Stress Relaxation Response is Decreased in Porcine Thoracolumbar Fascia Following Surgical Injury

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Non-specific Low Back Pain (ns-LBP)

A Multifactorial Problem

Mechanistic
Pathoanatomic
Spinal Lesions
Imaging ≠ diagnosis

Kent & Keating, 2005

Behavioral/
Psychosocial
Kinesiophobia
→ Hypokinesia
Role of mechanics?

Leeuw et al., 2007

Altered Movement Strategies
Maladaptive Movement
Causal or adaptive?

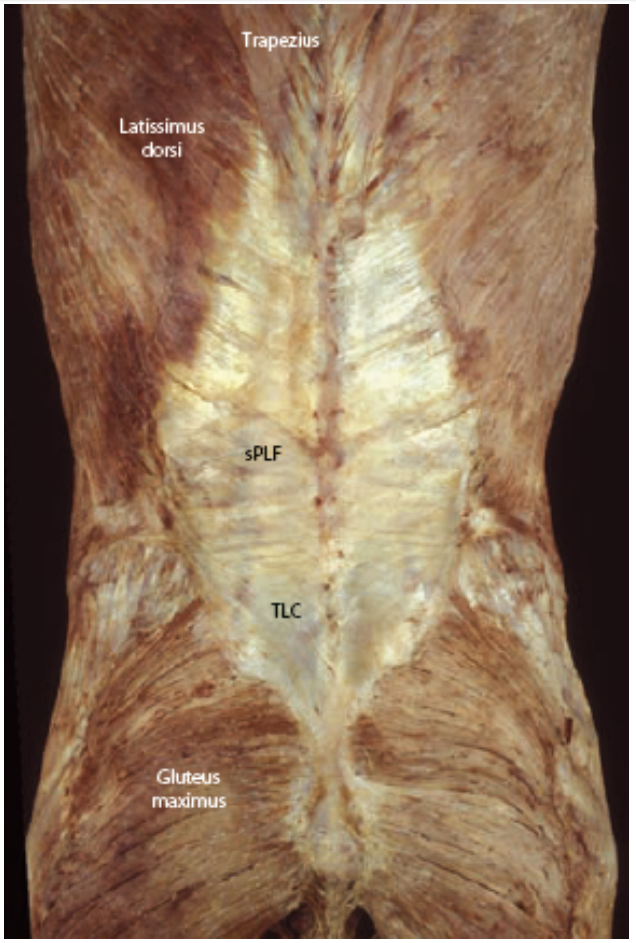
Hodges & Smeets, 2016
Nelson-Wong et al., 2010, 2013

Pathophysiological Model
Connective Tissue (perimuscular fascia)
Inflammatory Processes
In addition to above factors

Langevin & Sherman, 2007

Thoracolumbar Fascia (TLF)

- Function of the TLF
  - Sustains/**distributes loads**
  - Stabilizes spinal structures
  - Attachment point for muscles
  - Senses body position and ***pain***
- Decreased TLF shear plane mobility in people with ns-LBP
  - *Langevin et al., 2011*
- Replicated in porcine model with surgical injury to TLF
  - *Bishop et al., 2016*



Willard et al., *J Anat* (2012) 221, 507-536

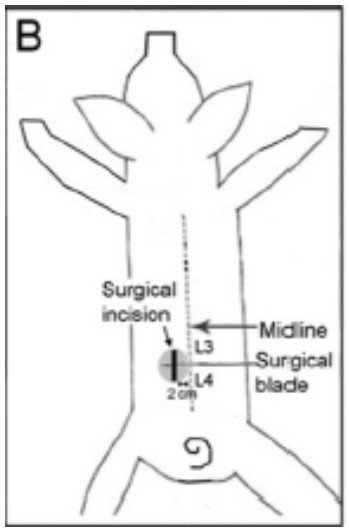
Purpose and Hypothesis

- Investigate the influence of a simulated muscle 'sprain' injury on the stress relaxation response of the TLF using a porcine model
  - Expected samples from injured pigs to have decreased stress relaxation response (lower stress decay) than those from healthy pigs.

