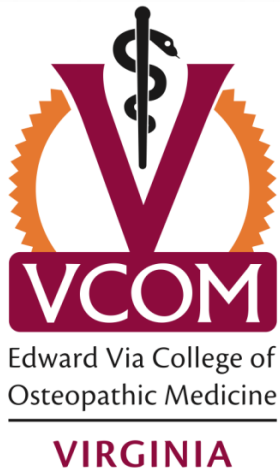


Multimodal Ultrasound Imaging and Radiomics Reveal Structural and Functional Changes to the Thoracolumbar Fascia in Individuals with Low Back Pain

MAJ Georgina Flynn-Smith, PhD, MBEE



Disclosure

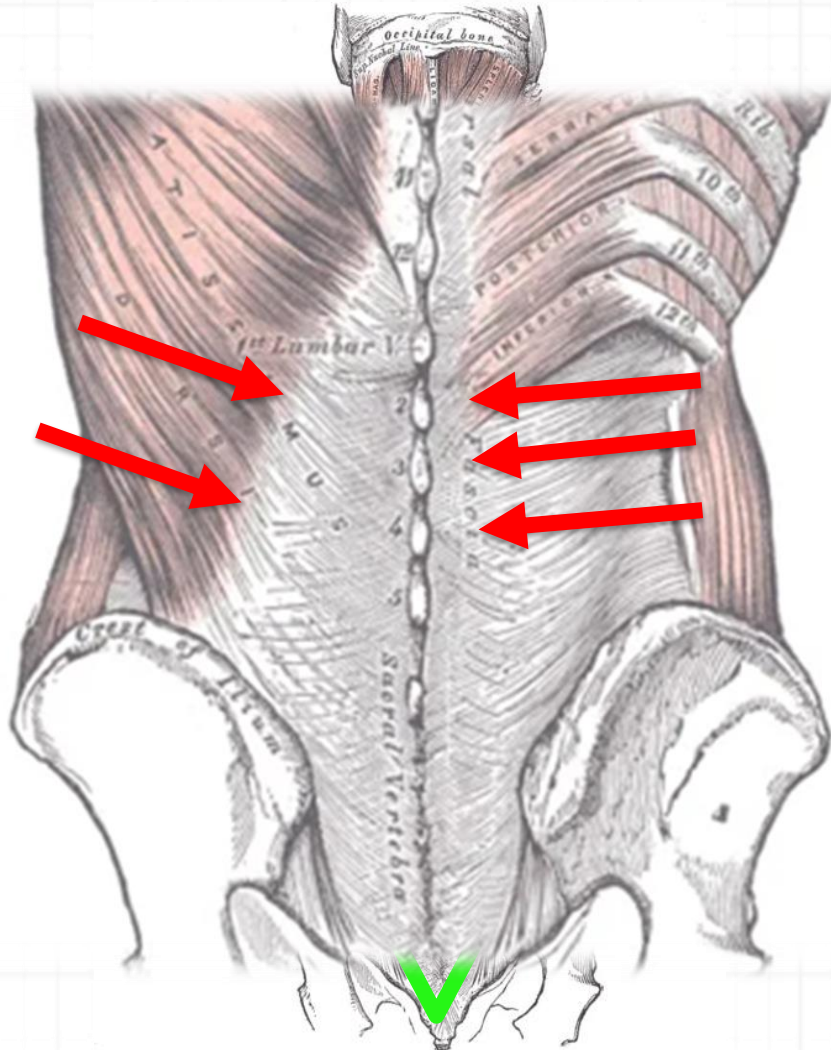
The views and information presented are those of the authors and do not represent the official position of the U.S. Army Public Health Command, West, the U.S. Army Medical Readiness Command, West, the U.S. Army Medical Command, or the Department of Army, Department of Defense, or U.S. Government.

Low Back Pain: A Multifactorial Condition



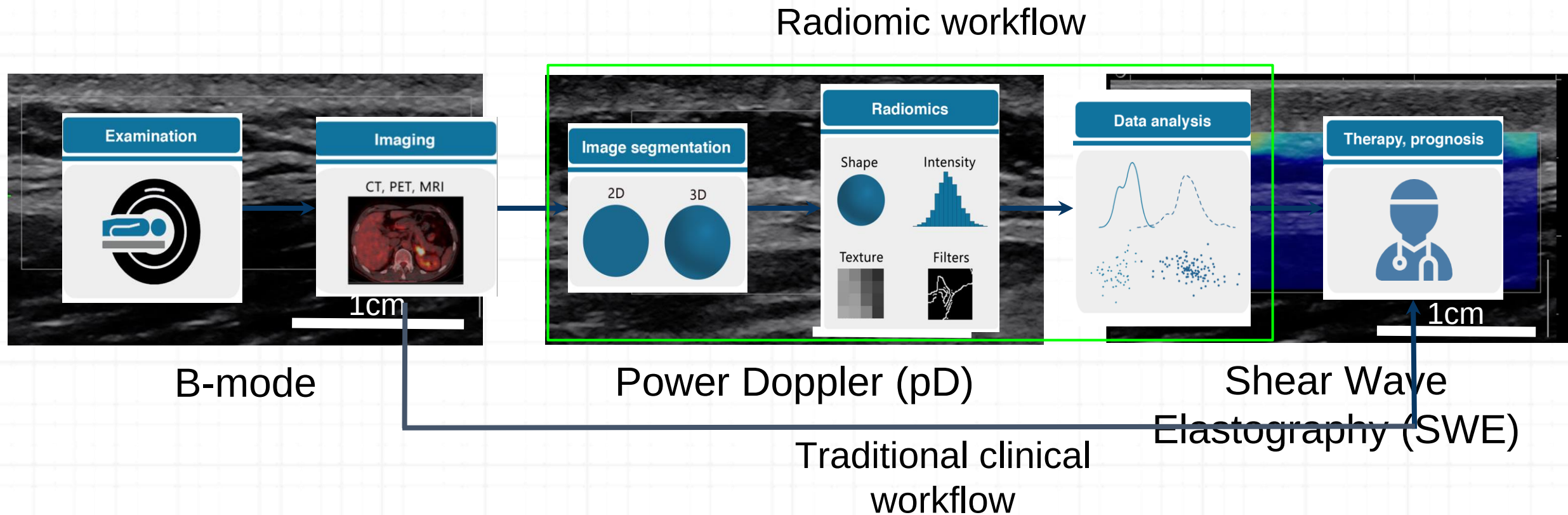
Created in **BioRender.com** **bio**

Thoracolumbar Fascia (TLF)



