


## Rethinking muscle changes in low back pain and injury: Novel mechanisms, new treatment targets

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Spinal Pain,  
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## Structural & functional changes in back muscles (multifidus) are an ubiquitous observation in back pain

Counterintuitive?  
Important or epiphenomenon?

## Outline


- Does control of the lumbar spine & pelvis depend on muscle?
- How does back muscle dysfunction present in low back pain?
- What are the mechanisms for back muscle dysfunction?
- Is back muscle dysfunction relevant for spinal health?
- Does back muscle dysfunction have implications for injury/pain & rehabilitation?

## Outline

- Does control of the lumbar spine & pelvis depend on muscle?

## Spine control depends on muscle

- Without muscle spine **inherently unstable**  
Lucas & Bressler, 1960
- **All** muscles important  
McGill et al., 2003
- Muscles with **segmental attachments** are important
  - Segment with no muscle attachment – spine stability same as when not muscle  
Crisco & Panjabi, 1991



## Spine control depends on muscle

Crisco & Panjabi, 1991 Spine

## Spine control depends on muscle

**A Universal Model of the Lumbar Back Muscles in the Upright Position**  
**Euler stability of the human ligamentous lumbar spine**

**A Follower Load Increases the Load-Carrying Capacity of the Lumbar Spine in Compression**

**Importance of Trunk Muscles of the Lumbar Spine**

**Stability of the *in vivo* lumbar spine for injury and chronic low back pain**

**Cholewicki PhD, S M McGill PhD**  
 Occupational Biomechanics and Safety Laboratories, Department of Kinesiology, Faculty of Applied Health Sciences, University of Waterloo, Ontario, Canada

## Outline

How does back muscle dysfunction present in low back pain?

## Compromised activation

**Disc Herniation-Related Back Pain Impairs Feed-Forward Control of Paraspinal Muscles**

Ville Leinonen, BM,† Markku Kankaanpää, DMSc,†† Matti Luukkainen, MD,† Osmo Hänninen, DMSc, PhD,† Olli Aitakoski, DMSc,† and Simo Taimela, DMSc,†

**Corticomotor control of lumbar multifidus muscles is impaired in chronic low back pain: concurrent evidence from ultrasound imaging and double-pulse transcranial magnetic stimulation**

Hugo Massé-Alarie<sup>1,2</sup>, Louis-David Beaulieu<sup>1</sup>, Richard Preuss<sup>1,3</sup>, Cyril Schneider<sup>1,4</sup>

## Excessive activation

**Effect of Fatigue on Torque Output and Electromyographic Measures of Trunk Muscles During Isometric Axial Rotation**

Paul Hodges<sup>1\*</sup>, Wolbert J. van Dieën<sup>2</sup>, Joseph K.-F. Ng, PhD, Mohamad Partianpour, PhD, Carolyn A. Richardson, PhD, Vaughan Kippers, PhD

**Trunk Muscle Recruitment Patterns in Patients With Low Back Pain Enhance the Stability of the Lumbar Spine**

Jaap H. van Dieën, PhD,† Jaak Cholewicki, PhD,† and Andrea Radbold, MD,†

## Structural changes in multifidus


- Atrophy
  - Hides et al., 1994
  - Danneels et al., 2000
- Fatty infiltration
  - Alaranta et al., 1993
  - Kjaer et al., 2007
  - Battie et al., 2012
- Connective tissue
  - Hodges et al., 2015
- Muscle fibre changes
  - Mannion et al. 1997
  - Hodges et al., 2014

## Muscle dysfunction is common in pain & injury of the low back

- Multiple presentations
  - Compromised activation
  - Excessive activation
  - Structural changes
- Multiple muscles affected
  - vanDieën et al 2003
- Individual-specific presentation
  - Patient subgroups
  - Dankaerts et al, 200x; Hodges et al 2013
- Different time course of changes and consequences