Strain Energy and Hysteresis
Glinka et al., Poster #T49, Thursday

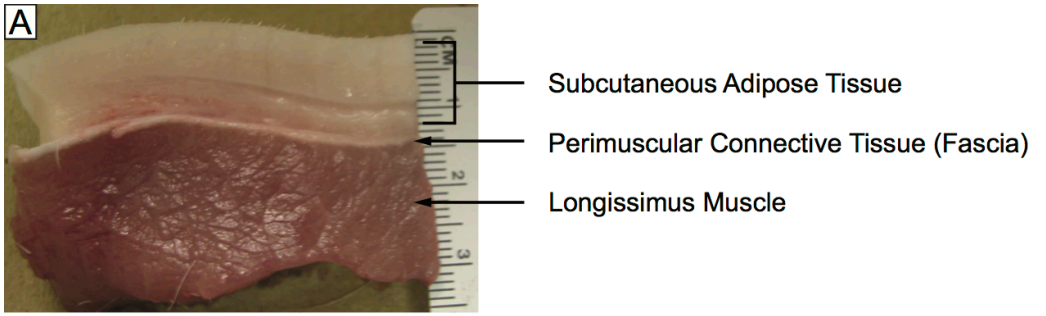
Stiffness
Nelson-Wong et al., ASB, poster

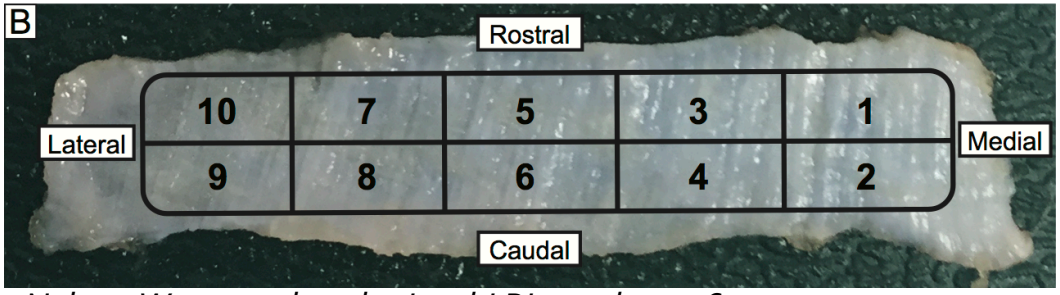
Methods



Bishop et al., 2016

- 10 domestic swine → Injured (n=5) and Control (n=5)
- Unilateral surgical injury (4 cm^2 at the L3/4 level) → usual activity
- Euthanized at 8 weeks, tissue blocks excised ***contralateral*** to injury
- Frozen at -80° C, shipped to Waterloo for mechanical testing