- Load transfer & stabilization
(Willard, 2012)
- Highly innervated & pain-sensitive
(Schilder et al., 2014 & 2016; Mense, 2019; Casato et al., 2019)
- Low back pain
(Langevin et al., 2009 & 2011; Schilder et al., 2014; Pirri et al., 2023)

Ultrasound & Radiomics



Adapted from van Timmeren, et al., 2020

Objective

Use **multi-modal ultrasound** imaging and **radiomics** to evaluate the TLF at 6 key transition zones in individuals with and without **low back pain (LBP)**

Aim 1: Targeted (hypothesis-driven)

Do TLF **thickness, stiffness, and vascularity** differ with **pain status**?

Aim 2: Exploratory (hypothesis-generating)

What else can ultrasound imaging reveal about the TLF & LBP?

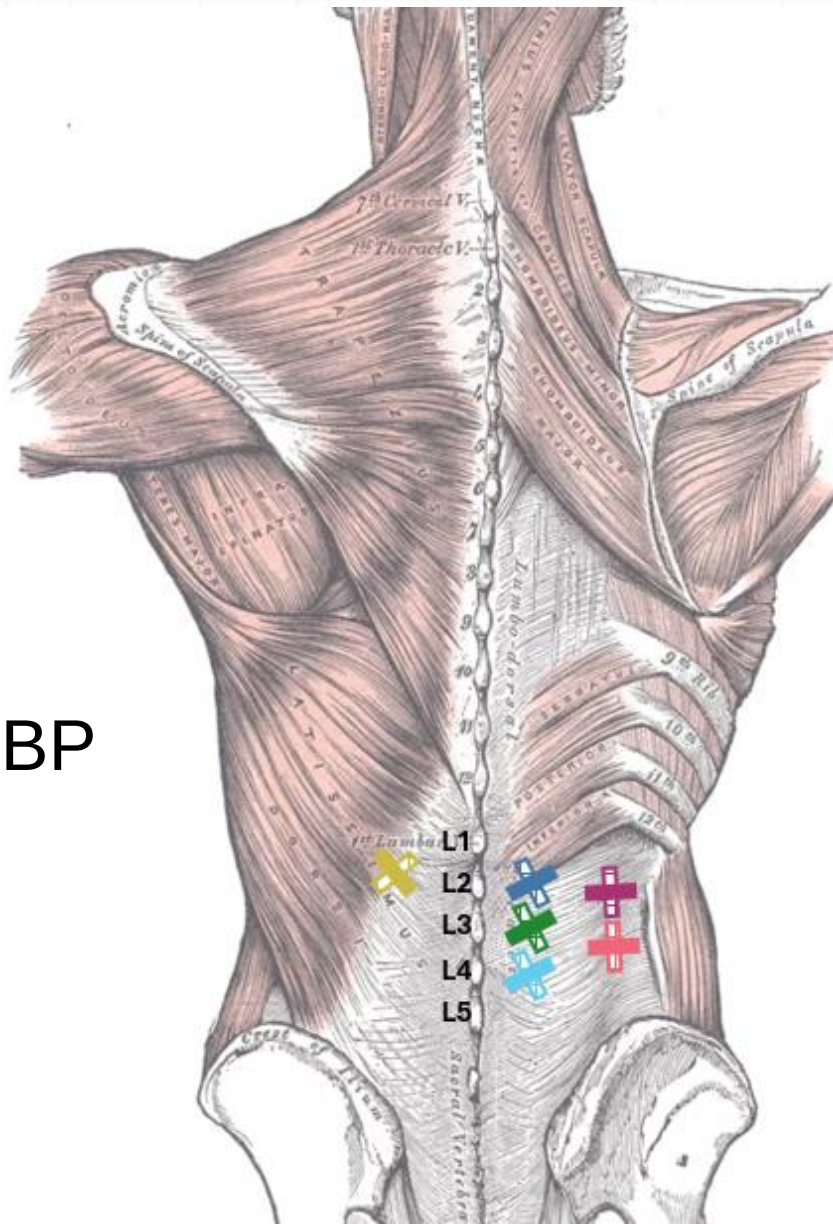
Image Dataset

58 participants

- 33 male, 25 female
- Age 22-86
- 14 w/LBP, 44 w/o LBP

B-Mode, SWE & PD

2,767 images total



Legend

Lat. dorsi muscle-tendon junction (MTJ)

L2 transverse process (TP)

L3 TP

L4 TP

Superior lateral transition zone (LTZ)

