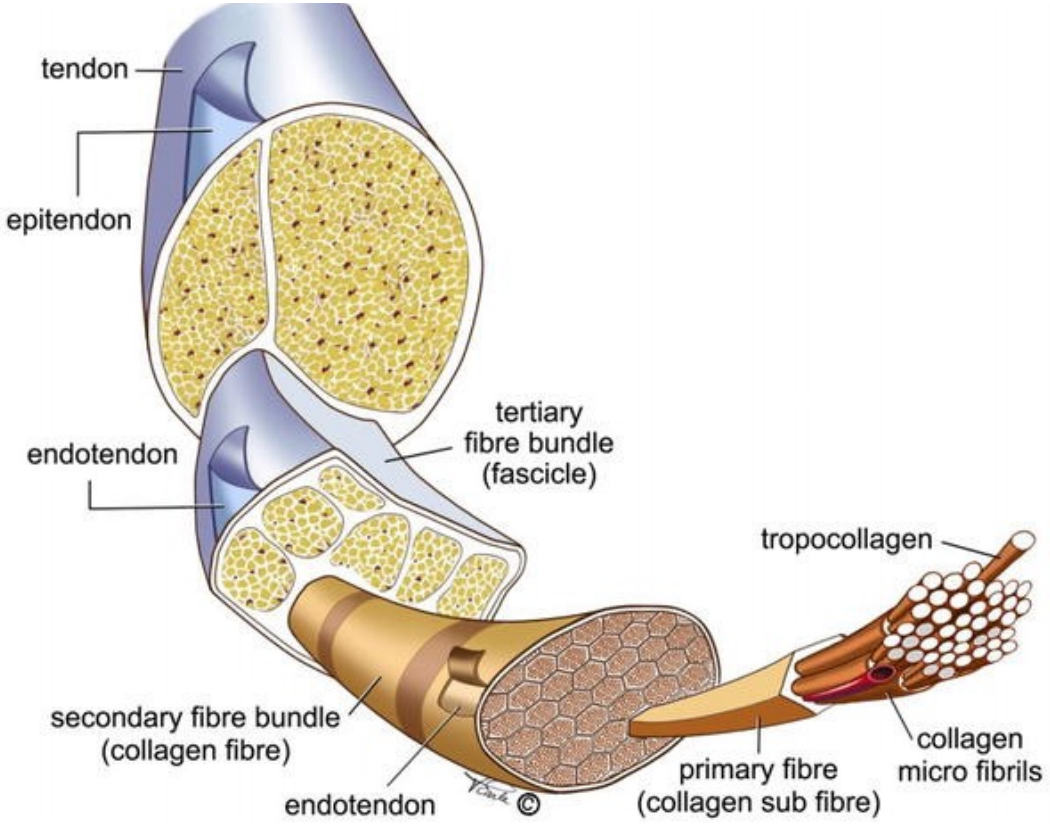
All About Tendon

Pain Control to Performance Boost

Dr. Junggi Hong

Structures of Tendon

