Connective Tissue, Stretching, Inflammation and Musculoskeletal Pain

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Disconnected physiological systems
Cross system integration

- Immune system
- Urinary system
- Respiratory system
- Digestive system
- Reproductive system
- Integumentary system
- Skeletal system
- Muscular system
- Nervous system
- Circulatory system
- Endocrine system
Cross system integration

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- Digestive system
- Immune system
- Endocrine system
- Circulatory system
- Nervous system
- Muscular system
Musculoskeletal system
Immune system
Can body movements influence immune processes such as inflammation?
Normal wound healing vs. persistent inflammation and fibrosis

- Acute inflammation
- Resolution
- Failed resolution
- Chronic inflammation
- Fibrosis
Normal wound healing vs. persistent inflammation and fibrosis

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Subcutaneous carrageenan injection model
Normal wound healing vs. persistent inflammation and fibrosis

Acute inflammation

Resolution vs. failed resolution

Chronic inflammation and fibrosis

Subcutaneous carrageenan injection model

Stretch

Sham
Daily stretching for 10 minutes reduces chronic inflammation of connective tissue

2 weeks after carrageenan injection

* p<0.05
** p<0.01
N=24 rats

Effect of active and passive stretching 2 weeks after carrageenan injection

* p<0.05
** p<0.01
Inflammation and resolution pathways

- Dietary Ω-3 fatty acids EPA, DHA
- Neutrophils
- Pro-resolving mediators
- Resolution
Persistent inflammation and failed resolution

Dietary Ω-3 fatty acids EPA, DHA

Failed resolution
Chronic inflammation
Fibrosis
Effect of stretching on acute inflammation

48 hours after carrageenan injection

*B*  *p<0.05*

**  *p<0.01*

***  *p<0.001*

Effect of stretching on pro-resolving and pro-inflammatory mediators within the inflammatory lesion

Effect of stretching on neutrophil migration and resolvin production ex vivo

** p<0.01

Biomechanical consequences of connective tissue injury

Normal

Post-injury
Ultrasound evaluation of thoracolumbar fascia in chronic low back pain

- 107 human subjects
- 60 chronic LBP
- 47 No-LBP
- LBP >12 mo
- Matched for age, sex, BMI
Ultrasound evaluation of thoracolumbar fascia in chronic low back pain

N=107 subjects  *P<0.01  **P<0.001
Connective tissue layers within thoracolumbar fascia
Shear plane motion of connective tissue layers within thoracolumbar fascia

No Low Back Pain

Low Back Pain
Thoracolumbar fascia shear strain in subjects with and without low back pain

N=116
p<.001
Effect of stretching on connective tissue thickness in scleroderma GVHD model

* $p < .001$

# $p < .01$

Xiong Frontiers Immunol 2017
Effect of stretching on connective tissue mobility in scleroderma GvDH model

No stretch

Stretch

#p<.01

Xiong Frontiers Immunol 2017
What are the effects of NOT stretching?
20 pigs randomized for 8 weeks to:

- Control
- Connective tissue injury
- Movement restriction
- Injury plus movement restriction
Ultrasound measurement methods
Pig growth

![Graph showing pig growth over weeks](image_url)
Gait analysis

ANOVA effect of hobble $p = .03$
Ultrasound tissue thickness measurements

ANOVA effect of injury $p = .007$
Thoracolumbar shear strain measurements

ANOVA main effects of injury $p = .027$ and hobble $p = .021$
Model linking connective tissue, inflammation, fibrosis and musculoskeletal pain

- Acute inflammation
- Resolution
- Failed resolution
- Chronic inflammation
- Fibrosis
- Reduced tissue mobility
- Fear of movement
- Pain
How would stretching impact this model?

- Acute inflammation
- Decreased fear of movement
- Inflammation resolution
- Improved tissue mobility

PAIN
Effect of stretching on gait velocity in pigs 4 weeks after removing hobbles

ANOVA p<.05
Effect of stretching on thoracolumbar fascia mobility in pigs 4 weeks after removing hobbles

ANOVA p<.05
Why did stretching work in rats but not in pigs?
Why did stretching work in rats but not in pigs?
Integrative medicine: making new connections
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