Inferior LTZ

Solid fill = longitudinal view

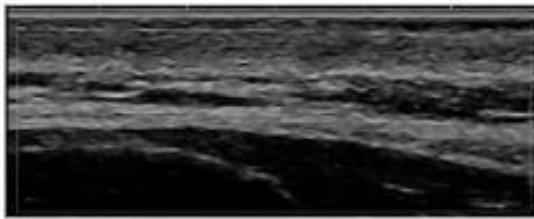
Hatched fill = transverse view

Imaging study: Roldan et al., Fascia Research Society Congress 2022

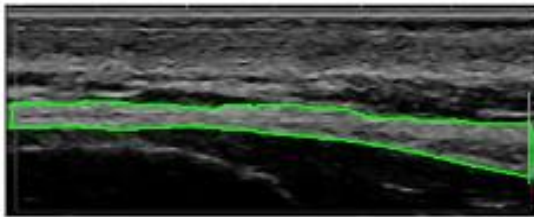
TLF Thickness

Feature: Segmentation Height

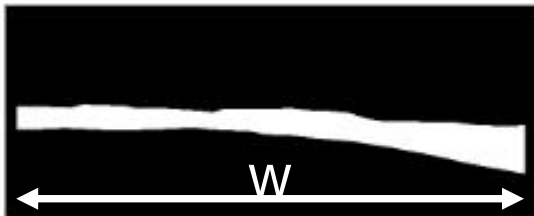
Raw image



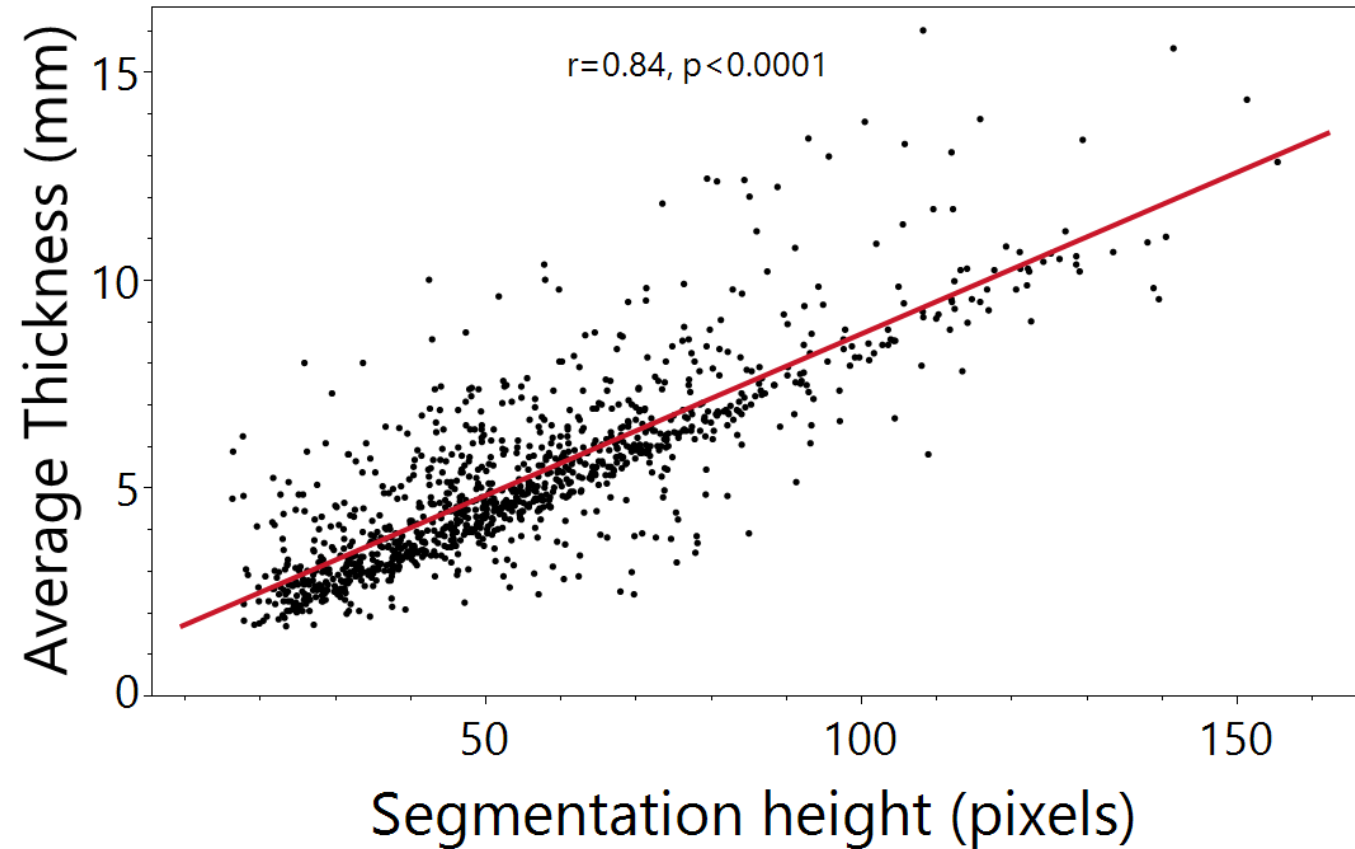
Tissue border



Segmentation mask



$$h = \frac{A}{w}$$

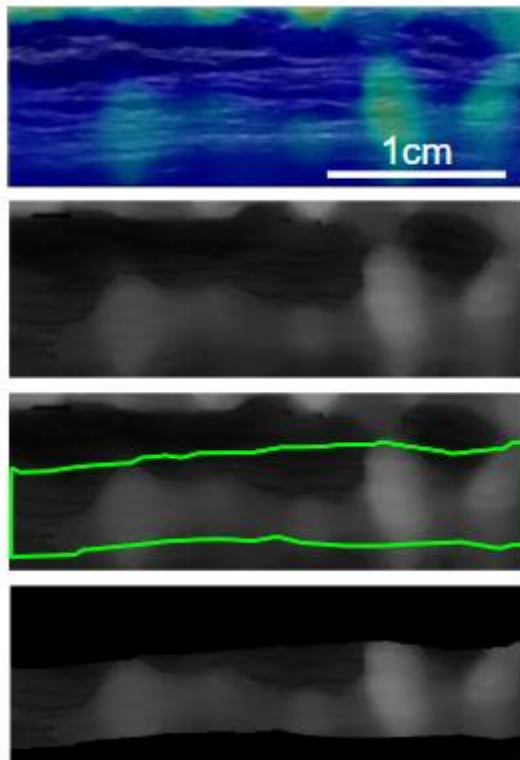


- Linear Mixed-Effects Model
- Pain status
- Covariates:
 - Age
 - Sex
 - BMI
 - Side
 - TLF region (6)
 - Probe orientation

