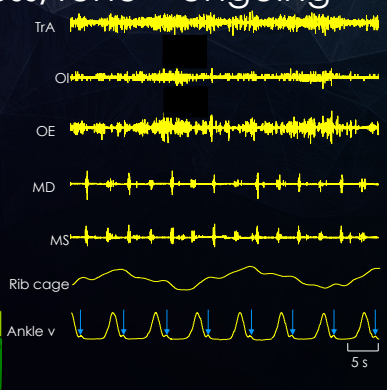
Smith, Coppieters & Hodges, 2007 *Exp Brain Res*

29

Optimal motor control involves: #4: Three basic control strategies

- **Tonic**
  - Modulation of intrinsic properties – inc. muscle stiffness/tone – ongoing





Saunders, Rath & Hodges, 2003

30

Optimal motor control involves:
#5: Spectrum – Static to Dynamic

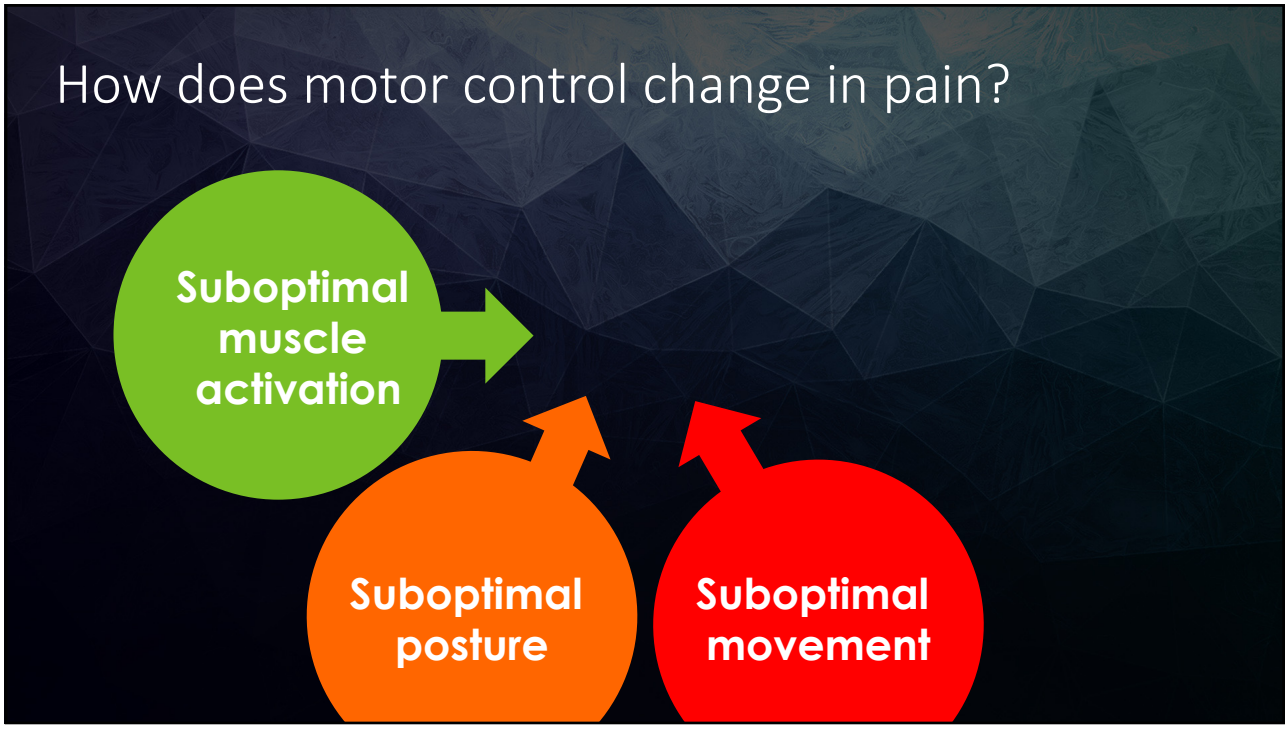
Static maintenance of position

Dynamic control of movement

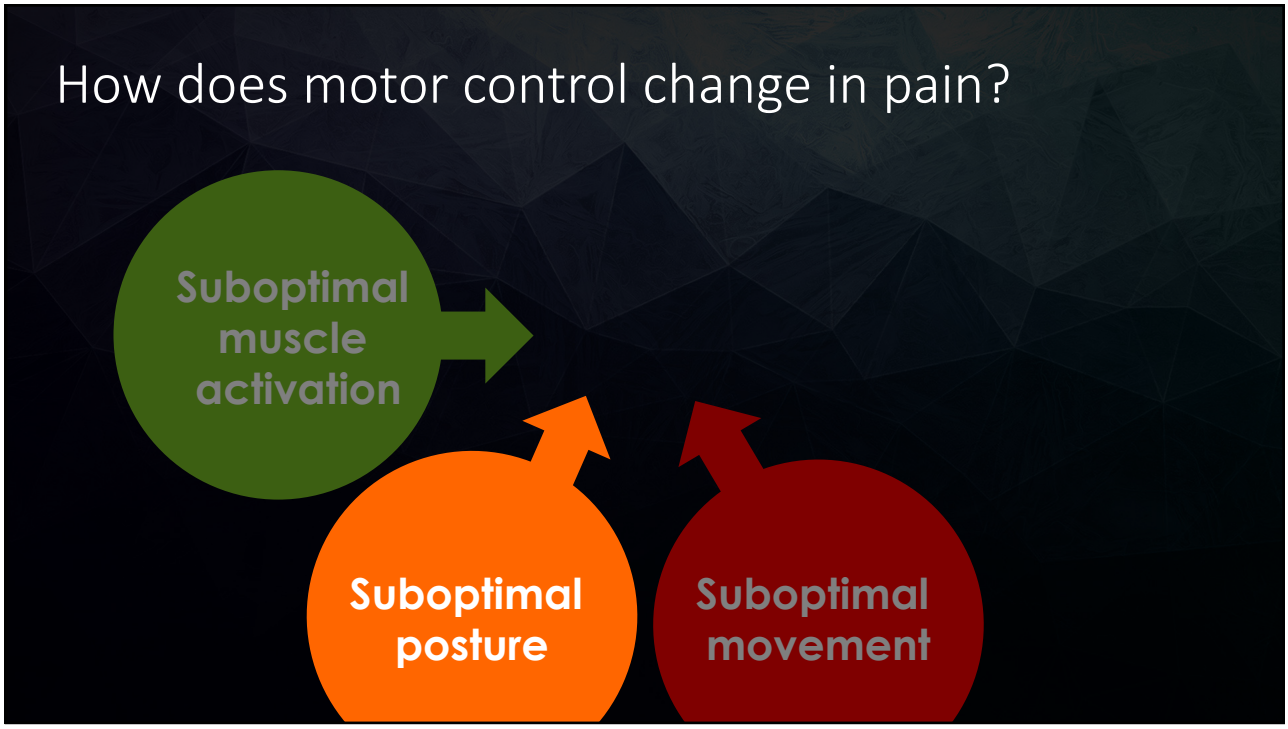
31

Movement is changed in **pain**

32


How does motor control change in pain?
Suboptimal muscle activation
Suboptimal posture
Suboptimal movement

33


How does motor control change in pain?
Suboptimal muscle activation
Suboptimal posture
Suboptimal movement

34

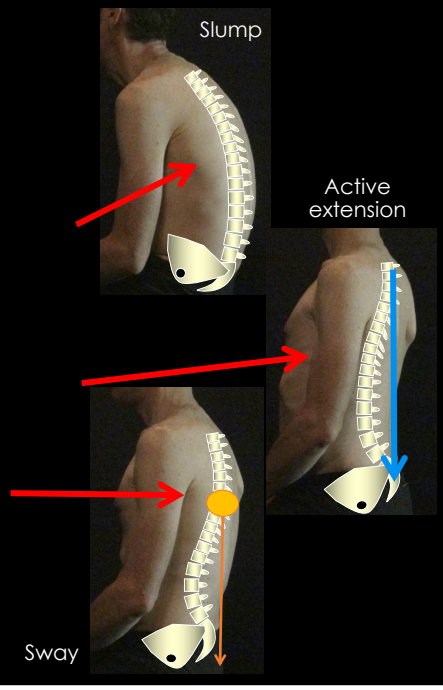
Posture/ alignment

- Alignment of the spine and adjacent segments in;
  - Static positions such as sitting, standing,
  - During whole body movement (e.g., alignment of the spine during walking)

35

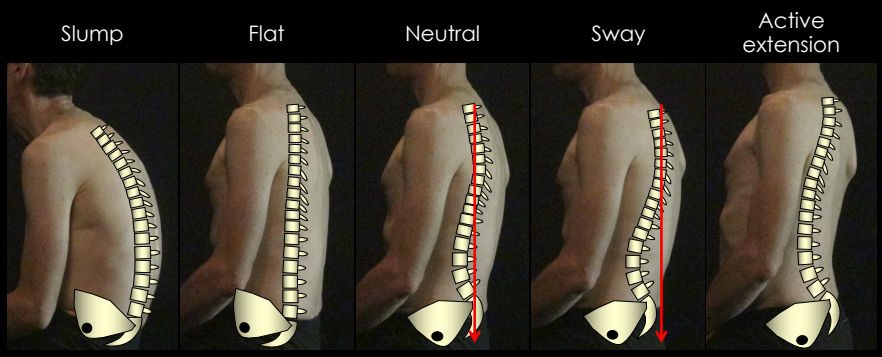
Individual variation

- There is not one "bad" posture
  - Both flexion & extension are important for different people (Dankaert et al., 2008)
  - Active vs. passive can both be important (Claus et al 2014)



36

Individual variation



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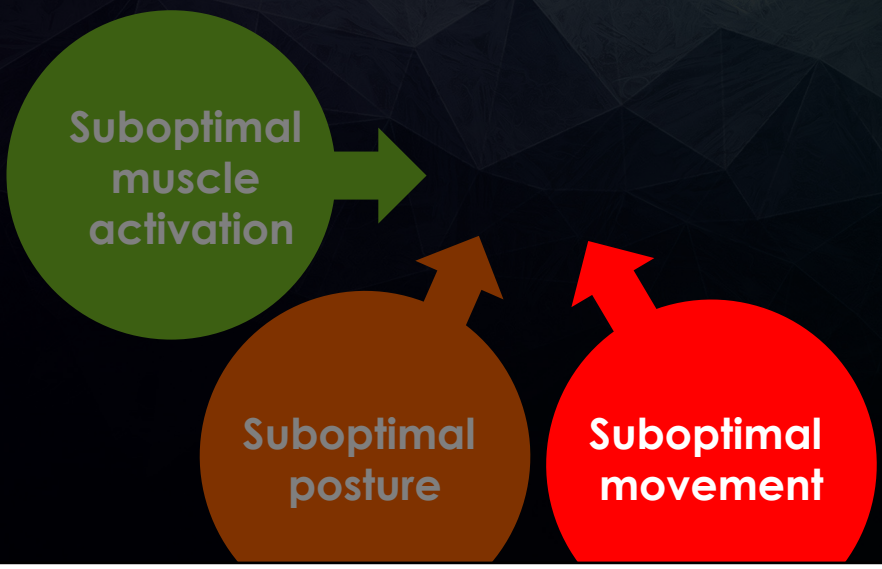
How does motor control change in pain?



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Movement

- Motion of;
  - Spine in space (e.g., trunk flexion or extension)
  - Regions of the spine (e.g., flexion of the lumbar spine)
  - Relative motion of adjacent regions (e.g., lumbar spine relative to thoraco-lumbar junction, hip relative to lumbar spine)
  - Intervertebral segments (e.g., rotation or translations at a specific spinal segment)

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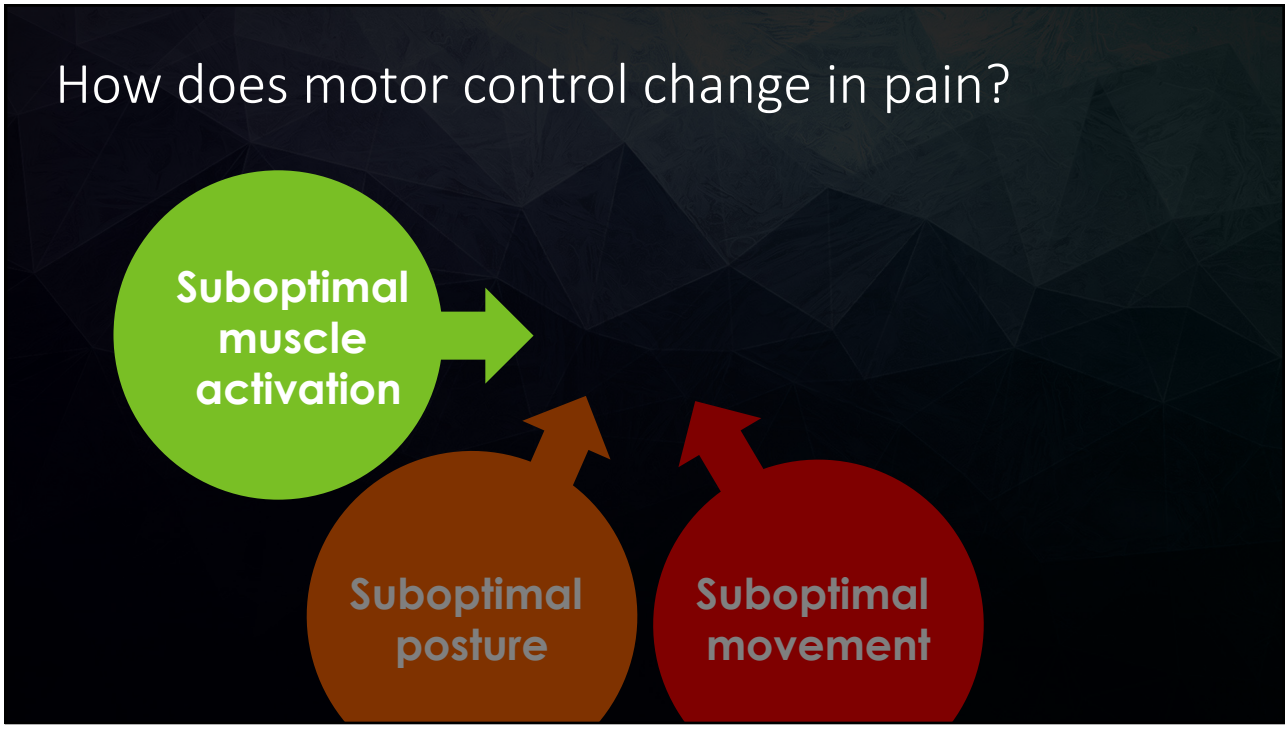
Movement

- Sub-optimal spine loading
  - Decreased movement or movement variability
    - ↑ load/↓ shock absorption Mok et al. 2008
  - Excessive movement
    - Provocative movement pattern
    - Imprecise movement pattern (e.g. accessory motions) van Dillen et al, 2009
  - Subgroups (Sahrmann 2002)

40



41

Muscle activation

- Activation of any muscle during static and/or dynamic activities
  - Timing, amount, pattern