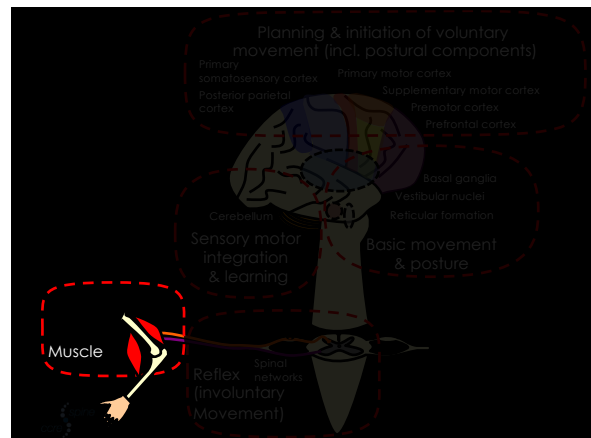
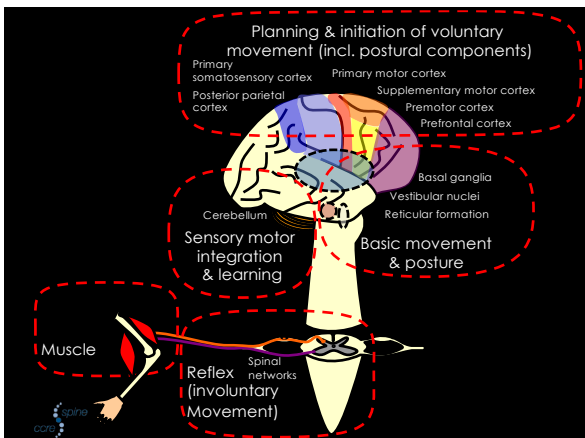
## Outline

What are the mechanisms for back muscle dysfunction?




## Mechanisms?

New ideas,  
novel mechanisms &  
potential clinical innovations

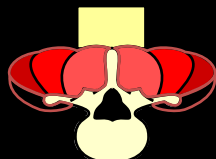
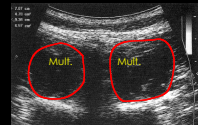



## Importance of muscle health


- Efficacy of motor control depends not only on whether the **command is correct**...but whether the **muscle can enact the command**
- Muscle is important for control of the spine – **regulates tissue loading**
  - Suboptimal tissue loading **may** contribute to ongoing nociceptive input (danger signals)

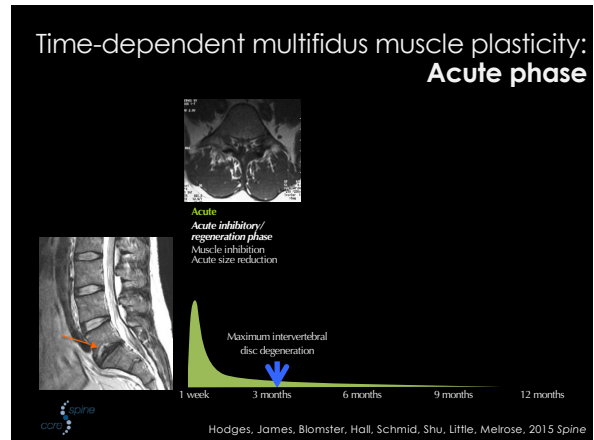
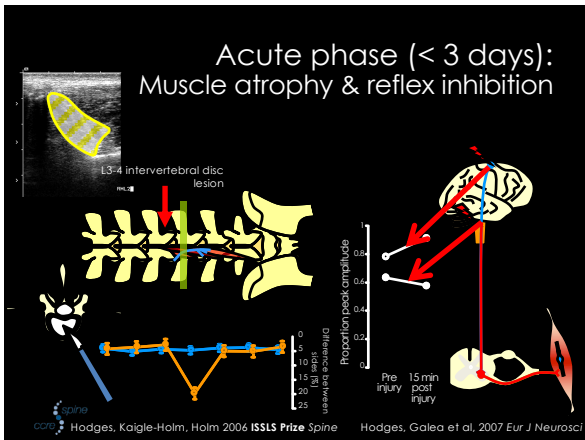