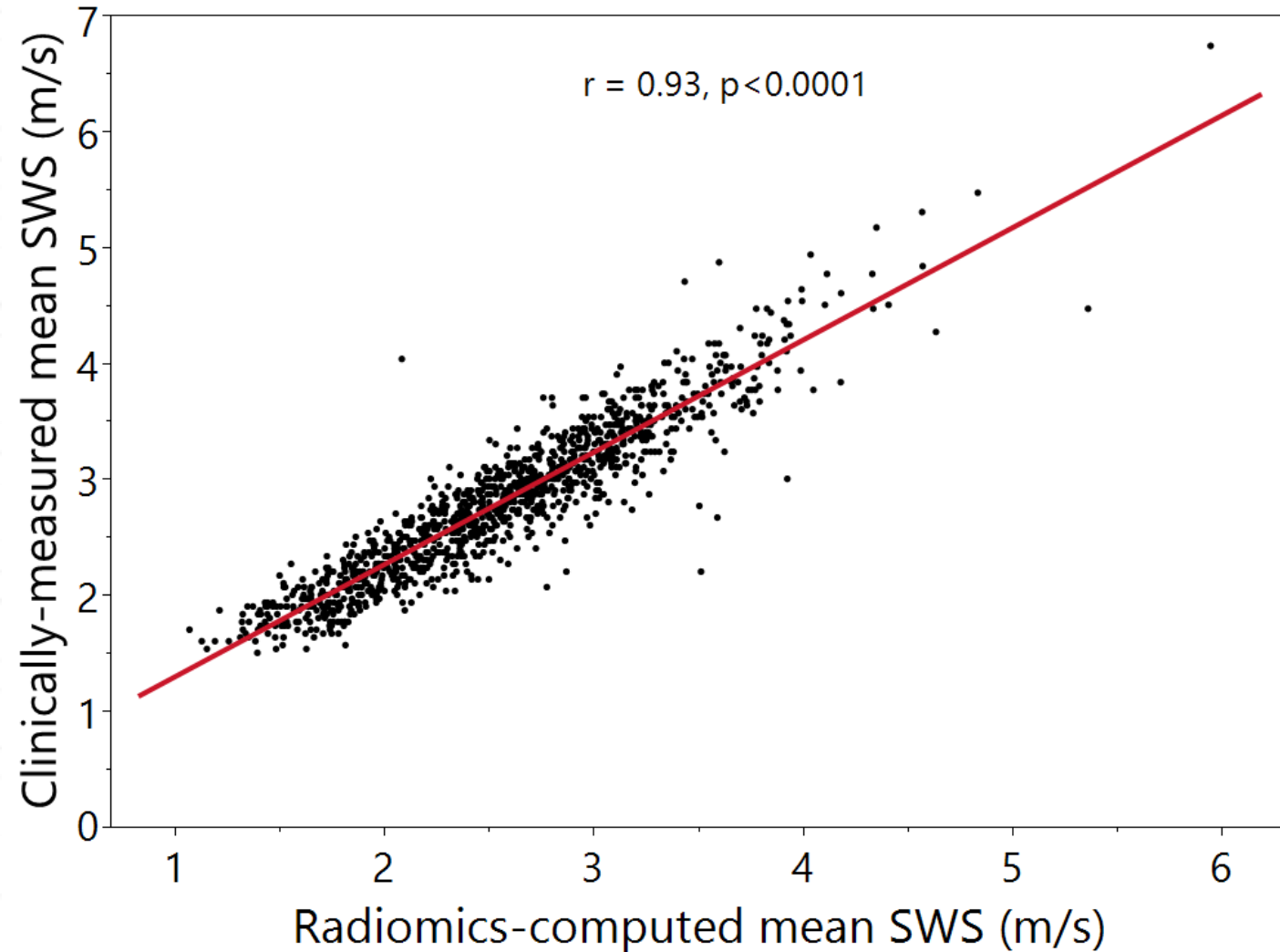


TLF Stiffness

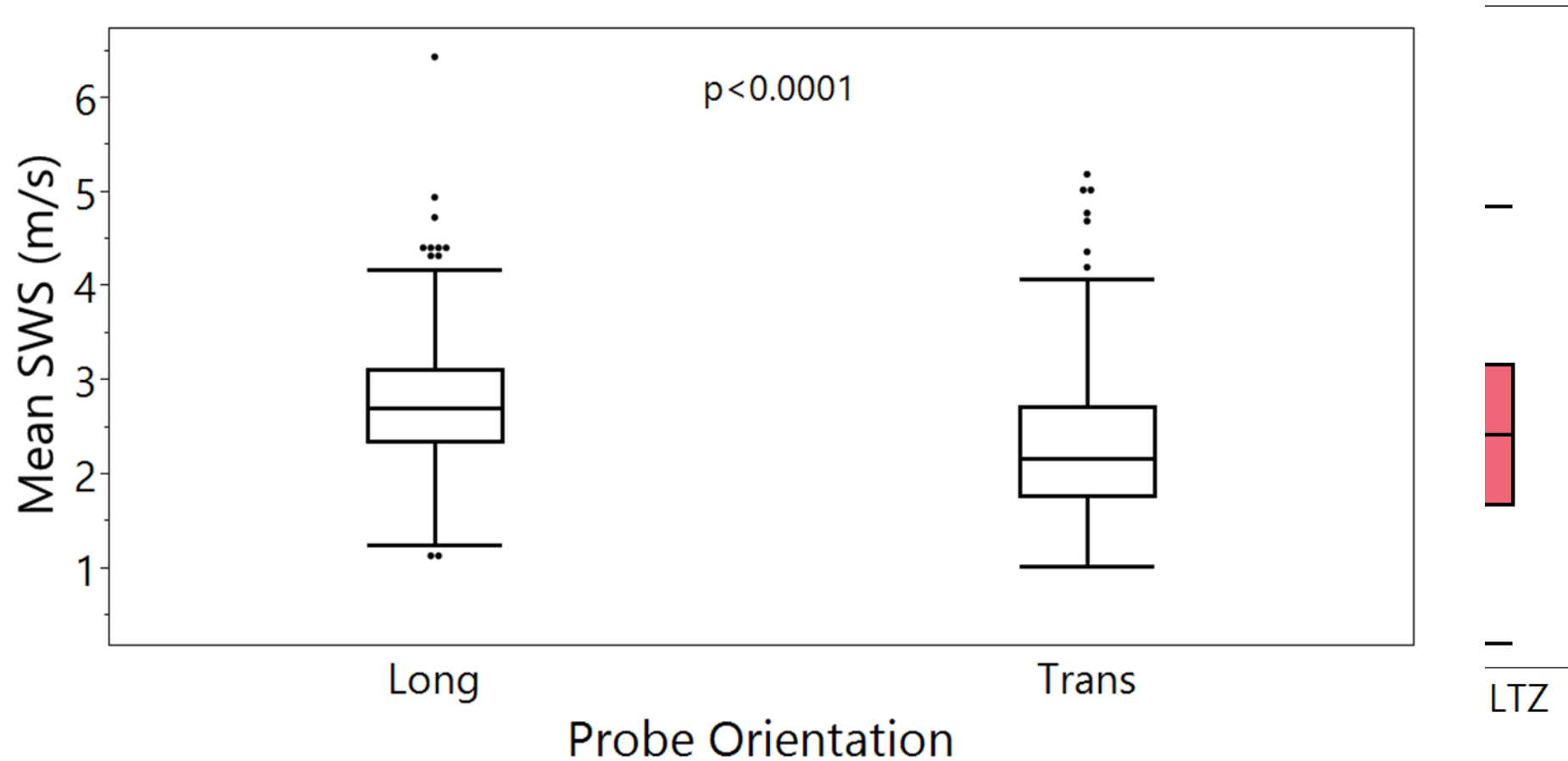
Feature: Mean shear wave speed



→ Mean shear wave speed

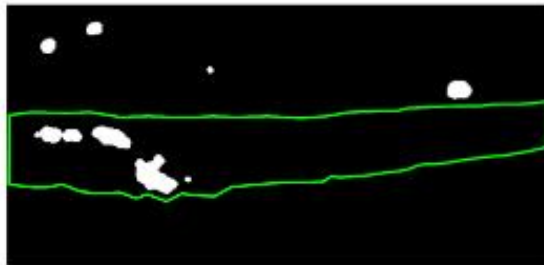
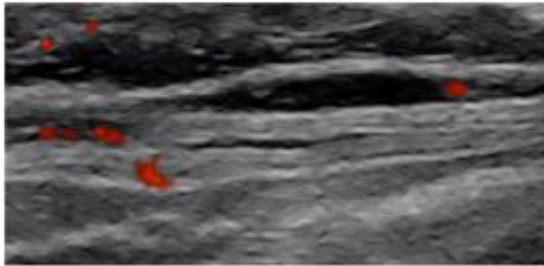