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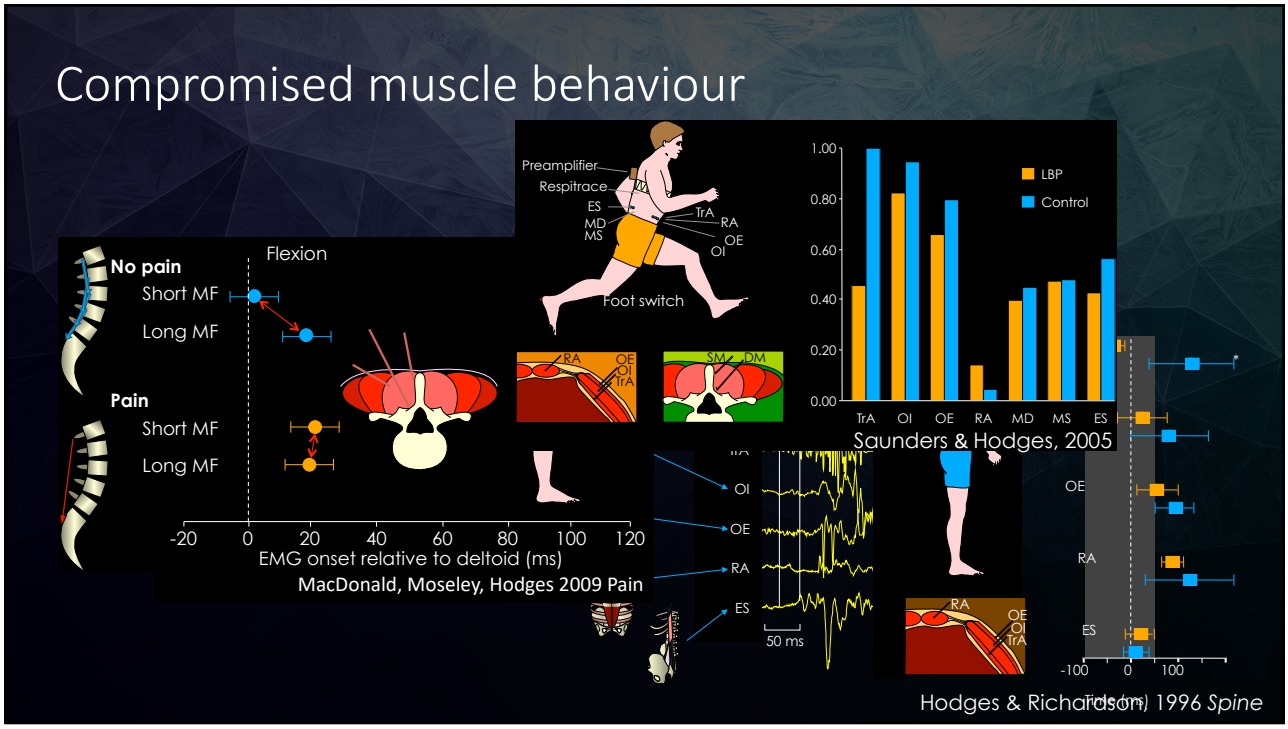
Compromised muscle behaviour



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How does motor control change in pain?

Suboptimal muscle activation

COMPROMISED MUSCLE
- Too little, too late

Delayed activation
Hodges et al,1996

Reduced activation
Ferreria et al, 2004

Atrophy/fat infiltration/fibrosis
Hides et al, 2004; Alaranta et al, 1993; Hodges et a, 2015

Suboptimal posture

Suboptimal movement

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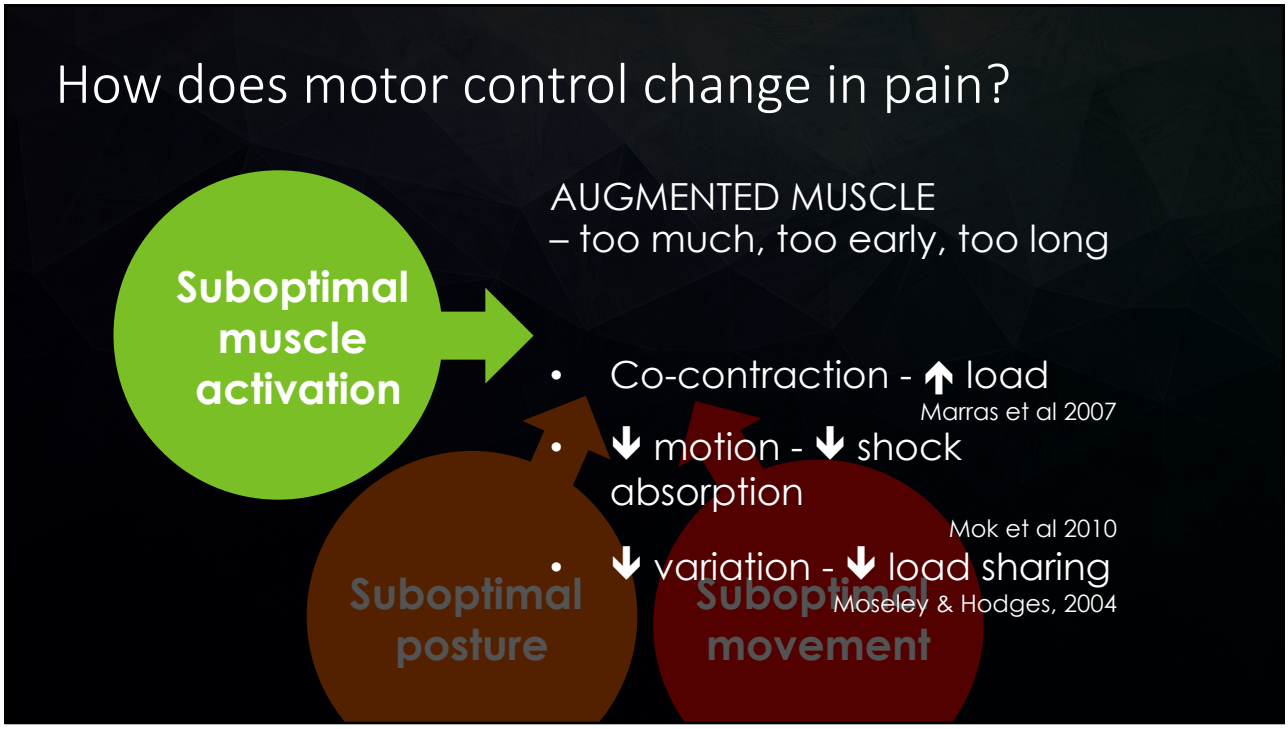
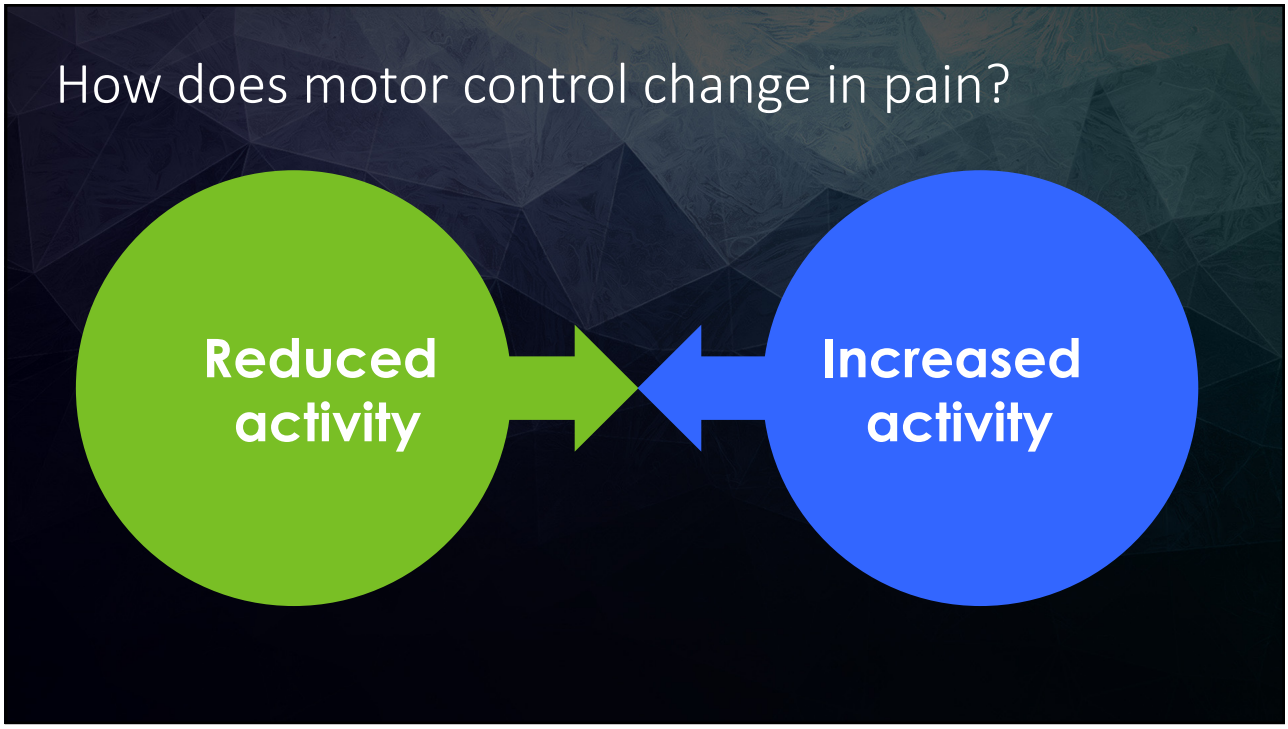
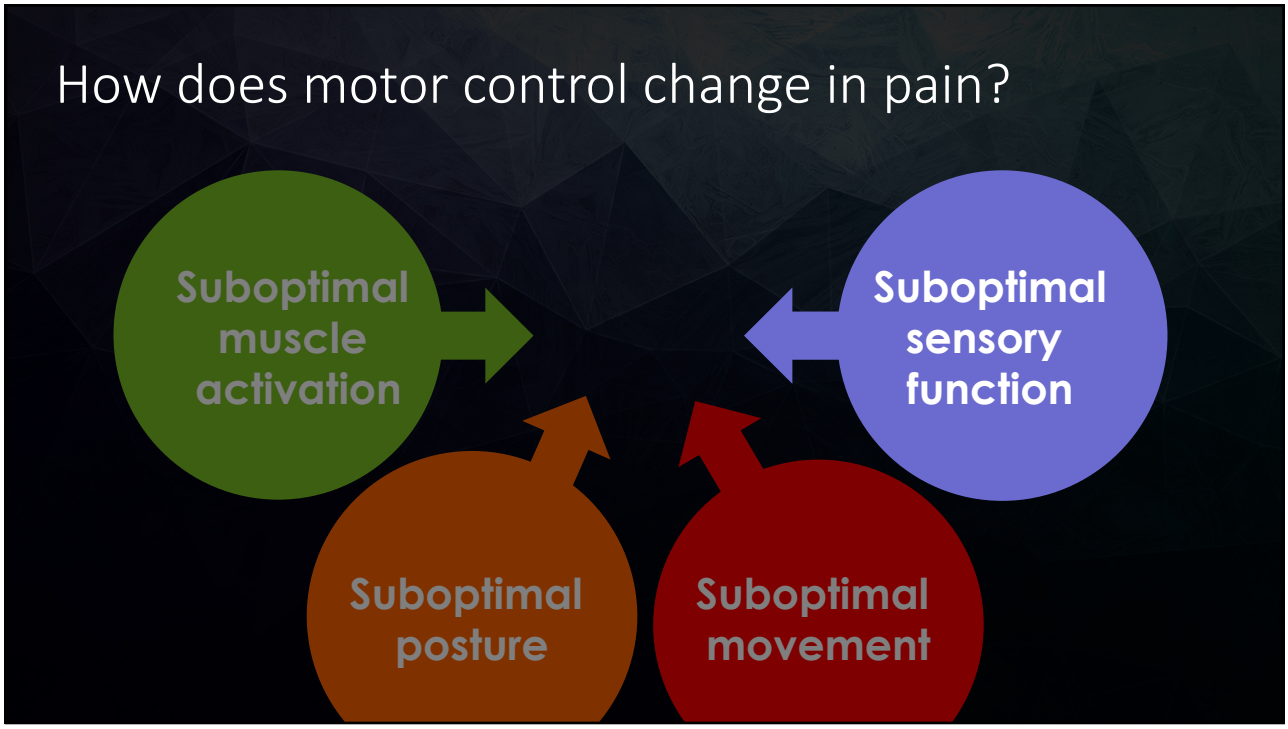

How does motor control change in pain?
Suboptimal muscle activation
AUGMENTED MUSCLE
– too much, too early, too long
• Co-contraction - ↑ load
Marras et al 2007
• ↓ motion - ↓ shock absorption
Mok et al 2010
• ↓ variation - ↓ load sharing
Moseley & Hodges, 2004
Suboptimal posture
Suboptimal movement

45


How does motor control change in pain?
Reduced activity
Increased activity

46



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Proprioception

- If your nervous system doesn't know where you are or how you are moving → cannot control movement accurately

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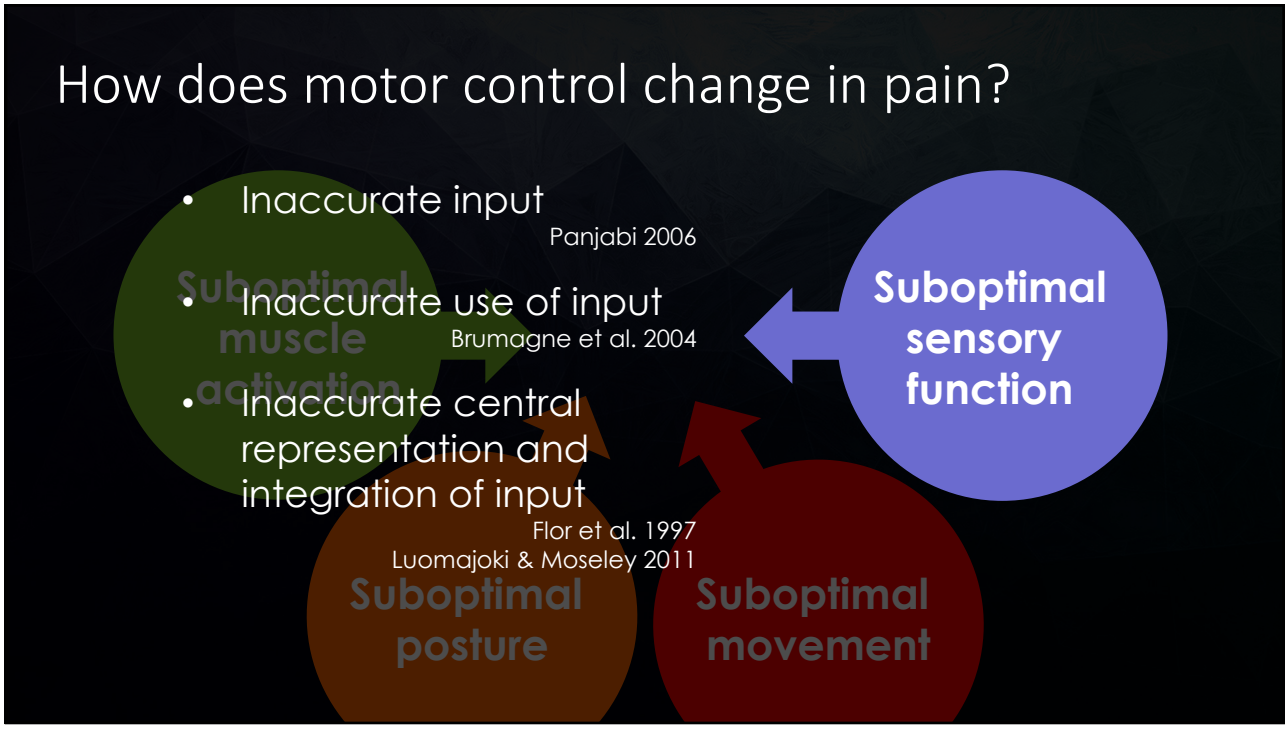
How does motor control change in pain?
• Inaccurate input
Panjabi 2006
• Inaccurate use of input
Brumagne et al. 2004
• Inaccurate central representation and integration of input
Flor et al. 1997
Luomajoki & Moseley 2011
Suboptimal muscle activation
Suboptimal sensory function
Suboptimal posture
Suboptimal movement