## Acute phase

Hides, Stokes, Saides, Jull, Cooper, 1994 Spine

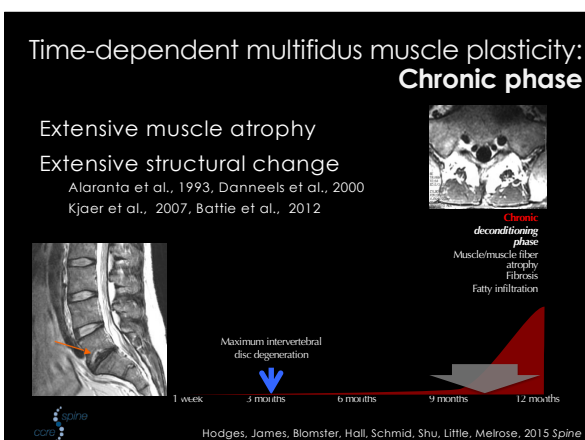
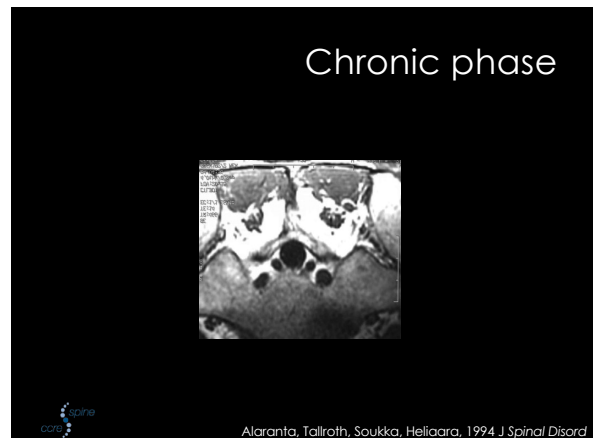




### Implications for rehabilitation

- Treatment targeting depends on timing based on different mechanisms
  - Acute – "inhibition mediated muscle change"
    - Activation
    - Reduce inhibition

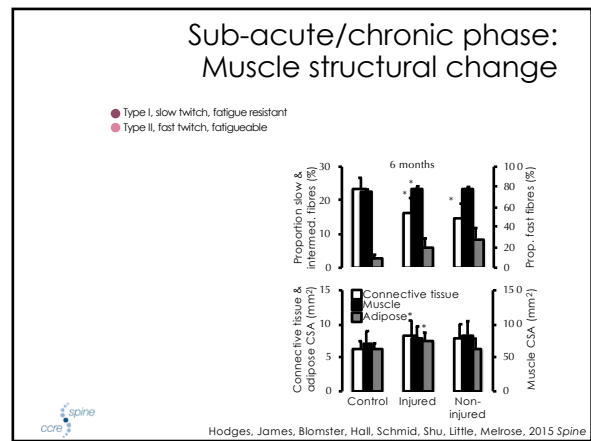
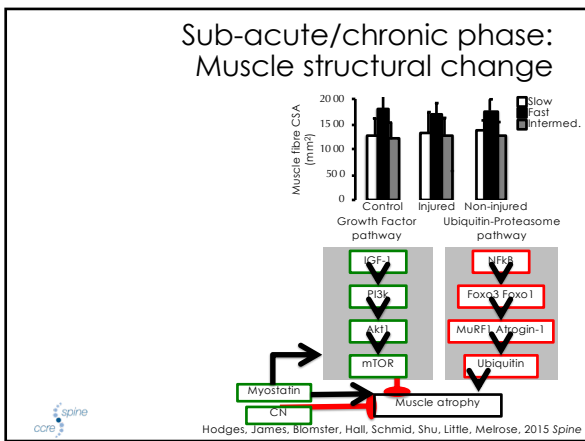
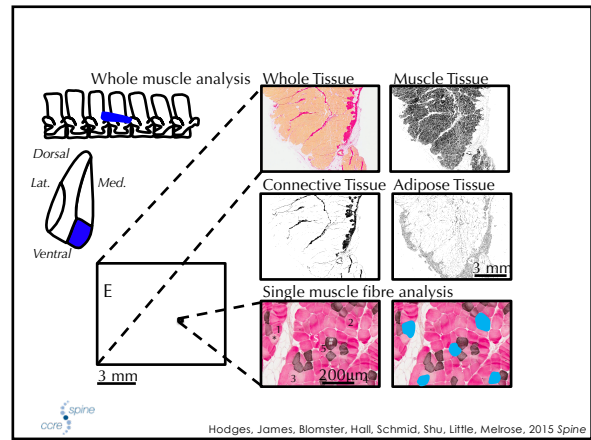
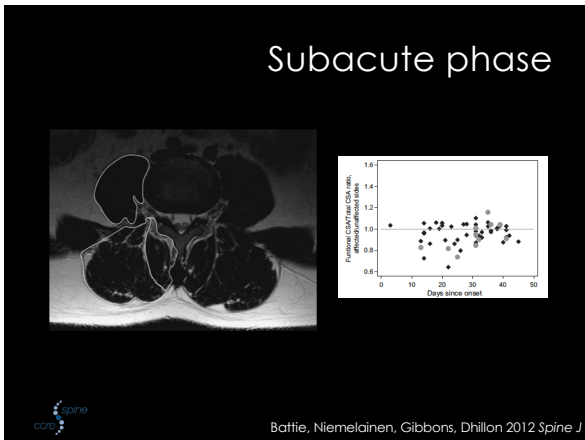
care spine