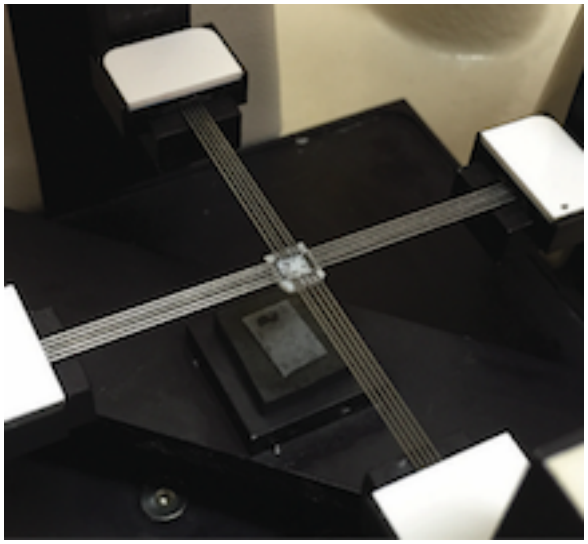


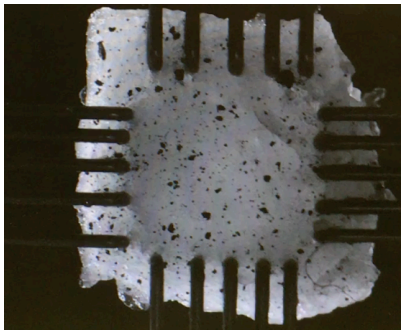


Nelson-Wong et al., submitted J Biomech, 2016

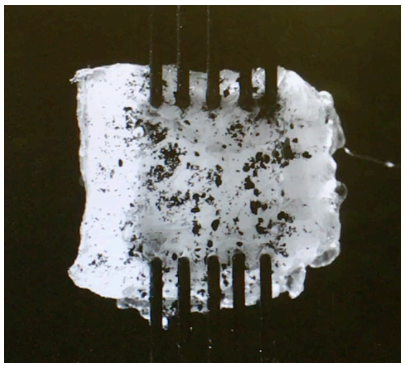
Biaxial Mechanical Testing System Cellscale Biotester 5000

- Displacement controlled
  - % initial rake width
- Measure force
  - transverse, longitudinal
- Rake displacement
  - 'stretch ratio' = amount of displacement relative to initial