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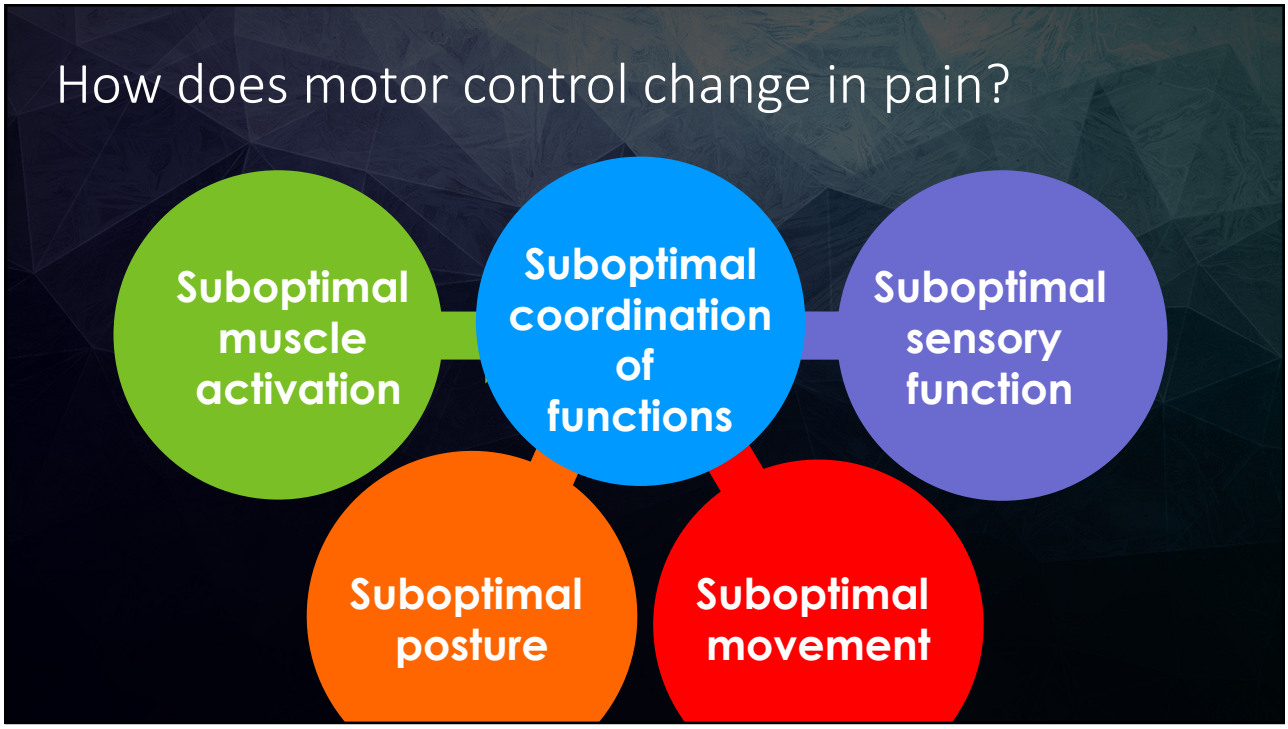
How does motor control change in pain?
Suboptimal muscle activation
Suboptimal coordination of functions
Suboptimal sensory function
Suboptimal posture
Suboptimal movement

50

How does motor control change in pain?

Balance

Mok, Brauer & Hodges 2004

Suboptimal coordination of functions

Breathing

Hodges et al 2001; O'Sullivan et al 2002

Pelvic floor function

O'Sullivan et al 2002; Smith & Hodges 2007a,b; Stuge et al 2013

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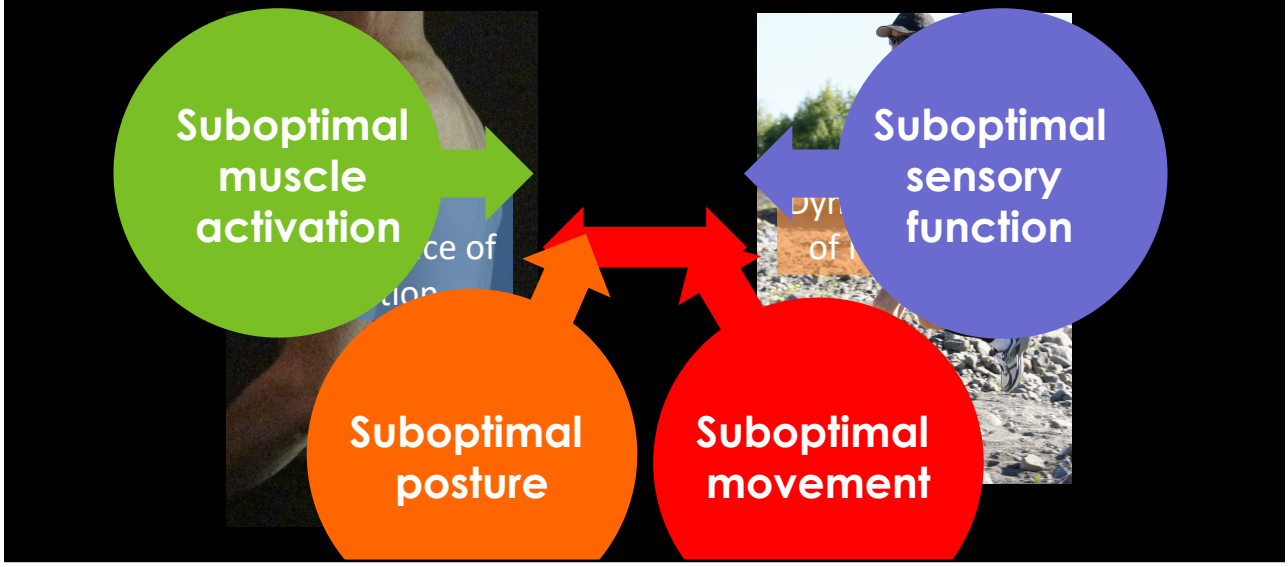
Requirements for spinal function



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Helpful and unhelpful motor control strategies

- "Helpful" motor control strategy
  - A motor control strategy that eases symptoms and/or improves impairment
- "Unhelpful" motor control strategy
  - A motor control strategy that provokes symptoms and/or worsens impairment

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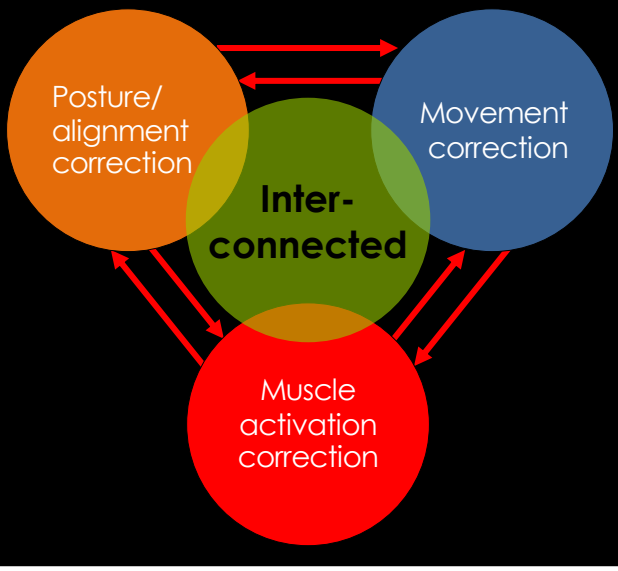
Treatment goals



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Treatment goals

Posture/ alignment correction

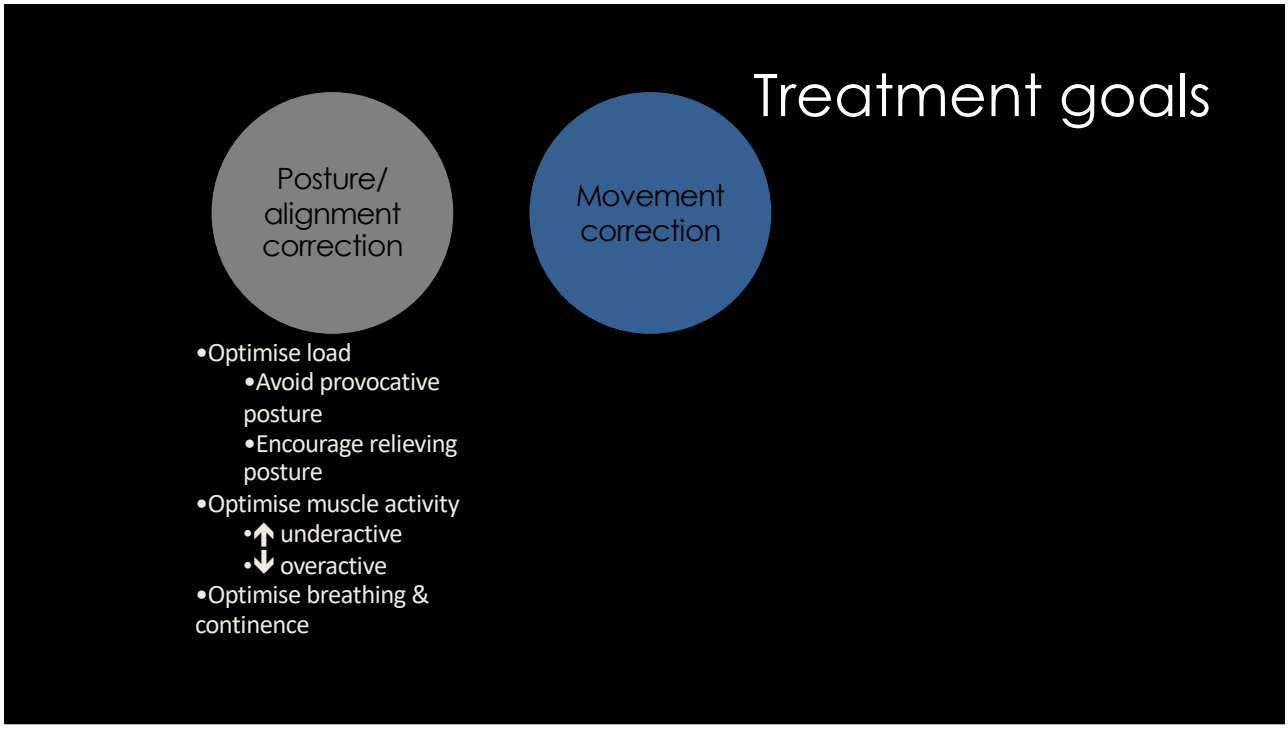
55

Treatment goals

Posture/ alignment correction

- Optimise load
  - Avoid provocative posture
  - Encourage relieving posture
- Optimise muscle activity
  - ↑ underactive
  - ↓ overactive
- Optimise breathing & continence

56


Treatment goals
Posture/ alignment correction
Movement correction
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•Avoid provocative posture
•Encourage relieving posture
•Optimise muscle activity
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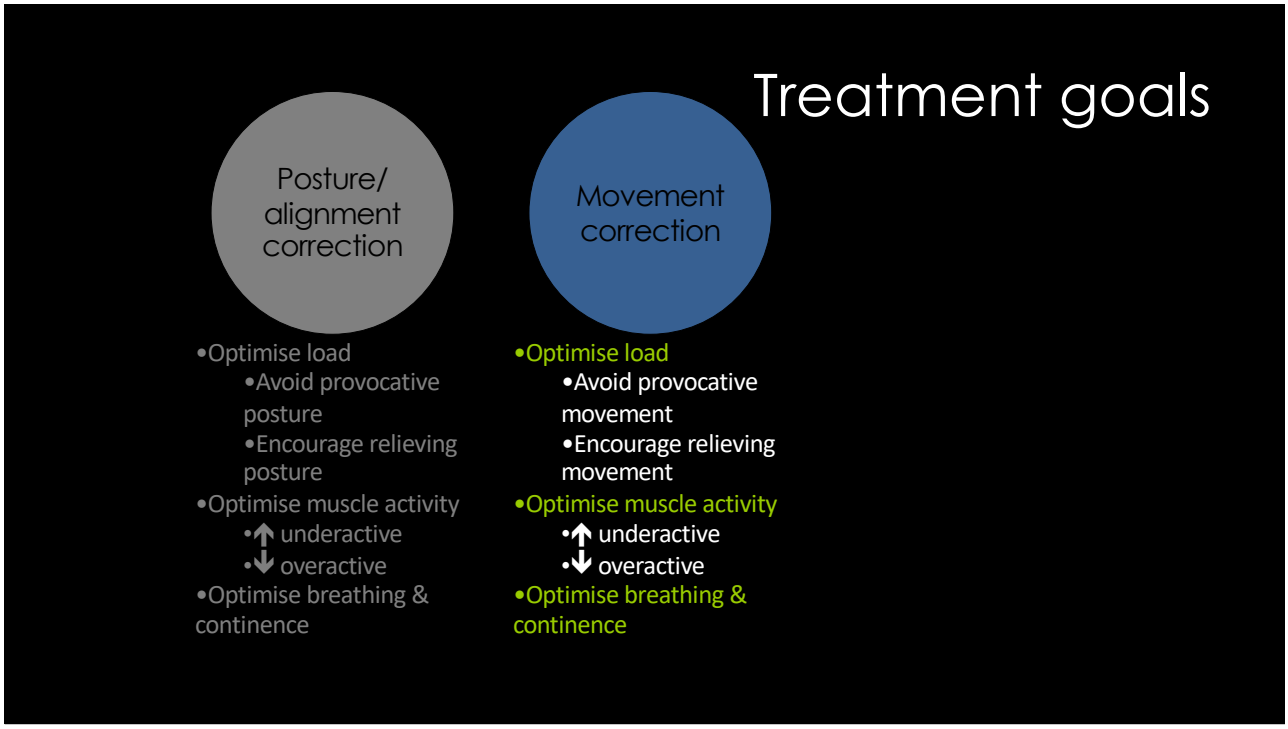
•↓ overactive
•Optimise breathing & continence