### Implications for rehabilitation

- Treatment targeting depends on timing based on different mechanisms
  - Chronic – "disuse mediated muscle change"
    - Exercise to promote hypertrophy and reduce fat/fibrosis
    - Correct pattern – resistance for hypertrophy

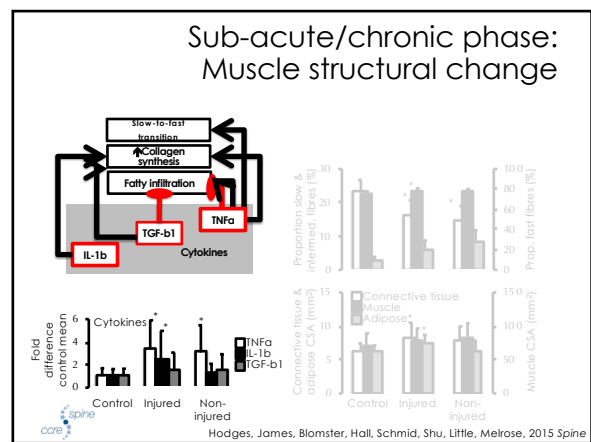
care spine




### Possible role of inflammatory response in muscle changes

- TNF expression increased after intervertebral disk disease (Omarker et al. Spine 1998; Burke et al. J Bone Joint Surg 2002)
- Role in muscle remodeling (Phillips et al FASEB J 2005; Li et al. FASEB J 2001)

core spine




## Where do the cytokines come from?



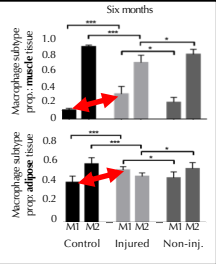
## Where do the cytokines come from?

- M1 macrophages – pro-inflammatory
- M2 macrophages – anti-inflammatory



## Where do the cytokines come from?


- M1 macrophages – pro-inflammatory
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James, Sluka, Blomster, Hall, Schmid, Shu, Little, Melrose, Hodges, 2015 Eur Spine J


## Where do the cytokines come from?

- Acute inflammation, typically short-lived & reversible event to promote healing of injured tissue
  - Remove injured cells
  - Injured cells – release factors – hypersensitivity (Pongs 1999, Amaya, Izumi et al. 2013)
  - Macrophages & Mast cells - inflammatory cytokines
- But...muscle is not injured