TLF stiffness varies by TLF region and probe orientation but not pain status



TLF Neovascularity

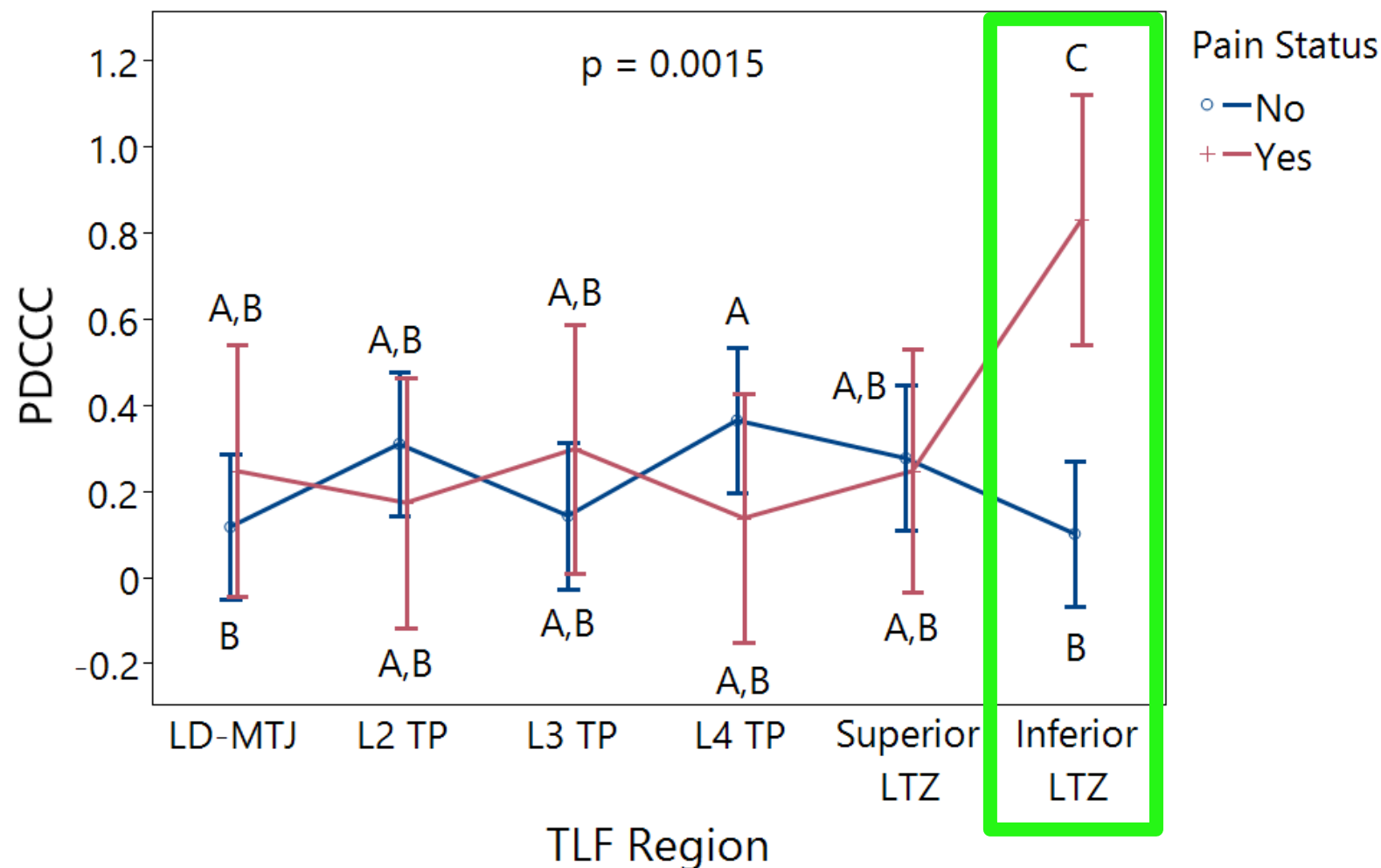
Feature: Power Doppler Connected Component Count (PDCCC)