57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•Optimise breathing & continence
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•Avoid provocative movement
•Encourage relieving movement
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•↓ overactive
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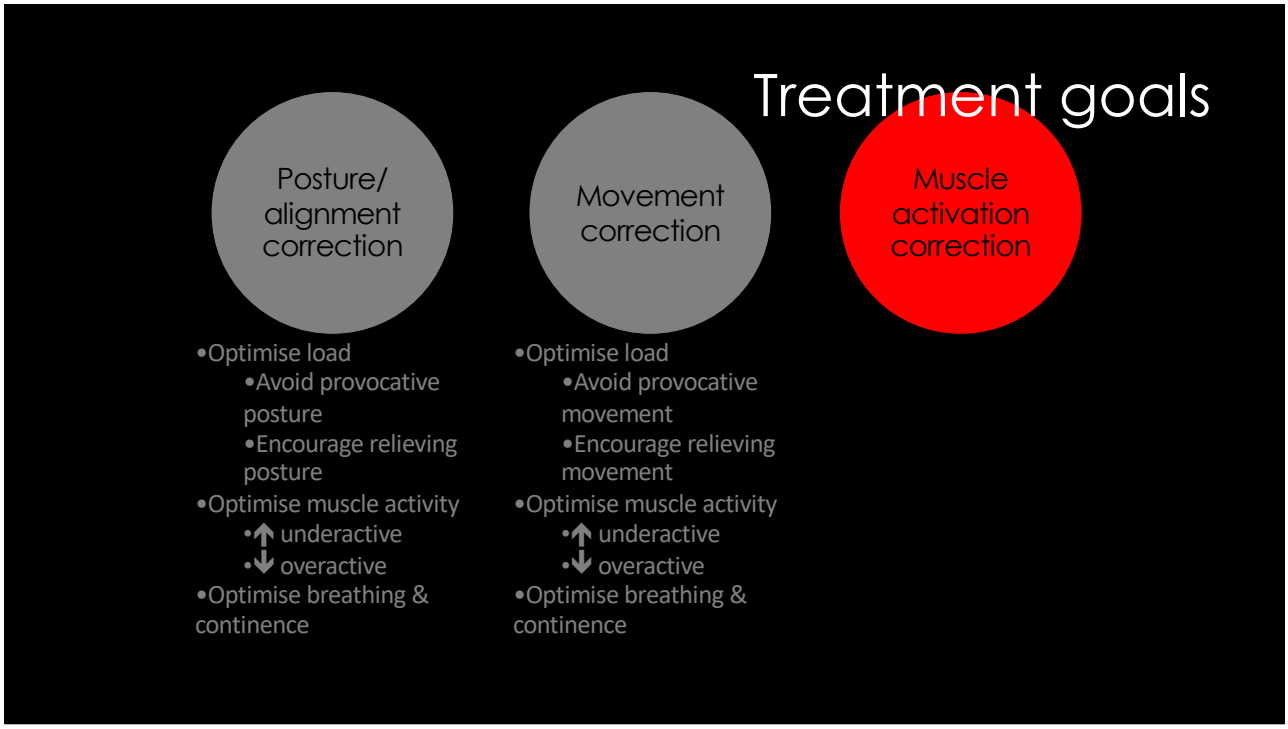
58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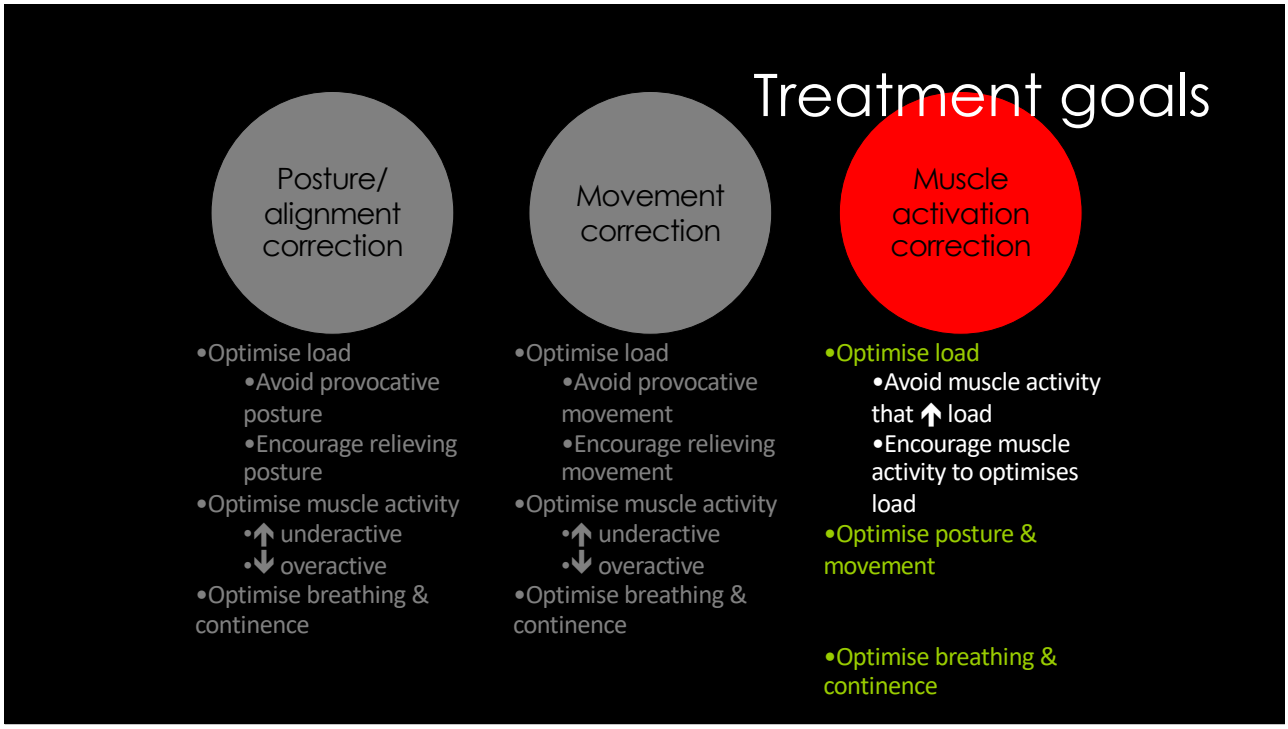
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•Encourage relieving movement
•Optimise muscle activity
•↑ underactive
•↓ overactive
•Optimise breathing & continence
•Optimise load
•Avoid muscle activity that ↑ load
•Encourage muscle activity to optimises load
•Optimise posture & movement
•Optimise breathing & continence

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Basic Principles

1. Control must be dynamic
2. Management of a whole system at fault
3. Must be considered within a bio-psycho-social framework
4. Treatment based on assessment
5. Draws on principles from multiple training approaches

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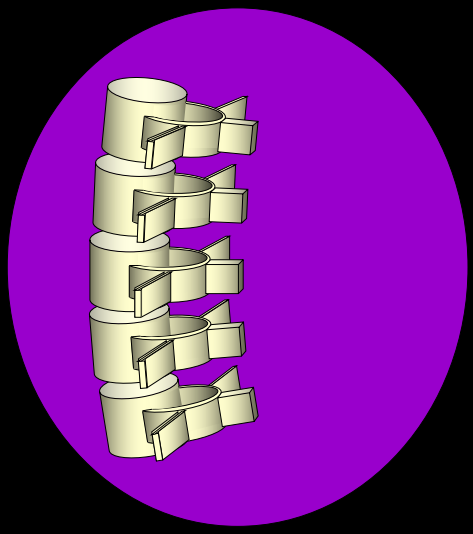
What should exercise interventions change?



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There is no universal Ideal/optimal strategy

- There is no single ideal/optimal strategy that every patient should aspire to achieve
- This must be "tuned" to match an individual's presentation
- Determine by
  - Anatomy
  - Pathology
  - Function
  - Task demands
  - History and experience
  - Etc…

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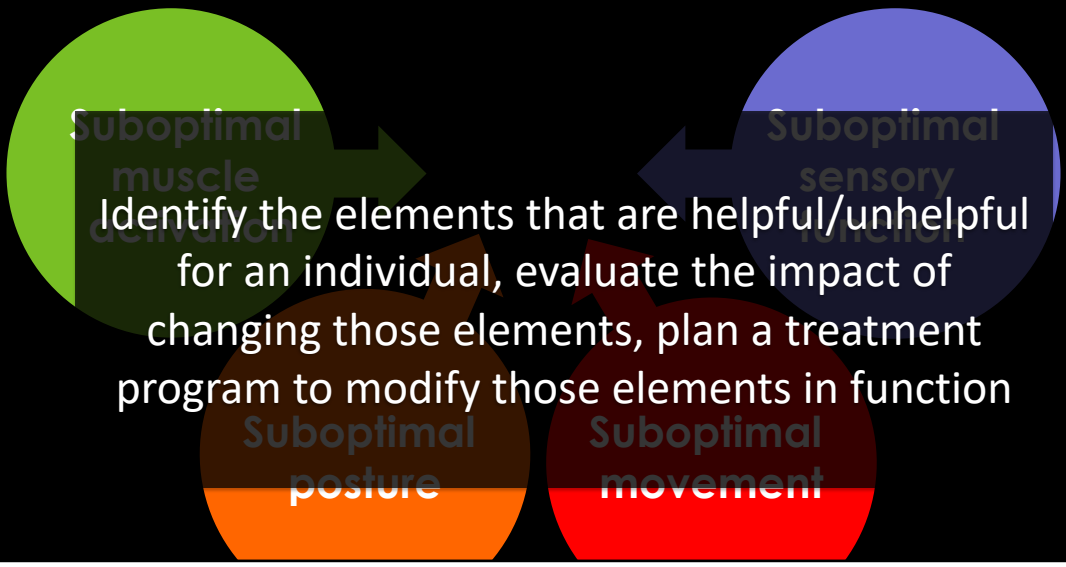
Motor control changes in LBP



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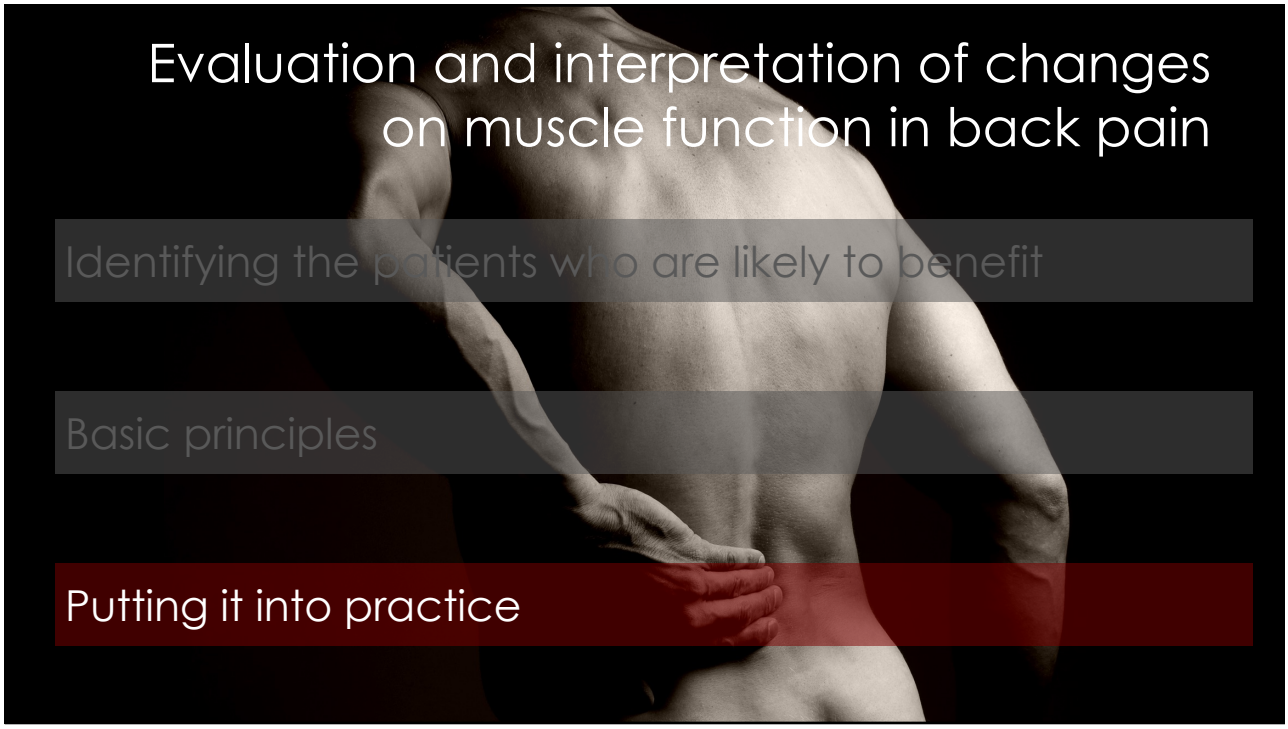