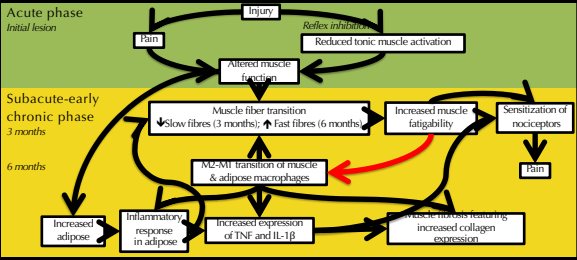


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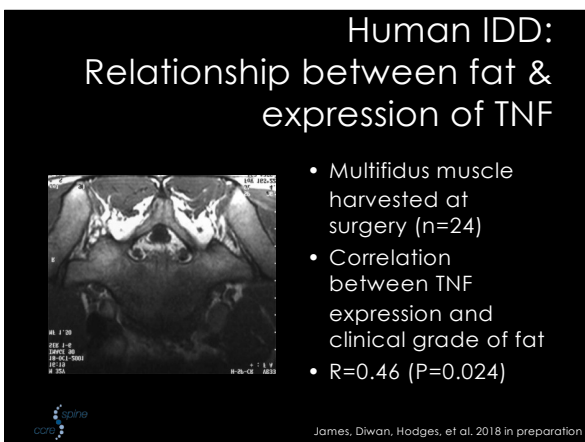
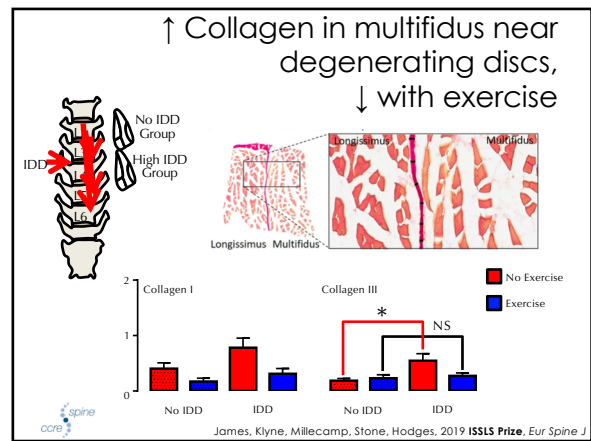
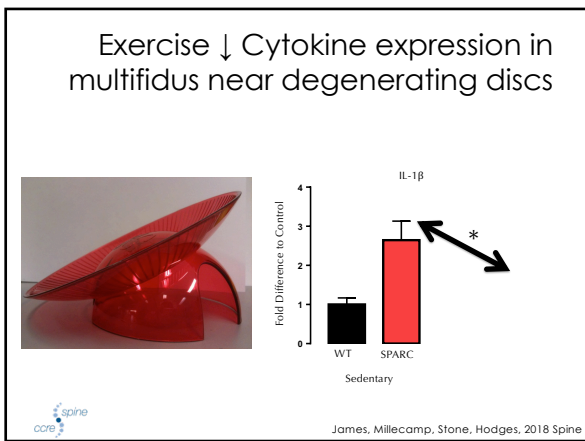
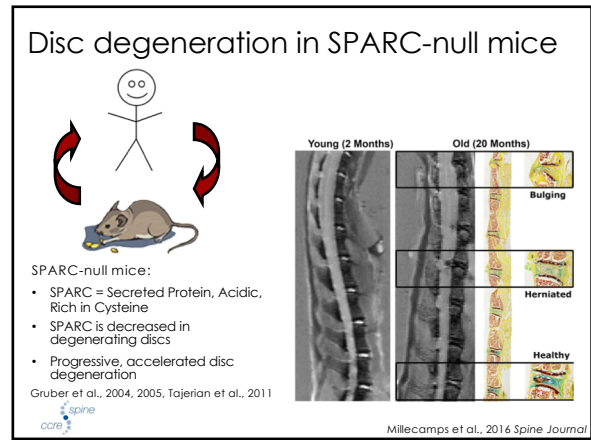
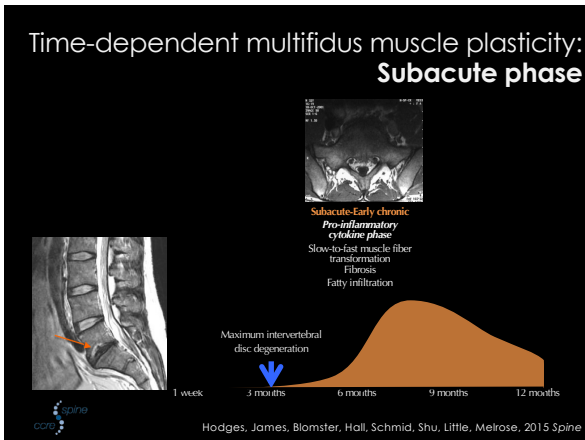
- Possible mechanism
  - Paracrine effects
  - Macrophages changed by micro-environment
    - Muscle fibre types changes
      - Less fatigue resistant – acidic environment\*