Modified Ohberg Scale, Adapted for TLF	
Grade 0	No vessels
Grade 1	1 or more vessels anterior or posterior to fascia
Grade 2	1 or 2 vessels throughout fascia
Grade 3	3 vessels throughout fascia
Grade 4	4 or more vessels throughout fascia

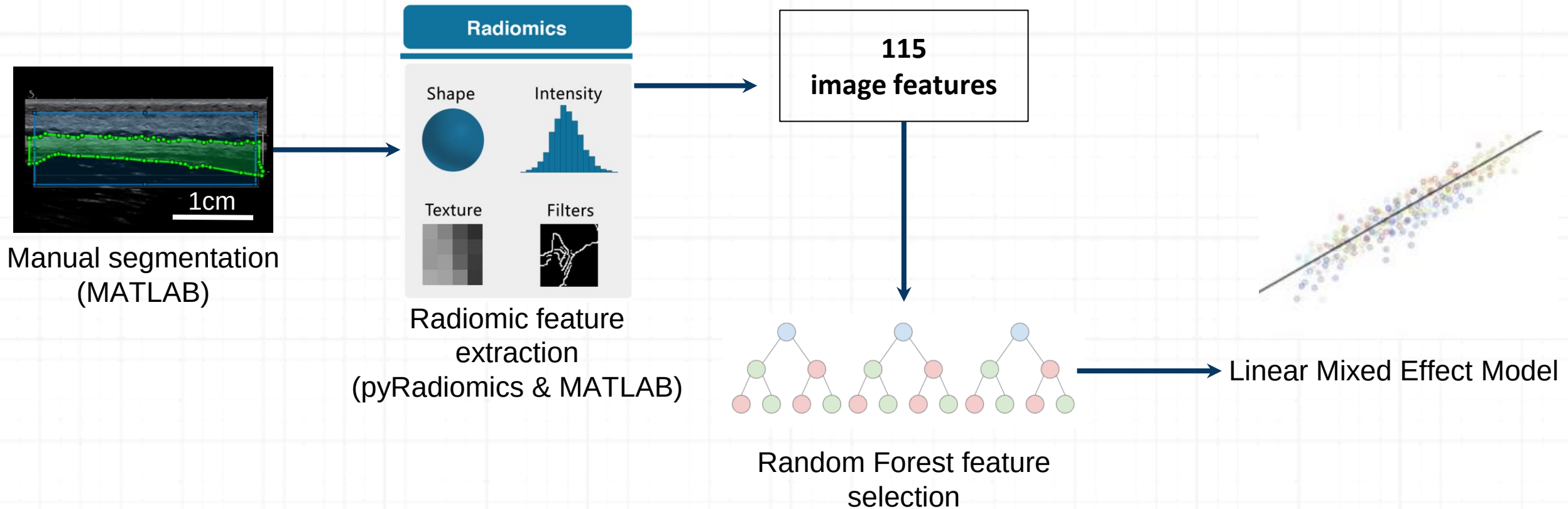
87.89% accuracy

TLF vascularity elevated at inferior LTZ in individuals with LBP

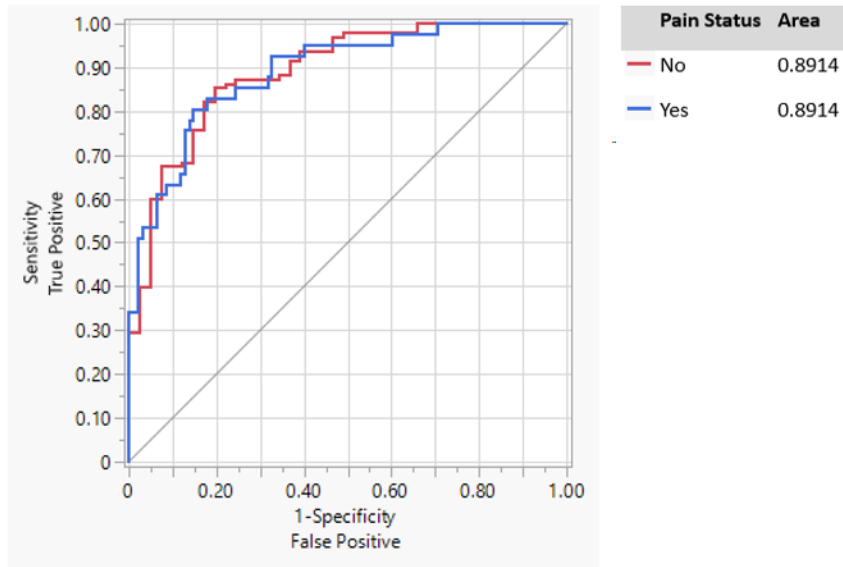


Exploratory Aim

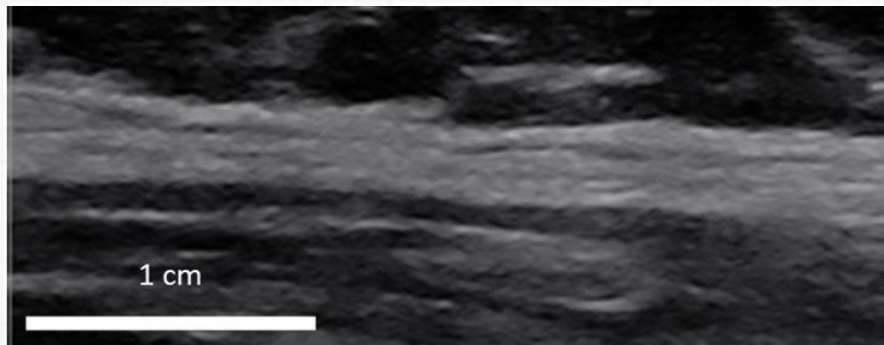
What else can ultrasound imaging reveal about the TLF & low back pain?