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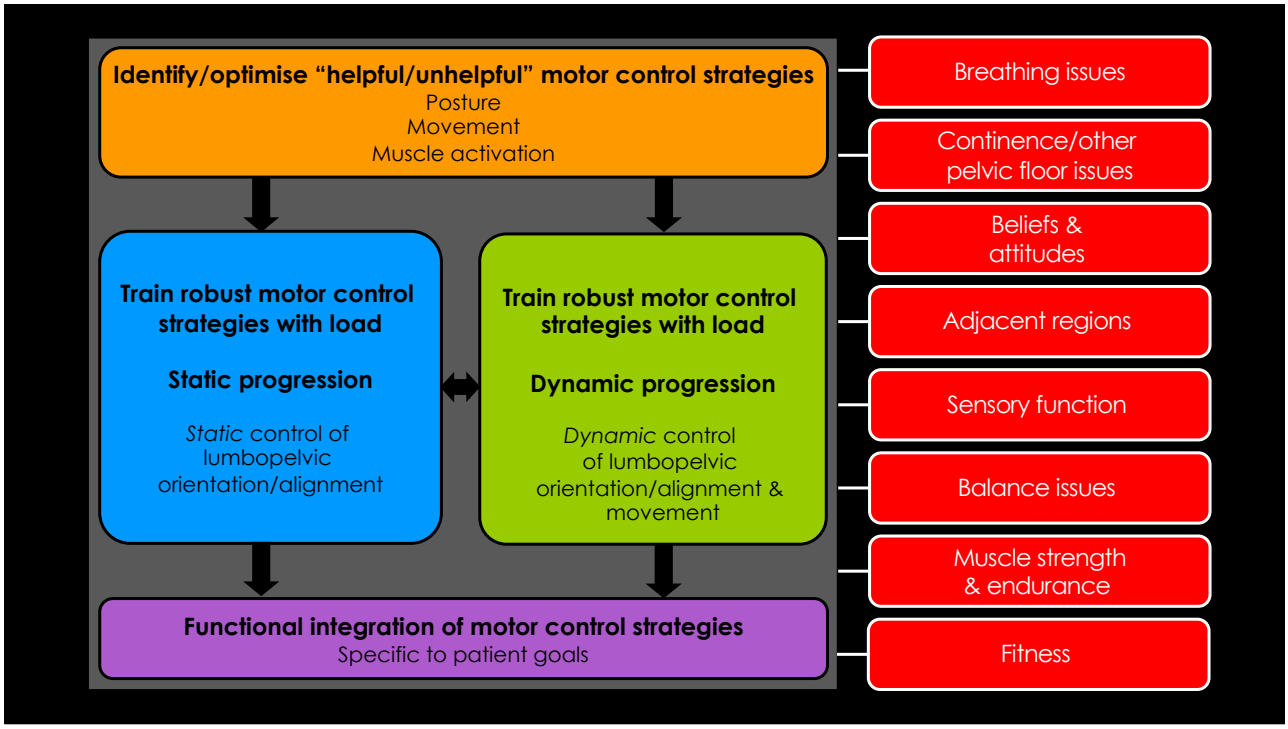
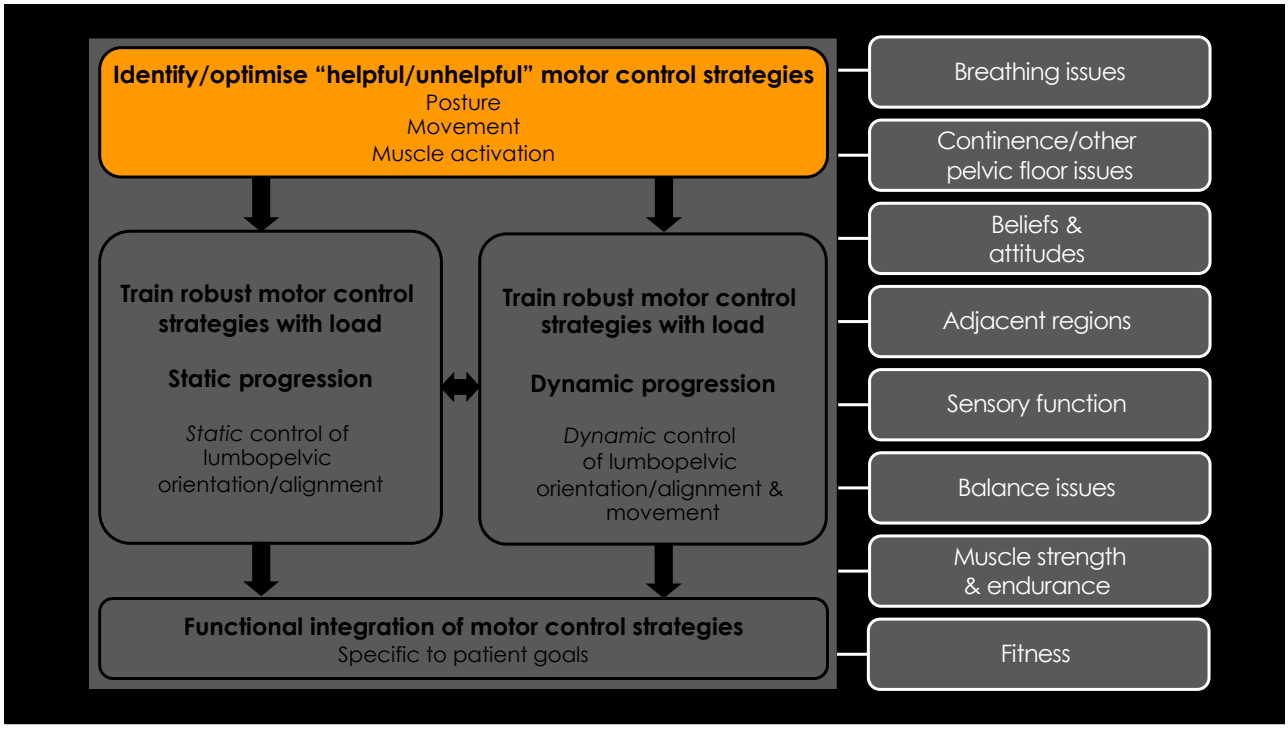
Motor control training for management of low back and pelvic pain

66


Identify/optimise "helpful/unhelpful" motor control strategies
Posture
Movement
Muscle activation
Train robust motor control strategies with load
Static progression
Static control of lumbopelvic orientation/alignment
Train robust motor control strategies with load
Dynamic progression
Dynamic control of lumbopelvic orientation/alignment & movement
Functional integration of motor control strategies
Specific to patient goals
Breathing issues
Continence/other pelvic floor issues
Beliefs & attitudes
Adjacent regions
Sensory function
Balance issues
Muscle strength & endurance
Fitness

67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Beliefs & attitudes
Adjacent regions
Sensory function
Balance issues
Muscle strength & endurance
Fitness

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Ideal motor control strategy

- What is an ideal motor control strategy?
  - A Motor control strategy (posture/movement/muscle activation) that is "helpful"
    - improves symptoms (e.g., decreases pain)

    and/or
    - Improves impairment (e.g., reduce spine loading)

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Ideal motor control strategy

- What makes a motor control strategy ideal?
  - Theorised to;
    - Optimise load distribution on the spine
    - Optimise orientation of muscle anatomy to resist control load and movement (McGill 2007)
    - Optimise distribution of muscle activation
      - Minimise excessive activation of muscles that load the spine (particularly of superficial muscles) thereby improving efficiency
      - Enhance activation of muscles that control (particularly of local muscles) (Sapsford et al. 2001; Sapsford et al. 2008; Claus et al. 2009a)
  - Note that;
    - Optimal motor control strategies (e.g. neutral spinal posture) can be considered a "blueprint for ideal" but may not be helpful for all patients

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Identify/optimise "helpful/unhelpful" motor control strategies

- Uses clinical reasoning to synthesise clinical information to refute and/or confirm hypotheses on relevance of features of motor control for patient presentation
- Consider
  - Posture
  - movement
  - muscle activation
- ASSESSMENT: Identify features of a motor control strategy of potential relevance, change it, and review effect on symptoms/impairment
  - Helpful → motor control strategy that eases symptoms and/or improves impairment
  - Unhelpful → motor control strategy that provokes symptoms and/or worsens impairment
- TREATMENT: Identify a strategy to change the motor control strategy
  - If helpful - to be used more by the patient
  - If unhelpful - to be used less

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Motor learning approach

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Consistent with motor learning theory/principles

- Fitts and Posner (1967)
  - Cognitive phase
  - Associative phase
  - Autonomous phase
- Gentile
  - "get" the idea
  - Integrate into function

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Motor learning program

- Segmentation
  - Break movement into components to practice the new "skills"
- Simplification
  - Make easier to learn the new "skill"
- Feedback
  - Ensure quality practice and learn new motor "skill"

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Motor learning

Principle	Implementation in motor skill training treatment condition
Practice of a movement results in improvement	Each skill incorporates the principles of reinforcement of helpful and discouragement of unhelpful elements of motor control
Large amounts of practice are required to truly master a motor skill	Participants will practice each skill for ~15-20 minutes per treatment visit. Participants will be given a home program of skills to practice daily. Participants will be asked to incorporate the principles of training from the treatment visit into activities across the day particularly during later stages of the treatment progressions.
Learning requires solving the motor problem and not rote repetition of tasks.	Skills should have grades of increasing difficulty. Progression to more difficult grades should continually challenge the participant's motor capacity.
Learning does not occur in the absence of feedback. Intrinsic feedback is optimal for promoting self-learning and generalization.	Tasks have clear goals (muscle activation, posture, movement) so patients can easily determine knowledge of results. LBP behaviour during practice will provide intrinsic feedback that can be used to make the appropriate adjustments to a participant's performance.

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Motor learning

Principle	Implementation in motor skill training treatment condition
Optimal learning occurs with high levels of motivation and engagement.	Patient should use goal setting to help to select skills for practice to increase engagement and motivation. Patients should practice 3 skills each visit to minimize boredom.
Variable practice conditions are optimal for learning and generalization.	Basic necessary movement principles stay the same but contexts change. Variation is accomplished within skills (e.g. sit ↔ stand: vary seat height, seating materials, constraints of surroundings) and across tasks.
Consider whether massed practice or distributed practice will promote better learning.	The treating environment is set up to allow for continuous practice. Patients are given encouragement by the therapist to continue practicing. Rest breaks are provided at the request of the person or if the participant's LBP symptoms begin to increase or performance deteriorates
Random practice of several tasks results in better learning than blocked practice of the same tasks in healthy adults.	Participants perform blocks of 10-15 trials of the 3 selected skills in random order at each visit.

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Training goals

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Posture/alignment training goals

- Optimise **lumbopelvic** loading
  - **Discourage** unhelpful postures
  - **Encourage** helpful postures
  - **Correct** asymmetry
  - **Minimise** activity of over-active muscles (often superficial/global muscles)
  - **Enhance** activity of underactive muscles (often deep/local muscles)
- Optimise **respiratory** pattern
- Optimise control of **pelvic floor muscles**

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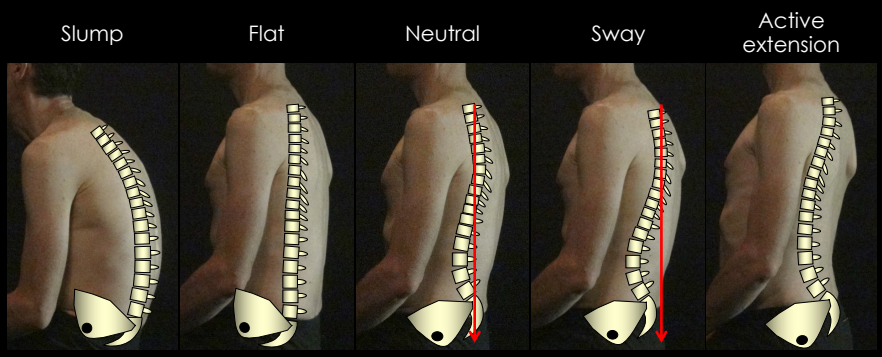
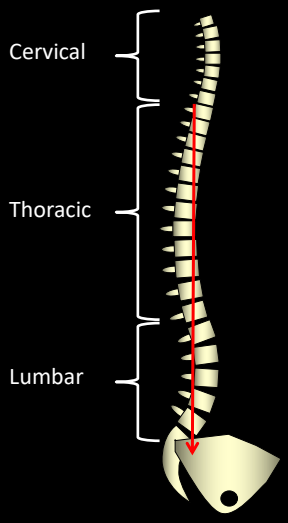
Posture/alignment



79

"Neutral spine"



- Aim:
  - Cervical lordosis
  - Thoracic kyphosis
  - Lumbar lordosis
  - Neutral pelvic tilt
  - Sagittal balance/alignment
  - Frontal alignment
- Benefits:
  - Optimal loading
  - Avoid creep
  - Reduce global muscle overactivity
  - Increase local muscle activity
- Consider:
  - Pathology (e.g. stenosis)
  - Spinal mobility
  - Not static – functional range

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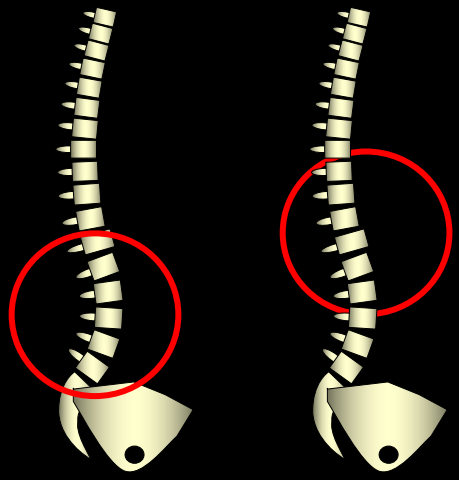
Key

- Control of
  - Lumbar lordosis/pelvic tilt
  - Thoracolumbar junction
  - Thoracic kyphosis
  - Sagittal/frontal alignment



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Key

- Control of
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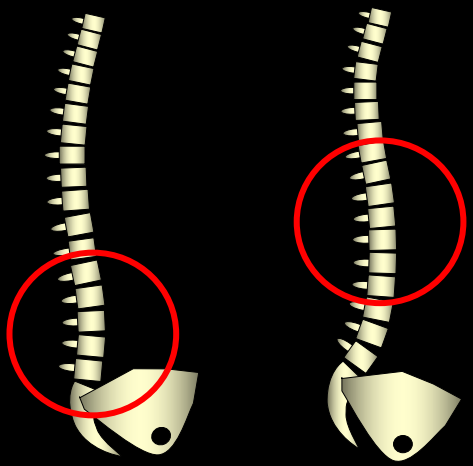

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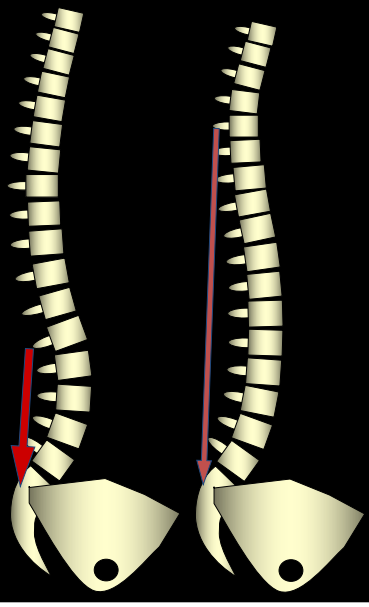
Muscle activity in different postures

- Lumbar lordosis - greater multifidus, greater low TrA/OI
- Thoracolumbar ext - greater TL ES
- Slump – minimal activity of extensors

Claus et al, 2010

- Sway – "hang" on OE



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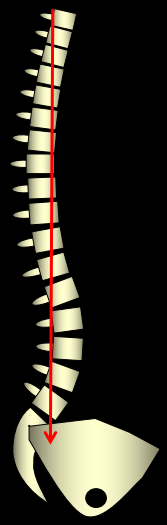
Posture/alignment - Assessment(1)

- Evaluation in multiple positions
  - Sitting – unsupported and supported
  - Standing
  - During functional task
- Identification of provocative/suboptimal elements
  - Presence of pain in naturally selected posture – location and response to change in posture (e.g. effect of lumbar support)

84

Posture/alignment - Assessment(2)

- Evaluation of sagittal alignment/ "balance"
  - Alignment relative to plumb line
  - Manubriosternal junction over pubic symphysis
    - Upright
    - Sway (thorax posterior to pelvis)
    - Kyphotic (thorax anterior to pelvis)



85

Posture/alignment - Assessment(3)

- Evaluation of spinal curvature
  - Approximate level of start and finish of sagittal spinal curves and depth of curves
    - Lumbar lordosis
    - Thoracic kyphosis
    - Transition between thoracic kyphosis and lumbar lordosis – flat or extended
    - Cervical lordosis and head position
  - Segmental changes – e.g. segmental lordosis
  - Pelvic position
    - Anterior/posterior tilt

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Posture/alignment - Assessment(4)

- Frontal plane (front/back)
  - Lateral shift/list
  - Lateral tilt pelvis
  - Right/left weight bearing
  - Scoliosis
  - Infra-sternal angle
- Evaluation of muscle activity
  - Palpation, observation, electromyography, ultrasound imaging
    - Hypertrophy/atrophy
    - Hyperactivity/underactivity
    - Asymmetry

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Posture/alignment – Assessment (5)

- Evaluation of posture of adjacent segments
  - Lower limb, including the feet
    - Hip angle – flexed, neutral, extended
    - Knee angle – flexed, neutral, (hyper)extended, internal/external rotation
    - Foot/ankle – pronated/supinated
  - Shoulder girdle
  - Neck/Thorax

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Posture/alignment – Assessment (6)