## Where do the cytokines come from?

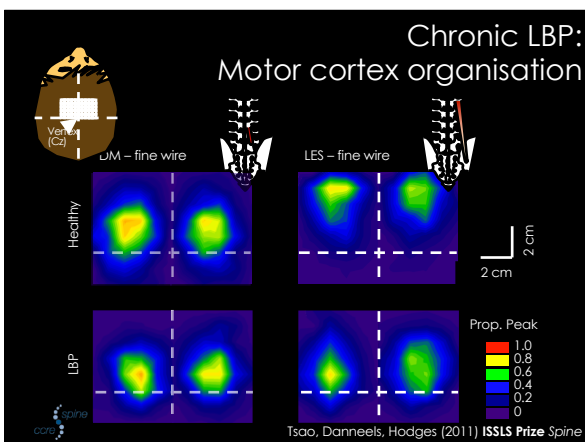
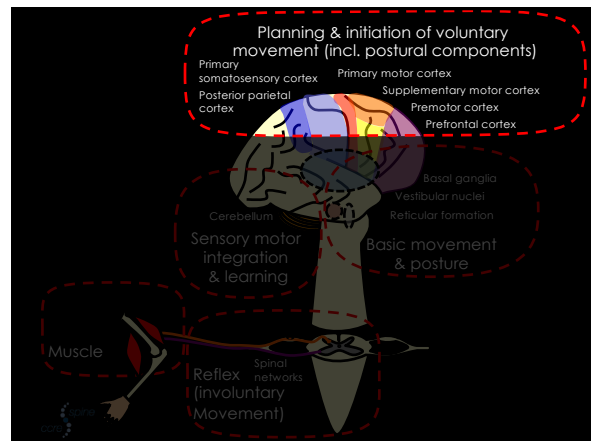
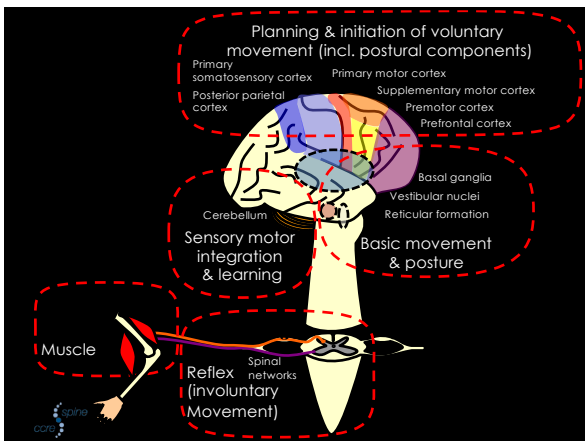
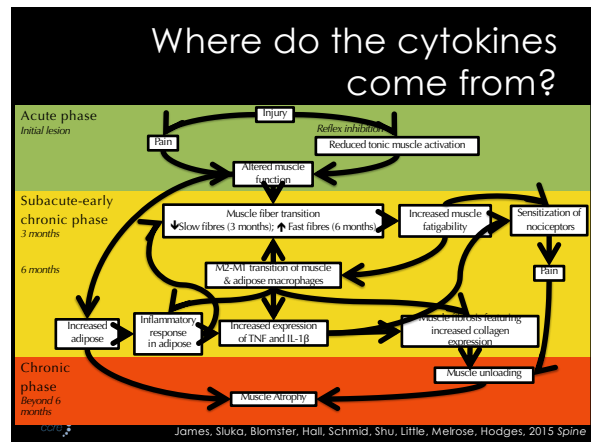
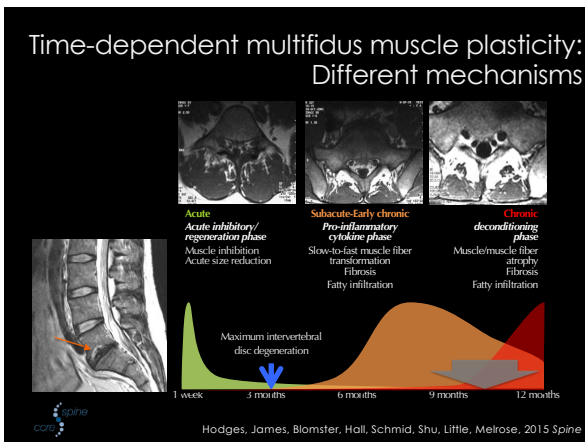


James, Sluka, Blomster, Hall, Schmid, Shu, Little, Melrose, Hodges, 2015 Eur Spine J