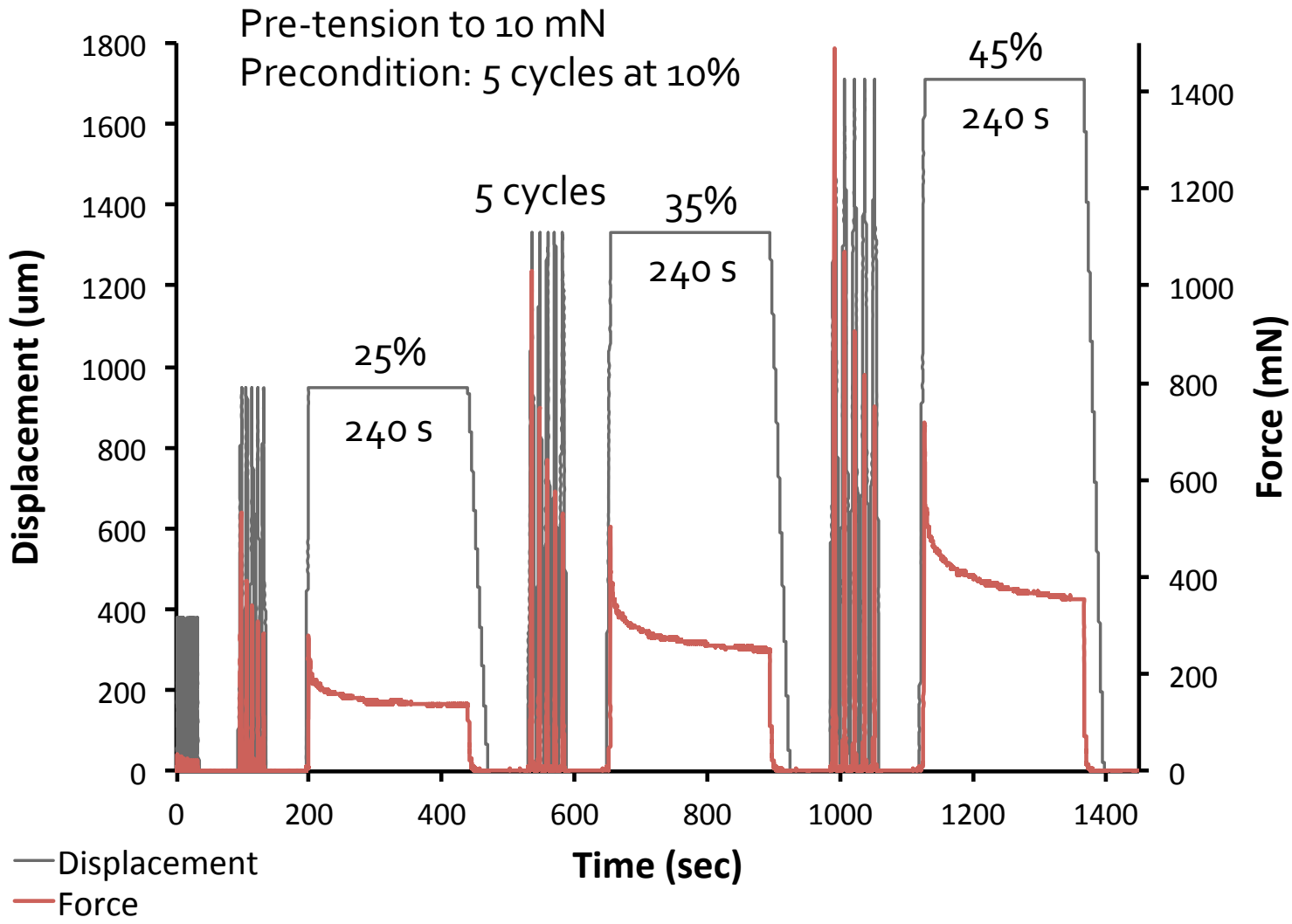
Biaxial configuration



Uniaxial longitudinal configuration

- Three Loading Conditions
  - Uniaxial Longitudinal
  - Uniaxial Transverse
  - Biaxial – analyzed independently as Biaxial Longitudinal, Biaxial Transverse

Test Protocol: 6%/s stretch rate



Analysis

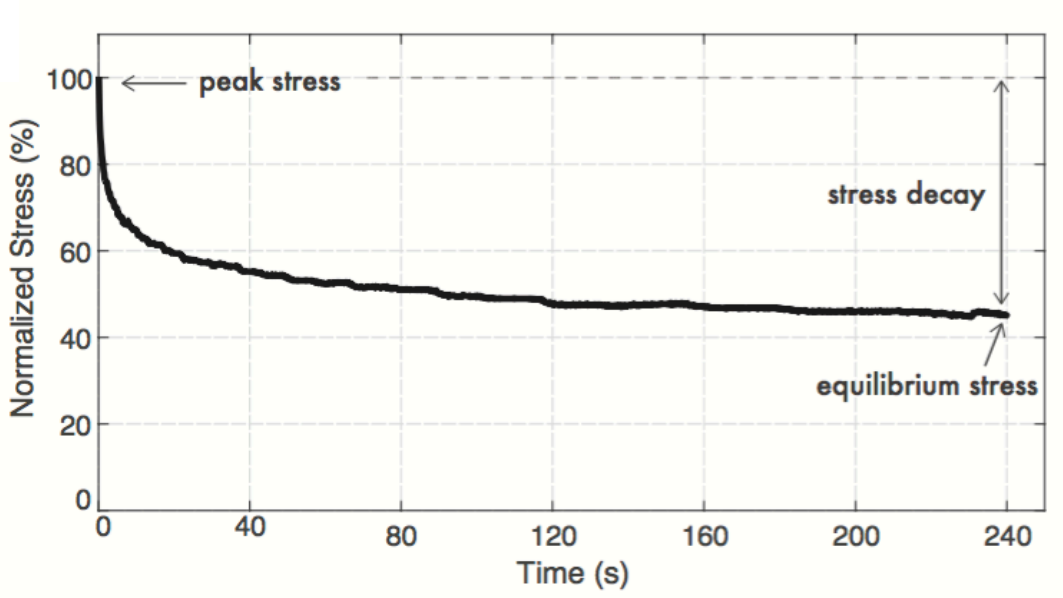
- Stress calculated from measured force and initial sample dimensions:

$$Stress = \frac{TensileForce}{InitialCrossSectionalArea}$$

- Normalized to peak, time-varying plots created for each condition

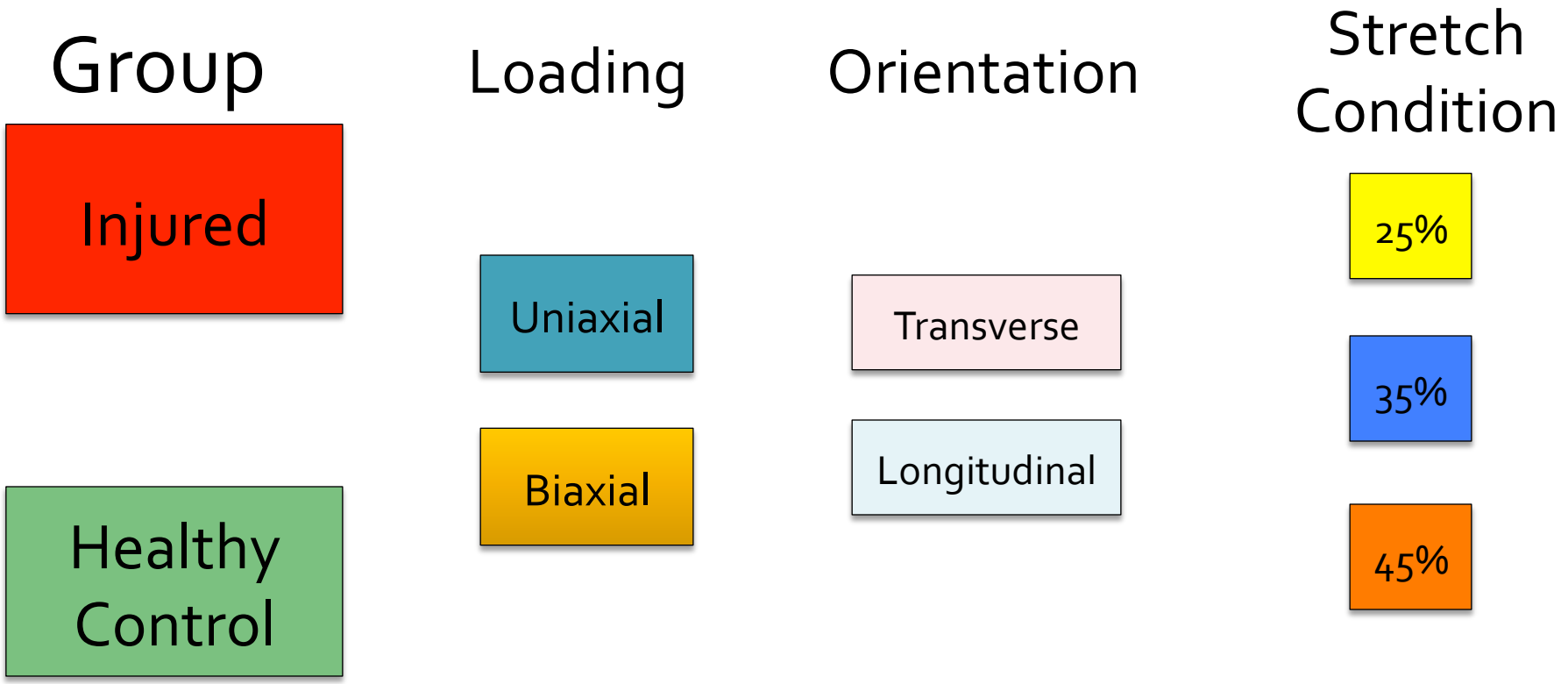
- Stress Relaxation Response expressed as stress decay:

$$SRR = 100\% - \frac{EquilibriumStress}{PeakStress}$$



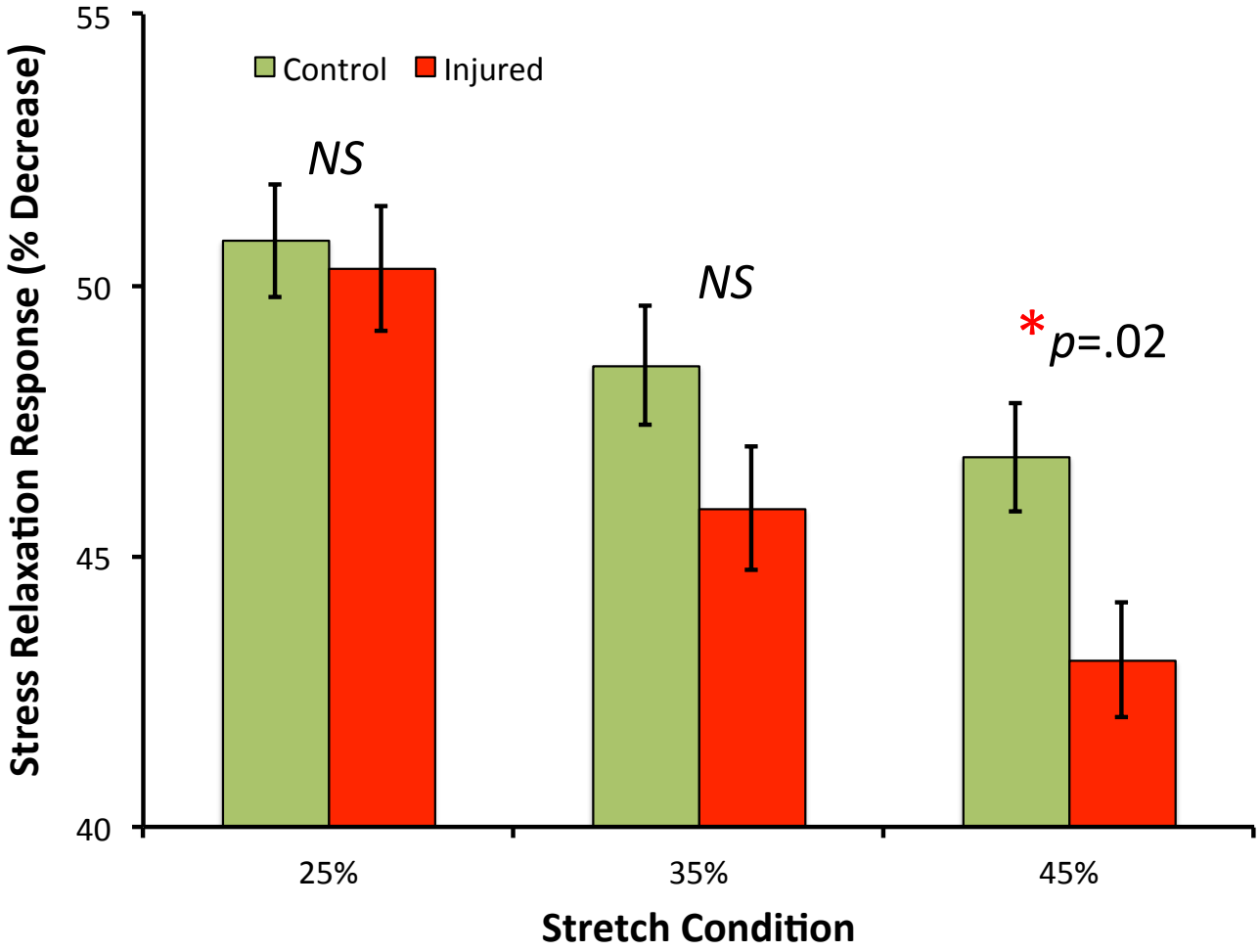
Nelson-Wong et al., submitted J Biomech, 2016

Statistical Analysis – 4-way ANOVA



Interested in main effect of injury group and/or significant interactions with injury group