- Identify features of a motor control strategy of potential relevance, change it, and review effect on symptoms/impairment
  - Helpful → motor control strategy that eases symptoms and/or improves impairment (less superficial muscle activity)
  - Unhelpful → motor control strategy that provokes symptoms and/or worsens impairment (more superficial muscle activity)

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Posture/alignment - Rehabilitation

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Posture/alignment - Techniques

- Cognitive correction
- Instructions
  - e.g. roll forwards on tailbone, breathe into base of ribs
- Imagery
  - e.g. lengthen spine
- Manual guidance
  - e.g. hand on sacrum to facilitate anterior rotation of pelvis
- Manual cues
  - e.g. finger on xiphoid and navel to control T-L junction
- Dissociation tasks
  - e.g. separate L/T-L motion
- Muscle activation
  - e.g. palpation, observation, EMG biofeedback
- Cues/reminders
  - e.g. taping

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Feedback/manual cue: Thoracolumbar junction

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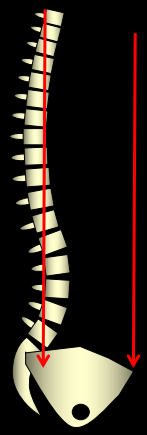
Feedback/Manual cue: sagittal alignment



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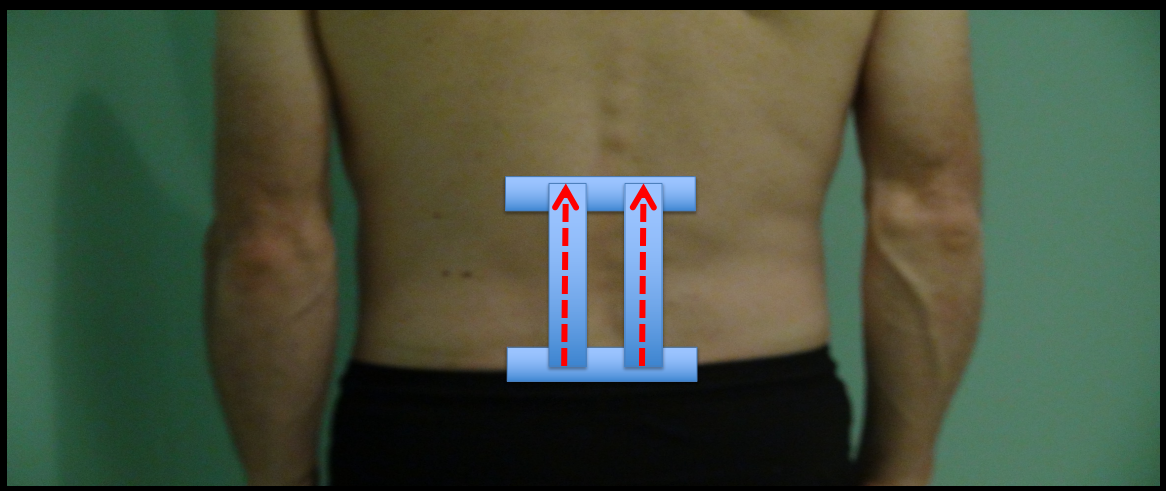
Tape: lumbar lordosis



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Posture/alignment - Treatment planning

CORRECTION OF POSTURE
- Find a strategy to change posture
  - E.g. cues, dissociation of hip/spine, lumbar/thoracolumbar spine
- Find a strategy to ensure correct practice at home
- Consider the home program (frequency, duration)

- Evaluate outcome
  - OK to feel "odd" or "awkward"
  - Should relieve pain
  - Should not be painful or difficult to hold
  - Consider patient - pathology, mobility
  - Consider muscle response - ?overactivity

- Start with few sessions progress to throughout day
- Find reminders…

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Muscle activation training goals

- Optimise **lumbopelvic** loading
  - **Discourage** unhelpful muscle activity (decrease overactivity)
  - **Encourage** helpful muscle activity that improves control
  - **Correct** asymmetry
  - **Encourage** functional use of improved muscle activation patterns in postures and movements
    - **Minimise** activity of over-active muscles (often superficial/global muscles)
    - **Enhance** activity of underactive muscles (often deep/local muscles)
- Optimise **breathing** pattern
- Optimise control of **pelvic floor muscles**

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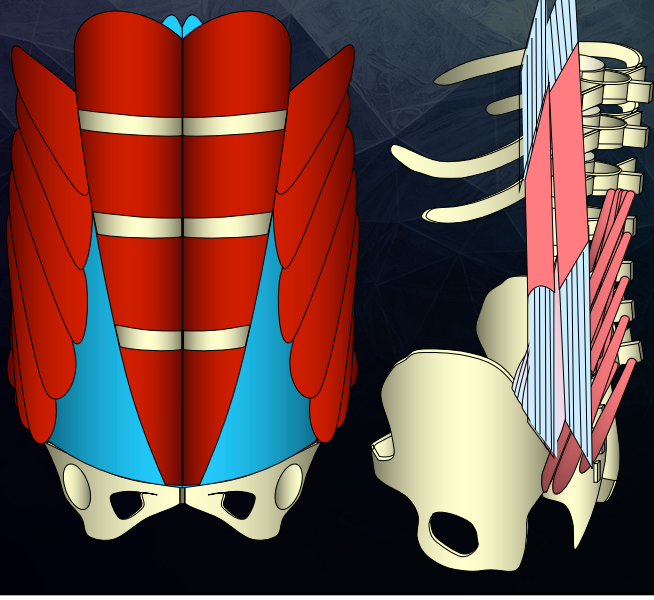
Complex interplay of whole muscle system



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Muscle activation: Assessment

- Principle: Identify features that deviate from presumed ideal
  - Underactivity (often deep muscles)
  - Over activity (often superficial muscles)
- Evaluate: Effect of correction
- Options:
  - Tests of isolated activity of deep muscles
  - Capacity and symmetry of superficial muscles

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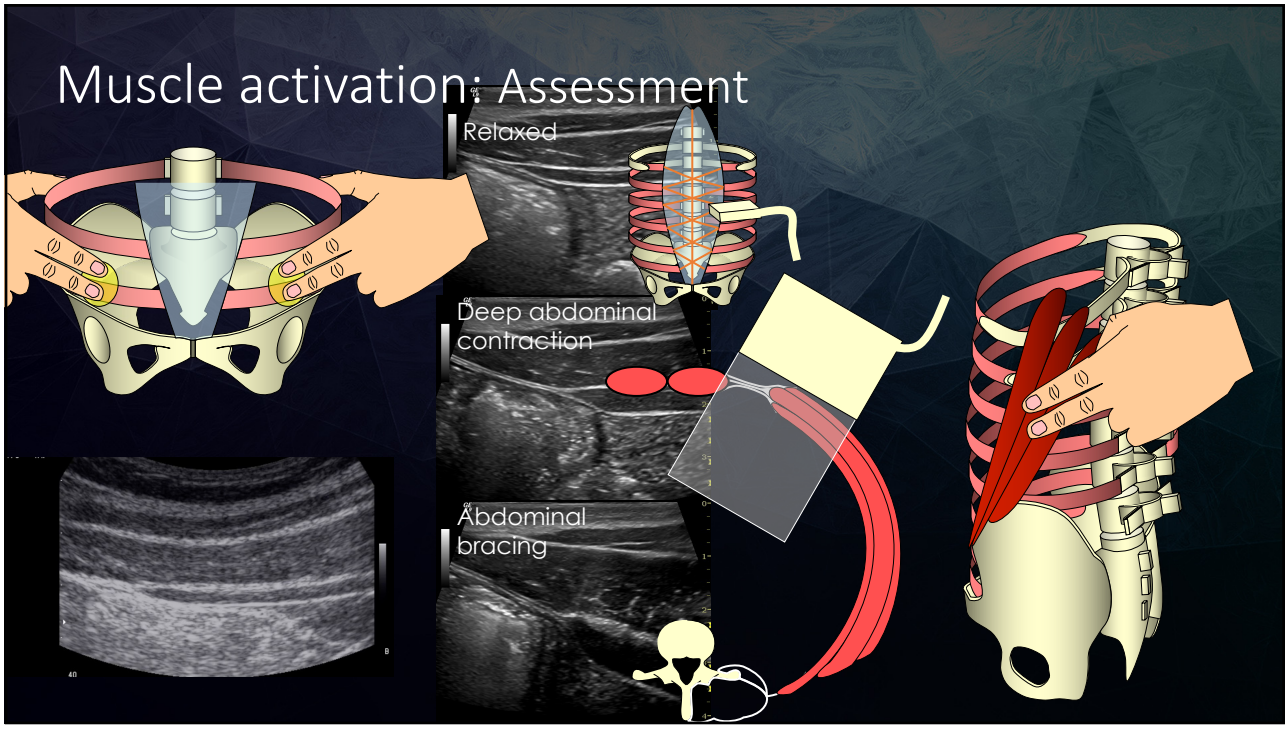

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Potentially helpful instructions

- Slowly draw the lower abdomen away from the elastic of your pants
- Slowly pull in your abdomen to gently flatten your stomach below your navel
- Slowly move my fingers together (fingers placed medial to iliac spines)

100

Muscle activation: Assessment

- Specific muscle activation test of anterior or posterior muscles
  - Test:
    - Ability to cognitively perform the motor skill of contraction of transversus abdominis or multifidus independently from the other superficial trunk muscles
  - Measure:
    - Precision
      - Which muscles
      - What sequence
      - What quality – smooth, symmetrical, slow

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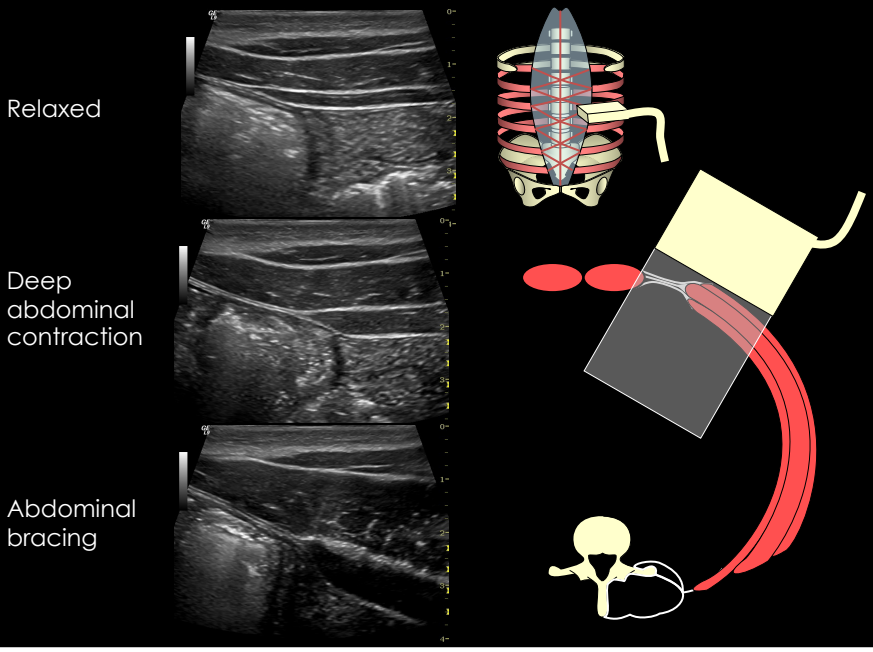
Test of "independent" muscle activation



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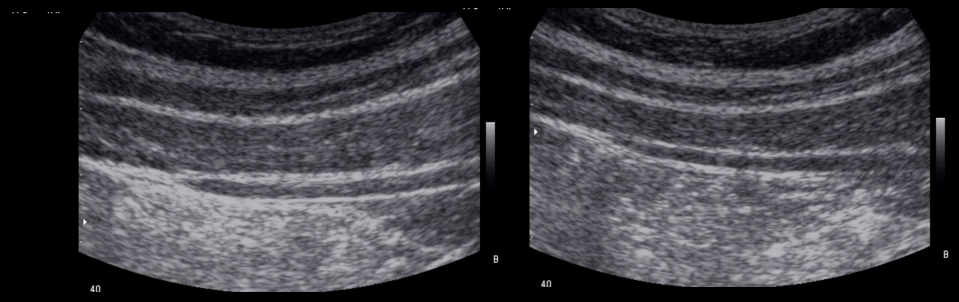
Test of "independent" transversus abdominis activation

Transversus abdominis contraction

Global abdominal muscle contraction



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Muscle activation: Assessment (Specific activation test)

- Ideal response
  - Palpable slow gentle increase in tension
  - Co-contraction with other deep muscles
  - No/little activity of superficial muscles
  - Symmetrical
  - Smooth and Sustained (not jerky)
  - Normal breathing
  - Repeat 10 x 10 s contractions
- Tools
  - palpation, observation, ultrasound

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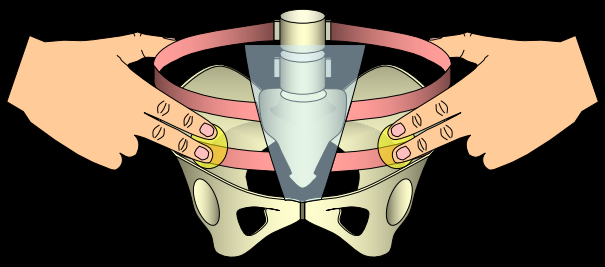
Palpation of transversus abdominis



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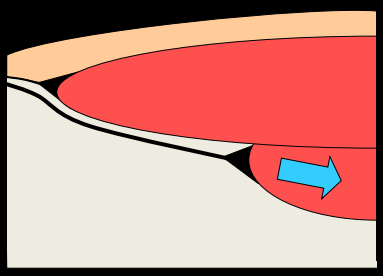
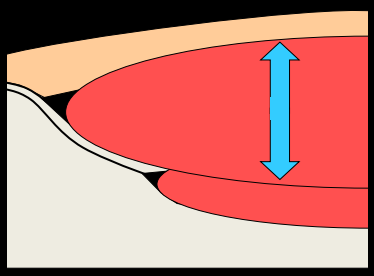
Palpation of transversus abdominis

Transversus abdominis
"DEEP TENSION"

Obliquus internus abdominis
"SWELLING"





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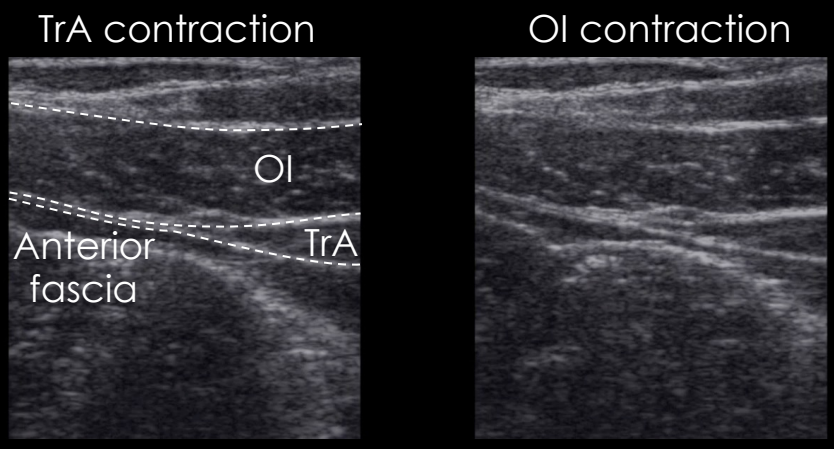
Palpation of transversus abdominis