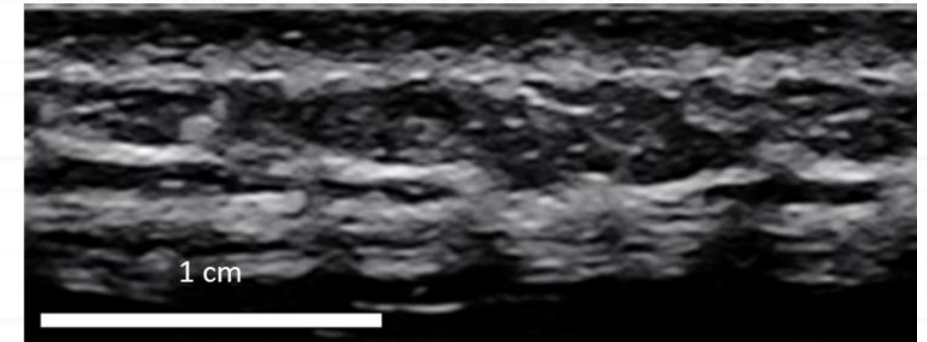
Exploratory Radiomics Results



- ▲ Contrast at L4 TP ($p < 0.0001$)
- ▲ Complexity at L3 & L4 TP ($p < 0.0005$)
- ▼ Run variance at L3 & L4 TP ($p = 0.0013$)
- ▼ Inverse Difference Normalized (homogeneity) at L4 ($p = 0.0005$)