Results – Group x Stretch Interaction



Discussion

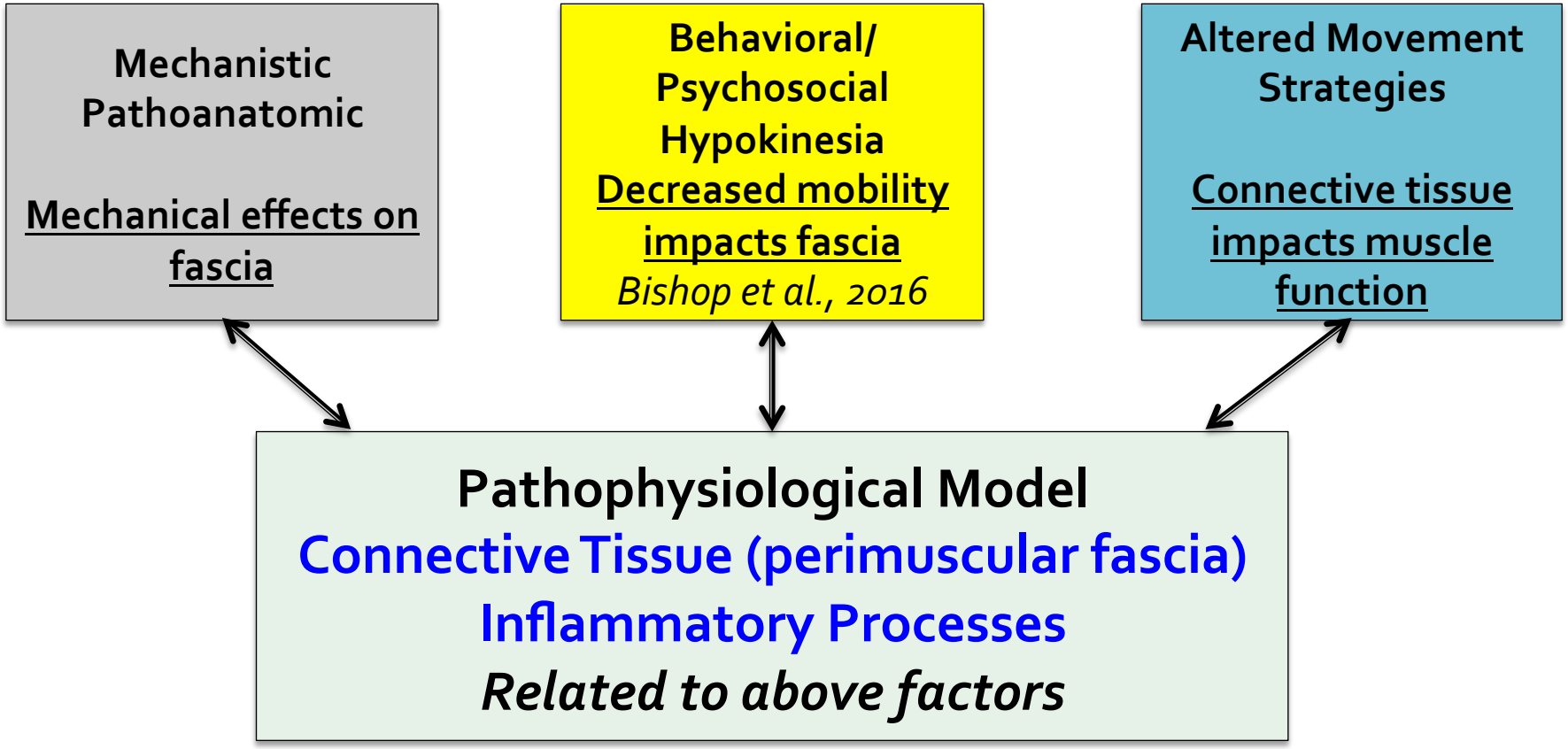
- Simulated muscle 'sprain' with surgical injury
  - Inflammation without structural damage
  - Low back mechanics unchanged (theoretically)
  - Tested tissue contralateral to injury site
- Stress relaxation
  - Time-dependent, viscoelastic response in biological tissues
  - Allows deformed tissues to return to relaxed stress state
  - Potentially minimizes total stress in the tissue

Relevance

- Decreased relaxation with injury at 45% stretch
  - 45% stretch ratio may be near end-range limits of physiological flexion
  - Could disrupt load sharing between passive connective tissues, impact muscle activation (flexion relaxation?)
  - Potential mechanism for LBP recurrence/chronicity following muscle injury (inflammation)?

Perimuscular fascia link to ns-LBP?

Biochemical studies required to isolate potential mechanisms



Langevin & Sherman, 2007

Acknowledgments

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