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Confirmation of activation of transversus abdominis

- Observation
  - Slow inward movement of lower abdomen without movement of spine or pelvis
- Palpation
  - Deep tension in low abdominal wall – specific palpation test
- Ultrasound imaging
  - Slow, gentle and independent lateral slide and muscle thickening

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Evaluation of activation of superficial abdominal muscles

- Observation
  - Movement – pelvis, lumbar spine, thoracolumbar junction
  - Abdominal contours
  - Muscles – OI/OE/RA/ES/hip muscles
  - Breathing
- Palpation
  - Movement
  - Muscles – OI/OE/RA/ES/hip muscles
- Ultrasound imaging
  - Muscle activation - OI
  - Not useful for OE
- Surface EMG biofeedback
  - OE/RA

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Muscle activation - Rehabilitation

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Muscle activation: Techniques

- Reduce activity
  - 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

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Muscle activation: Techniques

- Increase activity
  - 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

112

Muscle activation - Treatment planning

CORRECTION OF MUSCLE ACTIVATION STRATEGIES

- What strategy works best for the patient?
  - Find a strategy that gives best contraction of underactive components (often TrA or MF)
  - Find a strategy to reduce overactive components
- How can you be sure that the patient will practice the correct exercise at home?
  - Find a technique to ensure correct practice
- What would the home program be?
  - Indicate number of contractions and duration
- 2-3 sessions per day

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Assessment: Posterior muscles

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Assessment: Posterior muscles

Test of ability to cognitively perform the motor skill of contraction of lumbar multifidus (particularly the deep fibres) independently from the long erector spinae muscles at each lumbar segment

PRECISION

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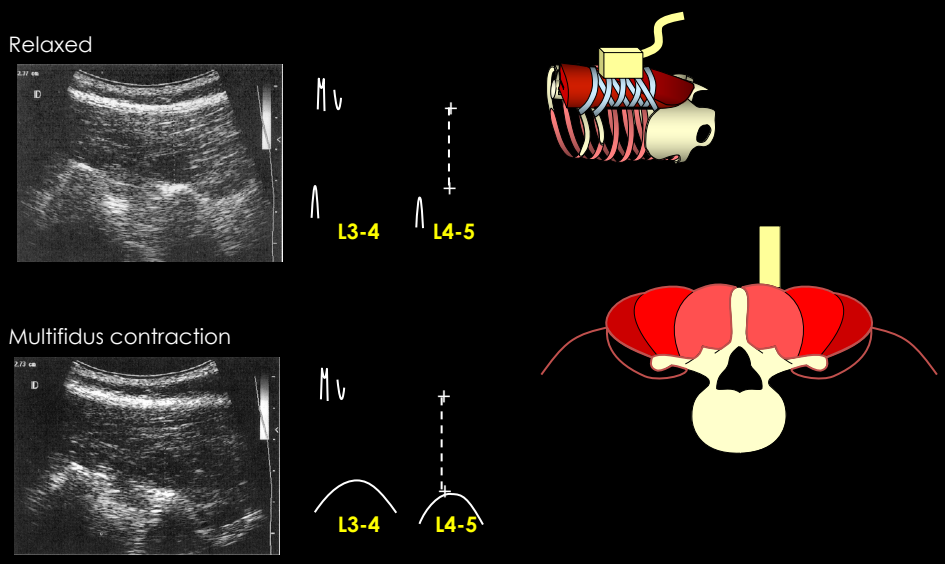
Test of "independent" muscle activation



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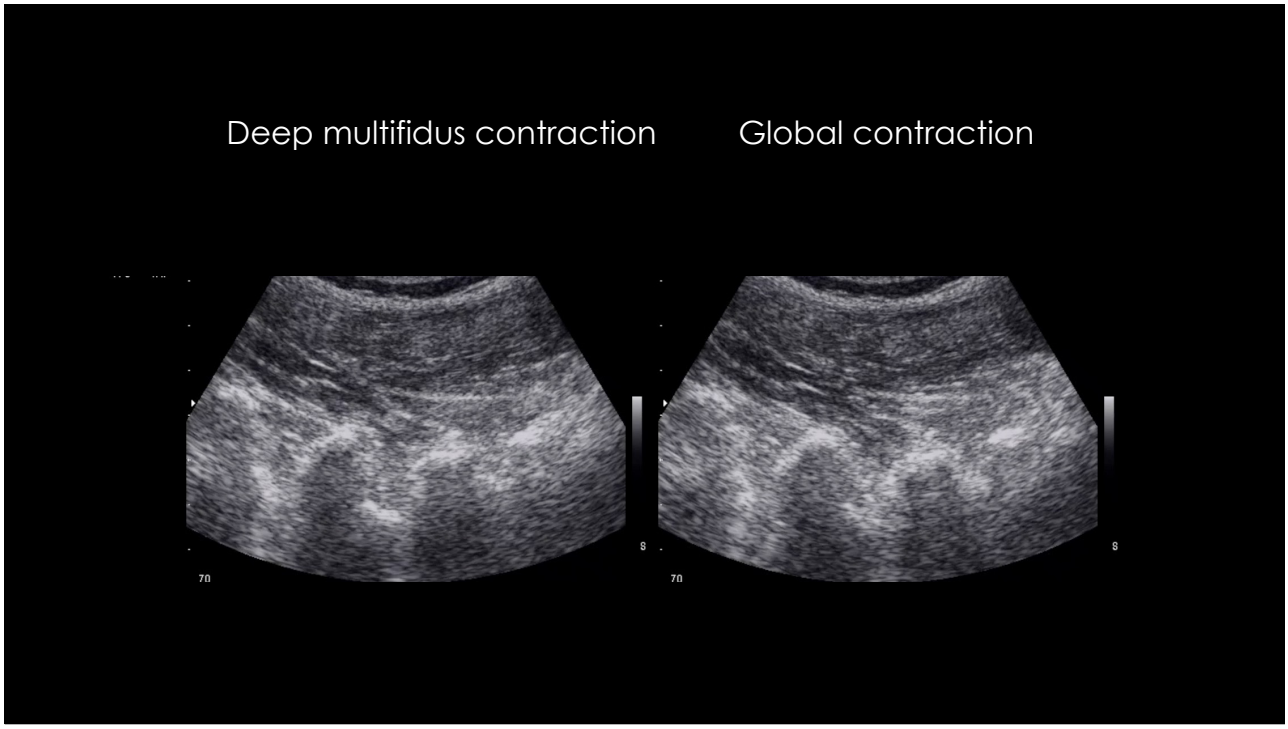

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Muscle activation: Assessment (Specific activation test)

- Potentially helpful instructions – Multifidus
  - Gently bugle the muscle into my fingers
  - Imagine you are tensing a cable between the front and back of your pelvis (show with fingers)
  - (in supine) imagine sliding this vertebra (show with fingers) up to the sky
  - Think about tilting without actually doing it
  - (in side lying with top hip flexed and foot behind opposite knee) Think about tensing a string connecting the hip to the hip joint

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Muscle activation: Assessment (Specific activation test)

- Ideal response
  - Palpable slow gentle increase in tension
  - Co-contraction with other deep muscles
  - No/little activity of superficial muscles
  - Symmetrical
  - Smooth and Sustained (not jerky)
  - Normal breathing
  - Repeat 10 x 10 s contractions
- Tools
  - palpation, observation, ultrasound

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Confirmation of activation of multifidus (focus on deep)

- Palpation
  - Deep tension
  - Close to midline
  - Symmetrical
- Observation
  - No pelvic motion
  - Co-contraction with TrA, not superficial abdominal muscles
- Ultrasound imaging
  - Slow, gentle and predominantly deep - muscle thickening and fascicle motion

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Evaluation of activation of superficial muscles

- Observation
  - Movement – anterior or posterior pelvic tilt
  - Muscles –
    - Rapid superficial contraction
    - Thoracolumbar ES; lumbar ES (lateral to multifidus); quadratus lumborum
    - Co-contraction of OI/OE/RA
    - Hip muscles – glut max
- Palpation
  - Movement
  - Muscles
- Surface EMG biofeedback
  - TES; LES lateral to multifidus
  - OE/RA

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Muscle activation - Rehabilitation

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Muscle activation: Treatment goals

- Find strategy to increase activity of underactive components (often local)
- Find strategy to decrease activity of overactive components (often global)

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Muscle activation: Techniques

- Reduce activity
  - 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

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Muscle activation: Techniques

- Increase activity
  - 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
  - Electrical stimulation?

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Movement

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Movement training goals

- Optimise **lumbopelvic** loading
  - **Discourage** unhelpful movements
  - **Encourage** helpful movements
  - **Correct** specific impairments in movement
    - Dissociation between regions/Encourage sharing of load between adjacent regions
    - Poor control at a specific segment/region
  - **Correct** asymmetry
  - **Encourage** functional use of improved muscle activation patterns
    - **Minimise** activity of over-active muscles (often superficial/global muscles)
    - **Enhance** activity of underactive muscles (often deep/local muscles)

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Movement - Assessment

- Evaluation of changes in sagittal/frontal/transverse alignment during movement
  - Timing
  - Amplitude
  - Sequence
- Evaluation of muscle activity
  - Palpation, observation, electromyography, ultrasound imaging

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Movement - Assessment

- Evaluation of posture/movement of adjacent segments and ability to dissociate movement of lumbopelvic region from adjacent segments
  - Lumbar vs. hip
  - Lumbar vs. thoracolumbar junction
  - Lower limb and feet
  - Shoulder girdle
  - Neck/Thorax

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Movement - Assessment

- Specific movement tests
  - Multiple approaches to identification of movements that sub-optimally load lumbopelvic structures
    - Kendall et al
    - Sahrmann et al
    - O'Sullivan et al
    - Richardson et al

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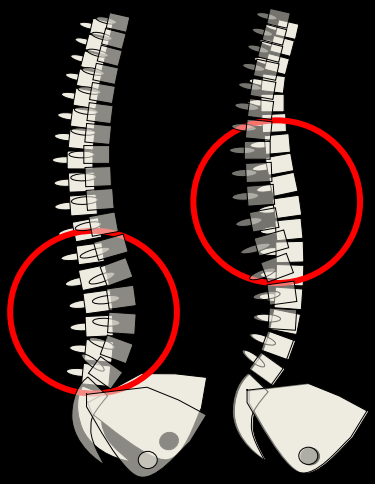
Movement - Assessment

- **Observe for:**
  - Thoracolumbar control
    - Excessive flexion/extension
  - Anterior pelvic sway
  - Lumbar spine - increased or decreased extension/lordosis
  - Anterior/posterior pelvic rotation
  - Relationship between hip and lumbar motion



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Movement – Assessment Essential test 1

- Sitting
  - Slump/Rock backward & Sit upright/erect
    - Observe for inability to move of lumbar spine and pelvis independently from thoracolumbar regions

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Movement – Assessment Essential test 2

- Sit-to-stand
  - Observe ability to maintain lumbar lordosis –
    - increased lumbar flexion,
    - decreased lumbar extension,
    - increased thoracolumbar extension,
    - increased posterior pelvic tilt,
    - anterior pelvic sway,
    - relationship between hip and lumbar motion

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Movement – Assessment Essential test 3

- Standing flexion
  - Flexion
    - Observe for
      - loss of motion
      - increased lumbar flexion/lateral shift
      - increased lumbar extension
      - increased thoracolumbar extension
      - increased posterior/anterior pelvic tilt
      - relationship between hip and lumbar motion
  - Return from flexion
    - Observe for
      - relationship between hip and lumbar motion,
      - increased thoracolumbar extension,
      - anterior pelvic sway,
      - increased or decreased extension,
      - anterior pelvic rotation

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Flexion from standing

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Movement – Assessment Essential test 4

- Single leg stand
  - Observe ability to control pelvic/trunk control during single leg stance
    - observe for trendelenberg,
    - lateral shift of thorax/lateral flexion,
    - medial hip rotation, pelvic sway,
    - Pelvic rotation

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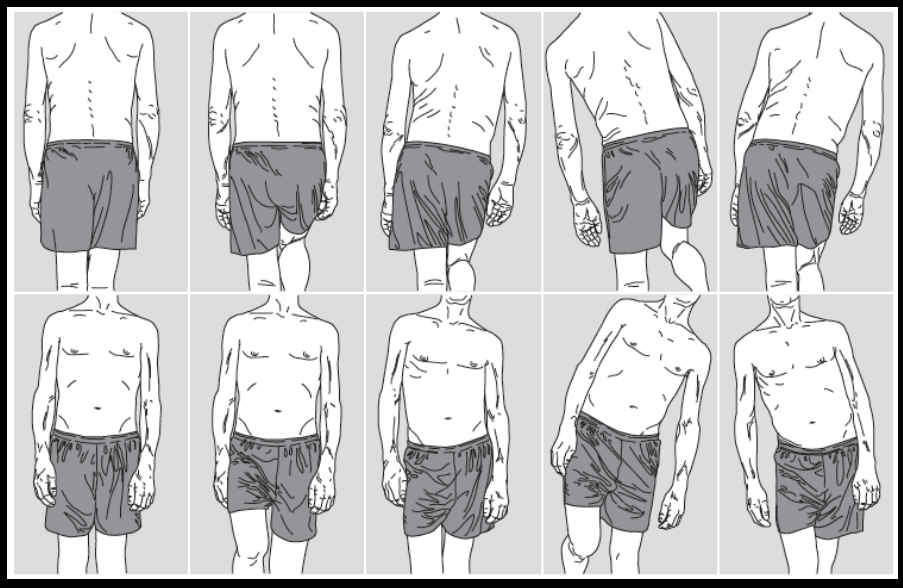

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Movement – Assessment Essential test 5

- Prone hip rotation
  - Medial and lateral (active & passive)
    - Observe for
      - pelvic rotation

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Hip medial rotation (active)

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Movement - Assessment

- Identify features of a motor control strategy of potential relevance, change it, and review effect on symptoms/impairment
  - Helpful → motor control strategy that eases symptoms and/or improves impairment
  - Unhelpful → motor control strategy that provokes symptoms and/or worsens impairment

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Movement - Rehabilitation

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Movement - Techniques

- Cognitive correction
- Instructions
  - e.g. hold lordosis when bend
- Imagery
- Manual guidance
  - e.g. hand on sacrum to facilitate anterior rotation of pelvis
- Manual cues
  - e.g. finger on xiphod and navel to control T-L junction
- Dissociation tasks
  - e.g. separate L/T-L motion, "waiters bow"
- Muscle activation
  - e.g. palpation, observation, EMG biofeedback
- Cues/reminders
  - e.g. taping

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Movement - Treatment planning

CORRECTION OF MOVEMENT

- Find strategies to change movement
  - E.g. cues, dissociation of hip/spine, lumbar/thoracolumbar spine
- Evaluate outcome
  - OK to feel "odd" or "awkward"
  - Should not be painful or require significant activity
  - Consider patient - pathology, mobility
  - Consider muscle response - ?overactivity