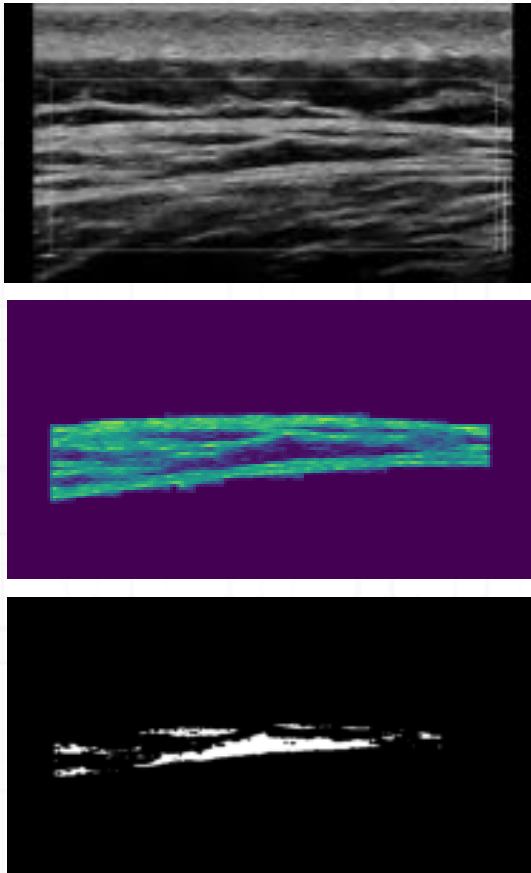
No LBP



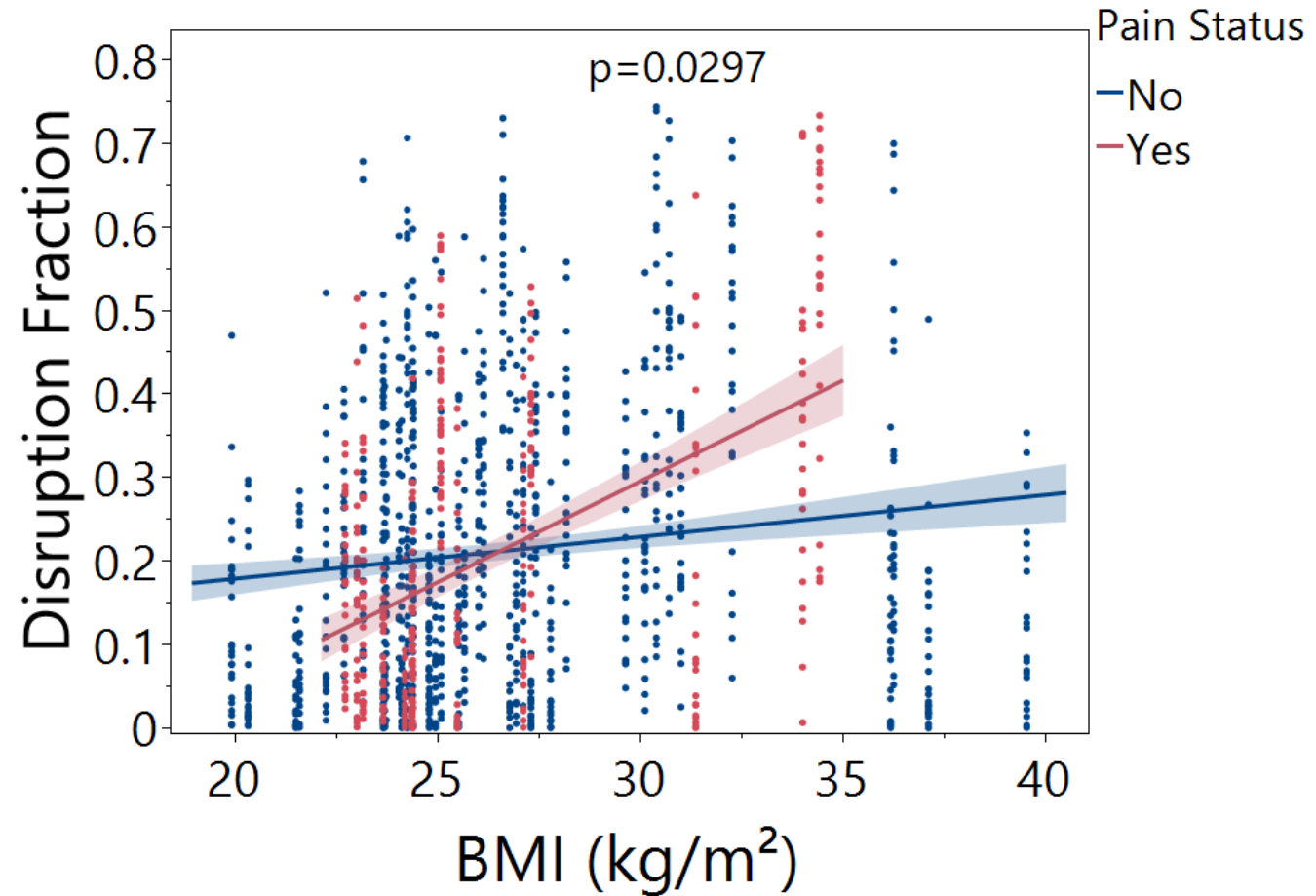
LBP

Is TLF disruption a hallmark of LBP?

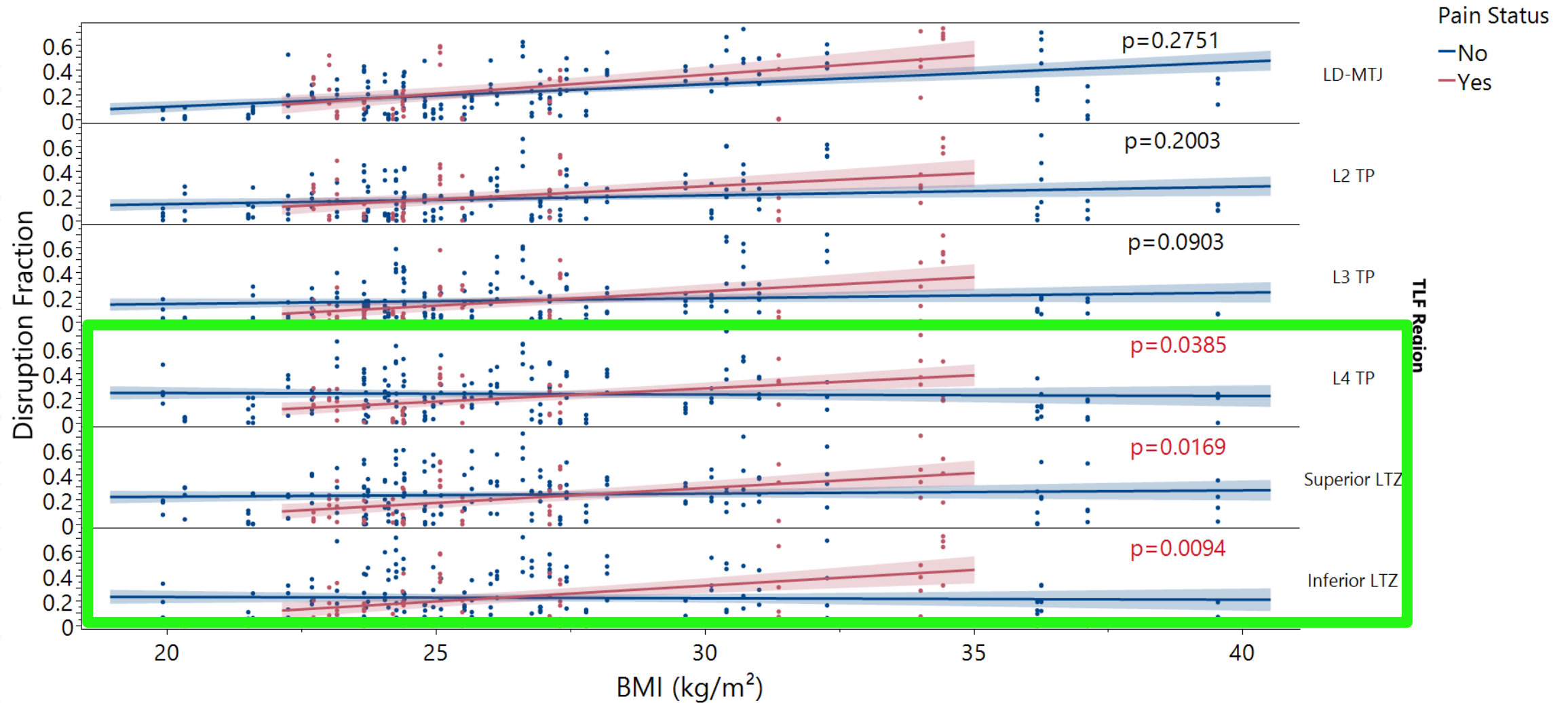
Feature: Disruption Fraction



$$DF = \frac{\text{Disruption Area}}{\text{Total Area}}$$



TLF Disruption by Region



Key Findings

- ↑ TLF thickness & vascularity, not stiffness
 - inflammation, not fibrosis
- ↑ TLF disorganization/nonuniformity
- Interaction between pain & BMI
 - fatty infiltration?
- Transition zones are crucial
 - L3 TP, L4 TP, *lat. dorsi* MTJ & LTZ
- 4 potential image-based biomarkers of LBP
 - Contrast, complexity, run variance, IDN

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UNCLASSIFIED

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