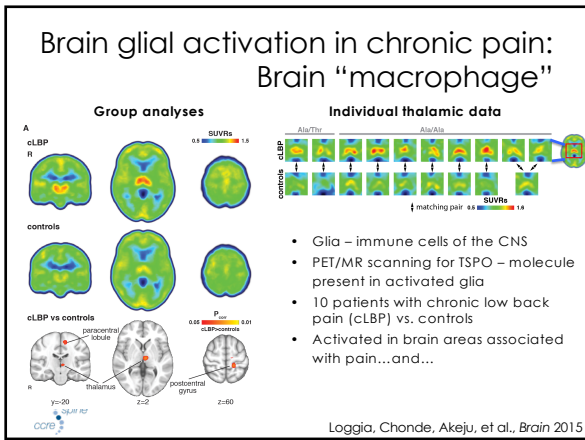
### Implications for rehabilitation

- Treatment targeting depends on timing based on mechanisms
  - **Sub-acute** – pro-inflammatory
    - Exercise has anti-inflammatory effects – correct pattern then add resistance – strength/endurance/muscle fibre type change



### Why does the motor cortex change?





### Biology

### Glial cells

- Immune cells of the brain
- Activated in the motor cortex in chronic pain
- Somatotopic – back area of S1/M1 in back pain
- What are they doing?
  - Driving change?
  - "Cleaning up" after change?

**[<sup>11</sup>C]PBR28 study**

**Pain fMRI studies**

Loggia et al., Pain 2012

### Implications for rehabilitation

Motor system function may be impacted by immune system response

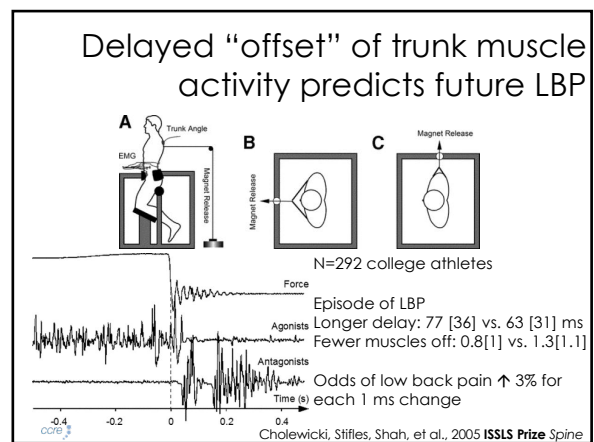
Motor learning strategies likely to be required to reshape brain motor networks

### Outline

Is back muscle dysfunction relevant for spinal health?

### Evidence for impact of muscle dysfunction on spine health

- Hypothesis** - Sub-optimal spine control will lead to;
  - Uncontrolled movement; "Instability"
  - Excessive loading
- Direct evidence** - limited & conflicting
  - FOR**
    - LBP recurrence linked to failure of recovery of multifidus Hides et al., 2001 Spine
    - Paraspinal muscle botox → Decreased disc height Han et al, 2016 SpineWeek
  - AGAINST**
    - Rat muscle injury – no change in IVD health at 3 months Maas et al, 2018
    - Facet denervation – positive clinical outcome Bogduk, 2008



### Evidence for efficacy of intervention

- Systematic/Cochrane review
  - Exercise interventions (motor control) that include restoration of back muscles are effective
  - Limited evidence that it is more effective than other treatments

*Saragiotto, et al 2017 Spine*
- Intervention applied generically – all patients treated, all treated in same manner

### Outline

Does back muscle dysfunction have implications for injury/pain & rehabilitation?

### Role of exercise

- Exercise might be the key to;
  - Prevent/restore muscle structure
  - Restore optimal muscle activation
  - Target novel inflammatory mechanisms
    - Right tissue
    - Right time
- But need to consider
  - Individual-specific patient presentation
  - Time-course → Mechanism

### Role of muscle dysfunction in pain

### Muscle dysfunction is one part of a complex puzzle

### Clinical questions

- Multifidi and transversus abdominis
  - Often coactivated
  - Not obligatory, can work independently
- Multifidi and the pelvic floor muscles
  - Coactivation present in some individuals
  - Need to assess

**Summary**

- Excessive & compromised** muscle activation  
→ negative effects on spine mechanics
- Changes have different **time courses/mechanisms**
- Rehabilitation of muscle** potentially modifiable & potentially relevant for recovery/transition to chronicity
- Individualisation is likely to be critical**

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