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

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

Langevin & Sherman, 2007
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

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

• 10 domestic swine → Injured (n=5) and Control (n=5)
• Unilateral surgical injury (4 cm² 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

*Bishop et al., 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

- Three Loading Conditions
  - Uniaxial Longitudinal
  - Uniaxial Transverse
  - Biaxial – analyzed independently as Biaxial Longitudinal, Biaxial Transverse
Test Protocol: 6%/s stretch rate

- Pre-tension to 10 mN
- Precondition: 5 cycles at 10%

Displacement (um)

Time (sec)

Displacement

Force

Displacement

Force

25%

240 S

35%

240 S

45%

240 S

5 cycles
Analysis

- Stress calculated from measured force and initial sample dimensions:
  \[ \text{Stress} = \frac{Tensile\ Force}{Initial\ CrossSectional\ Area} \]

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

- Stress Relaxation Response expressed as stress decay:
  \[ SRR = 100\% - \frac{Equilibrium\ Stress}{Peak\ Stress} \]

Nelson-Wong et al., submitted J Biomech, 2016
Interested in main effect of injury group and/or significant interactions with injury group
Results – Group x Stretch Interaction

<table>
<thead>
<tr>
<th>Stress Relaxation Response (% Decrease)</th>
<th>25%</th>
<th>35%</th>
<th>45%</th>
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</thead>
<tbody>
<tr>
<td>Control</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>Injured</td>
<td></td>
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<td>*p=.02</td>
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Stretch Condition

- 25%
- 35%
- 45%
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
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)?
Perimuscualr fascia link to ns-LBP?

Biochemical studies required to isolate potential mechanisms

Mechanistic Pathoanatomic
Mechanical effects on fascia

Behavioral/ Psychosocial Hypokinesia
Decreased mobility impacts fascia
Bishop et al., 2016

Altered Movement Strategies
Connective tissue impacts muscle function

Pathophysiological Model
Connective Tissue (perimuscualr fascia)
Inflammatory Processes
Related to above factors

Langevin & Sherman, 2007
Thank you!

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