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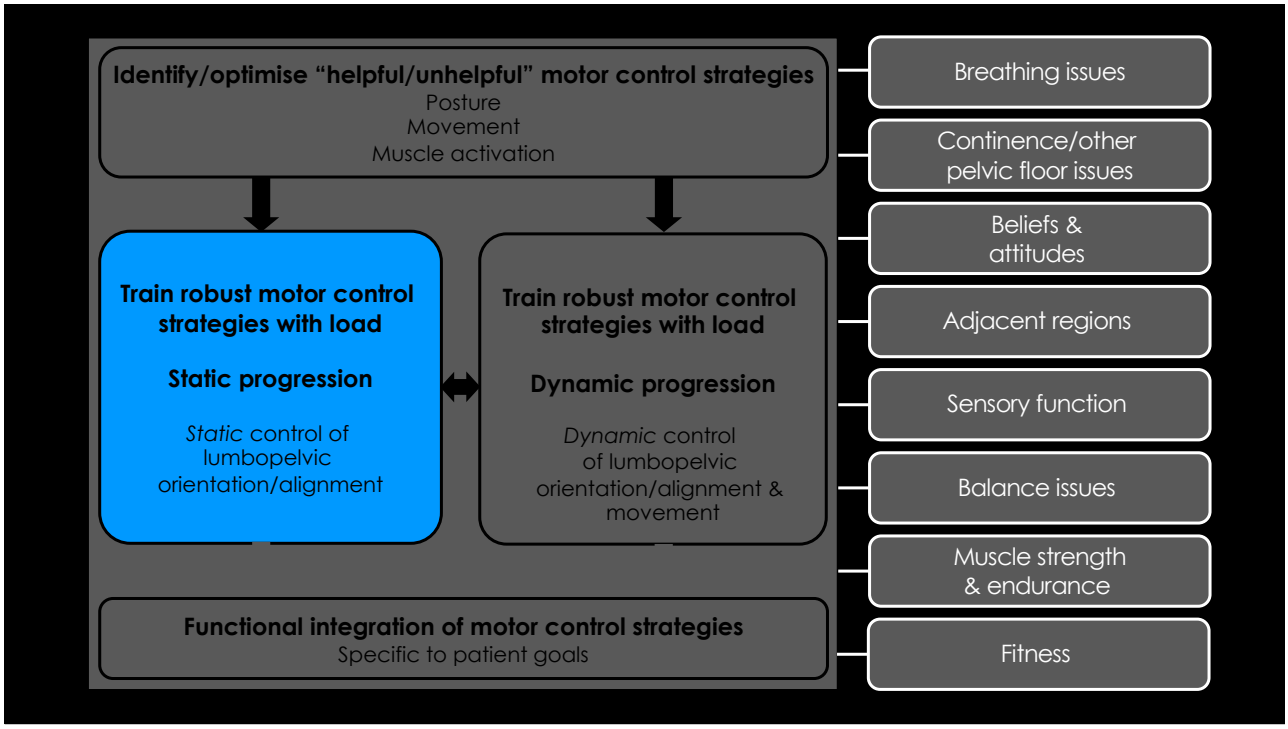

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Static progression - Training goals

- Robust control of motor control strategies in challenging situations - static
  - Train integration of helpful **muscle activation**
  - Train integration of helpful **posture**
  - Train integration of helpful **movement**
- Focus on **static** control of lumbopelvic orientation/alignment

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Static progression: Assessment

- Test:
  - Evaluation of control of orientation/ alignment of spine and pelvis during loading or limb movement
- Components
  - Evaluation of **co-activation** of deep and superficial muscle system
  - **Threshold** for loss of control
  - Evaluation of **asymmetry** of control
    - e.g. Rotation

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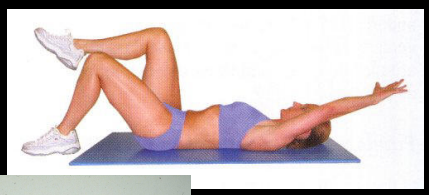
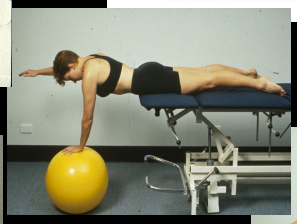
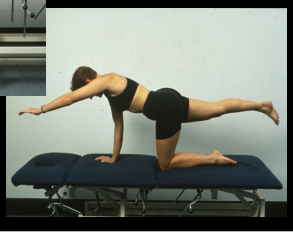
Static progression: Examples



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Identify/optimise "helpful/unhelpful" motor control strategies
Posture
Movement
Muscle activation

Train robust motor control strategies with load

Static progression

Static control of lumbopelvic orientation/alignment

Train robust motor control strategies with load

Dynamic progression

Dynamic control of lumbopelvic orientation/alignment & movement

Functional integration of motor control strategies
Specific to patient goals

- Breathing issues
- Continence/other pelvic floor issues
- Beliefs & attitudes
- Adjacent regions
- Sensory function
- Balance issues
- Muscle strength & endurance
- Fitness

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Dynamic progression - Training goals

- Robust control of motor control strategies in challenging situations - dynamic
  - Train integration of helpful **muscle activation**
  - Train integration of helpful **posture**
  - Train integration of helpful **movement**
- 2 major issues
  - Control of **motion of the spine**
  - Control of the **spine during whole body function**
- Focus
  - Dynamic control of lumbopelvic alignment
    - e.g. on unstable surface
  - Incorporate lumbopelvic movement into simple dynamic functions
    - e.g. counter-rotation of shoulders and pelvis in walking

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Dynamic progression: Techniques

- Unstable surfaces
  - Impossible to maintain balance if stiff
  - Must be targeted to the individual
  - Must be controllable - within tolerance as load is increased

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Dynamic progression: Techniques

- Control contraction and posture while move
  - e.g. golf swing

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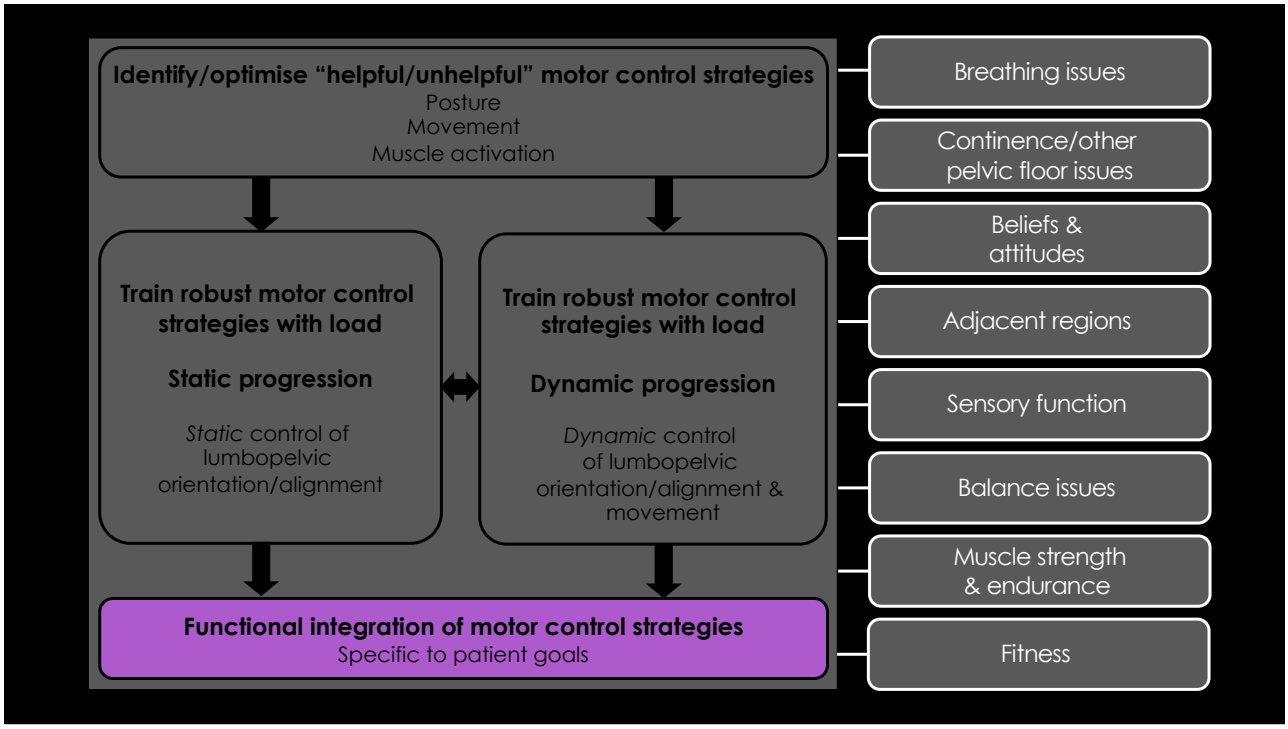

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Functional re-education - Training goals

- Robust control of motor control strategies in function
  - Train integration of helpful **muscle activation**
  - Train integration of helpful **posture**
  - Train integration of helpful **movement**
- Specific to patient presentation
  - Priority tasks (functions that are compromised)
- Use principles of motor learning
  - **Segmentation** - practice parts
  - **Simplification** - speed, position, load
  - **Feedback** – of specific elements during "whole" task
- Focus on transfer – practice close to function

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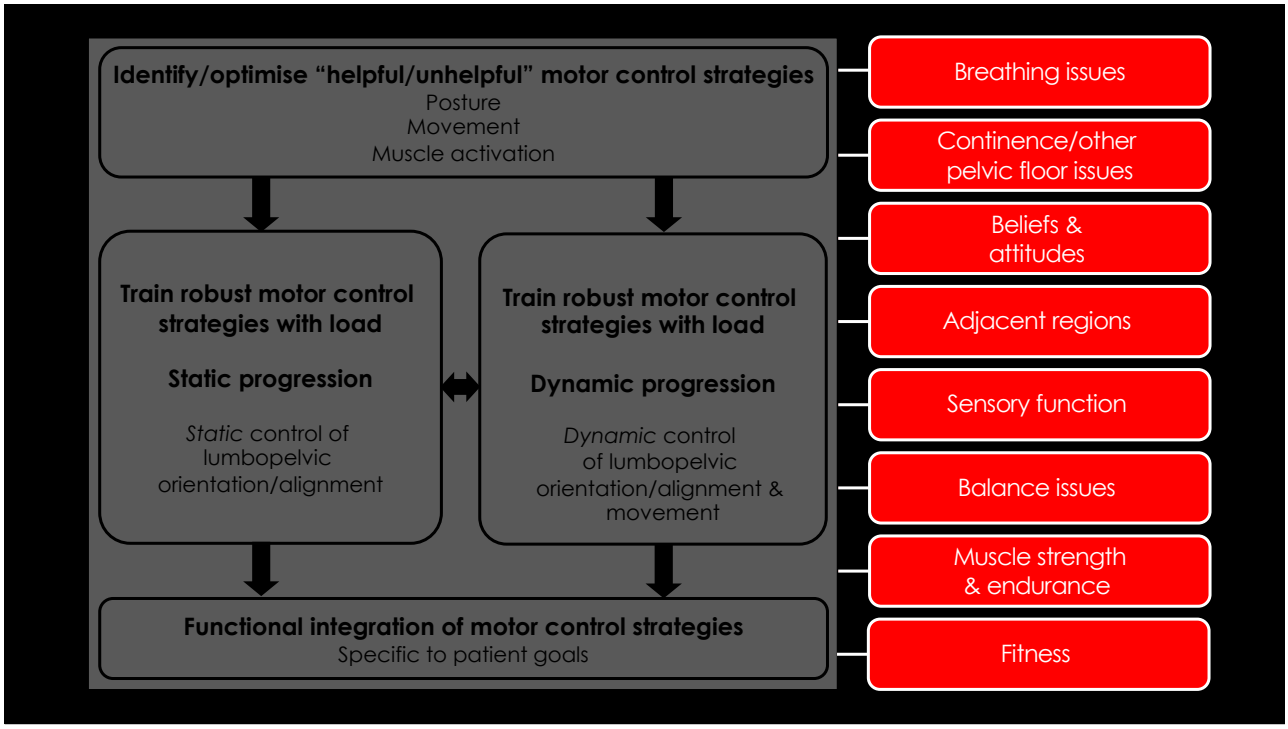

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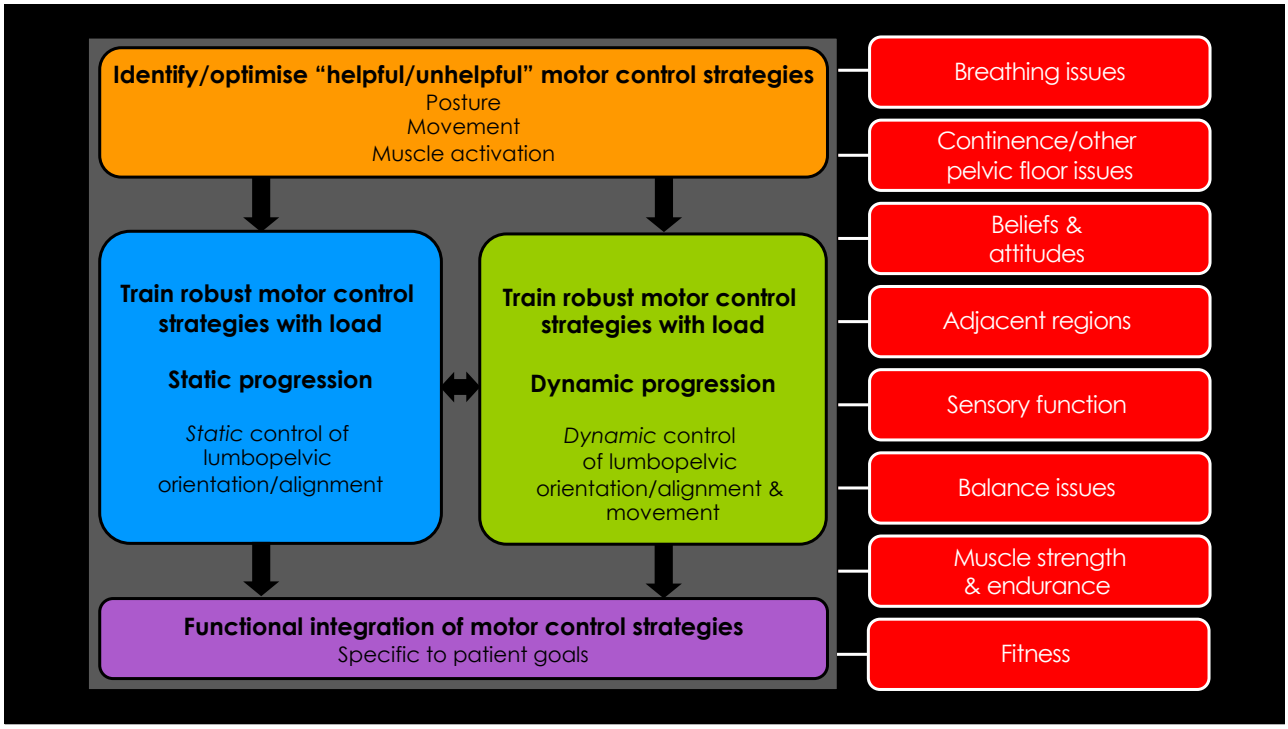
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Sensory function
Balance issues
Muscle strength & endurance
Fitness

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