- Regular Collagen Fibers
- Minimal Vascularity
- Spindle Shaped Tenocytes



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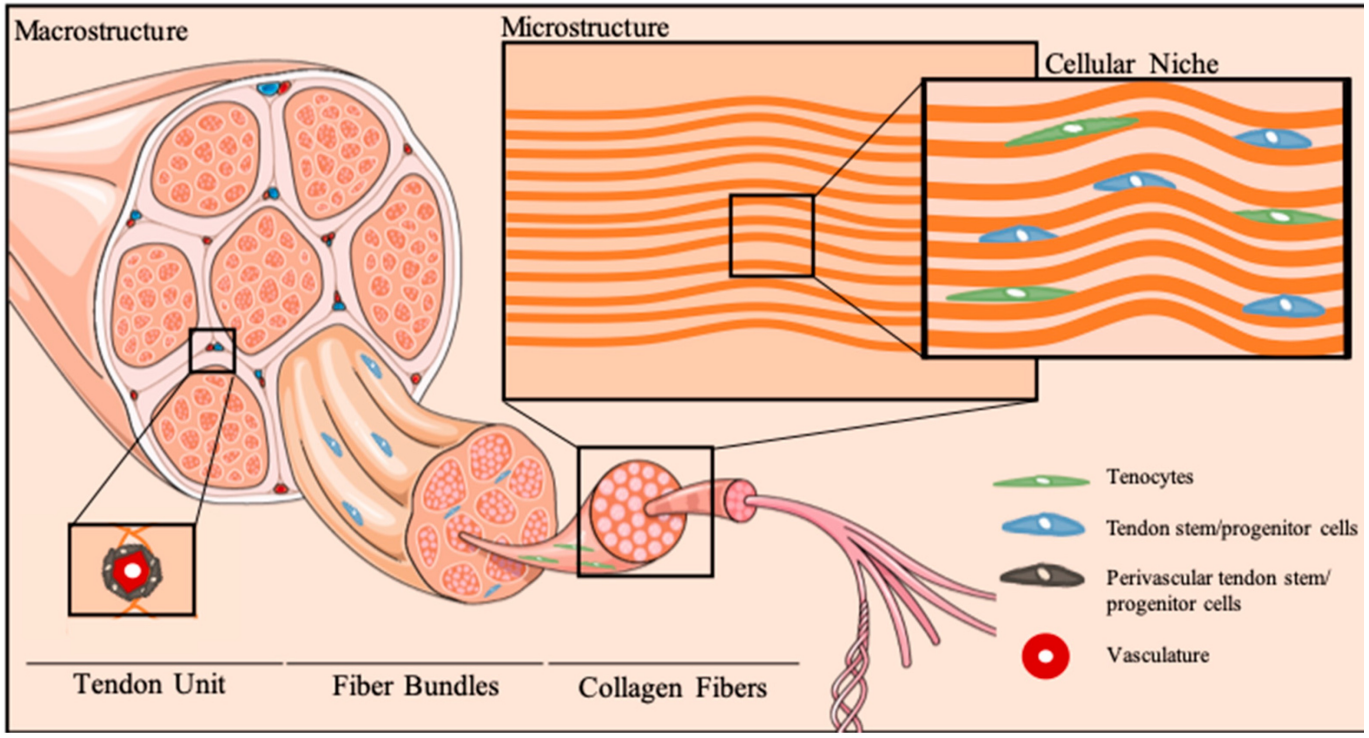
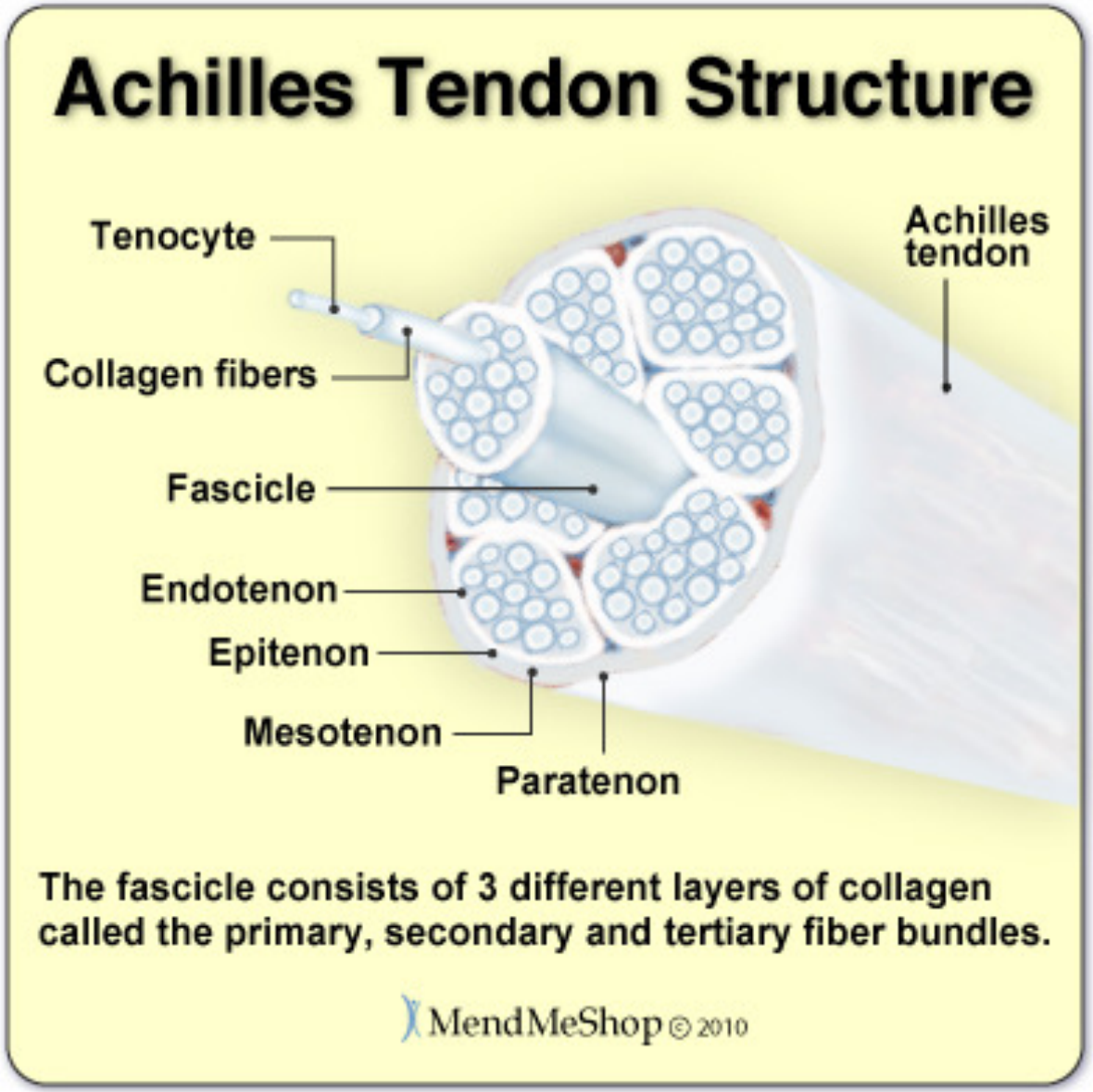
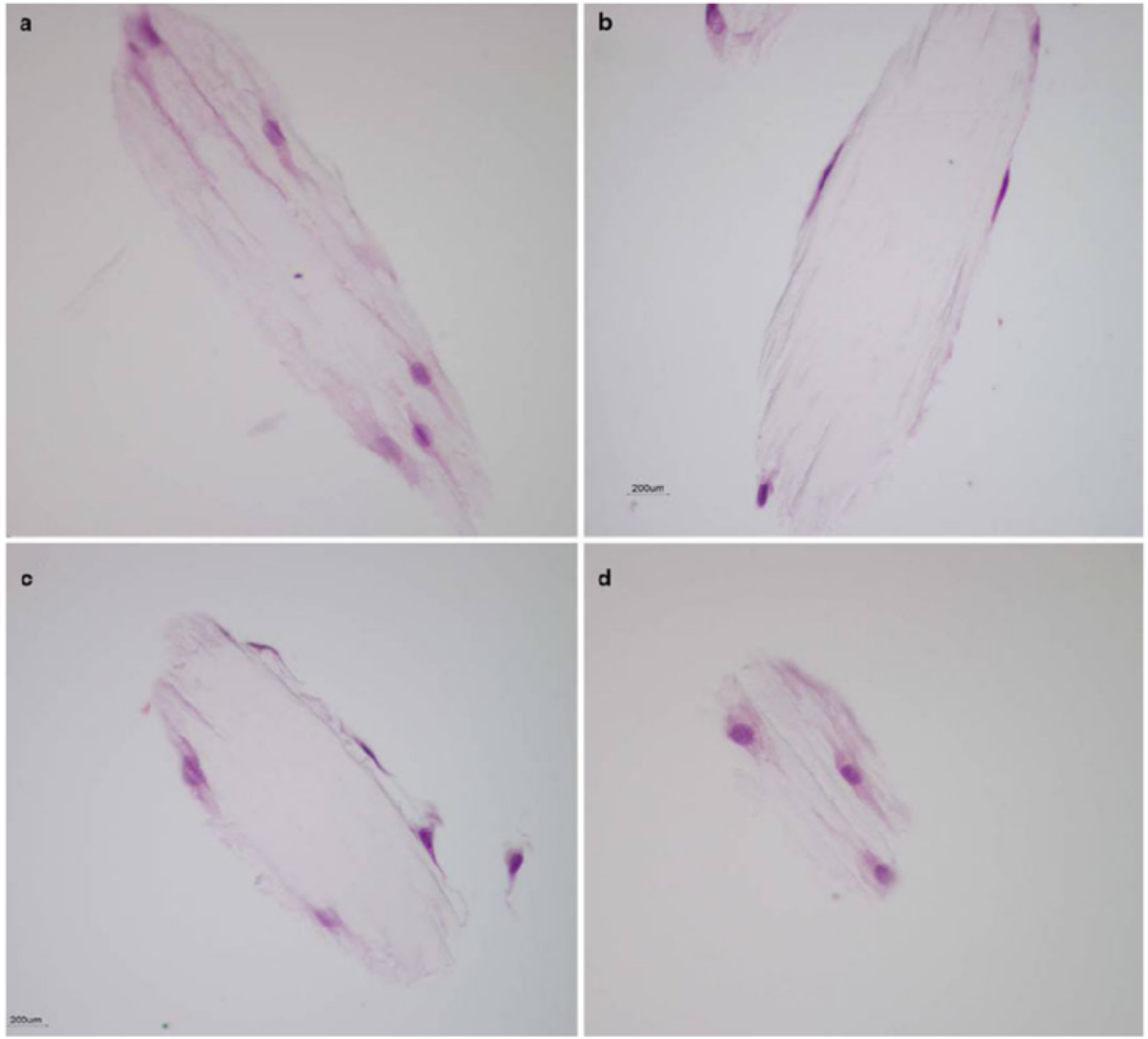
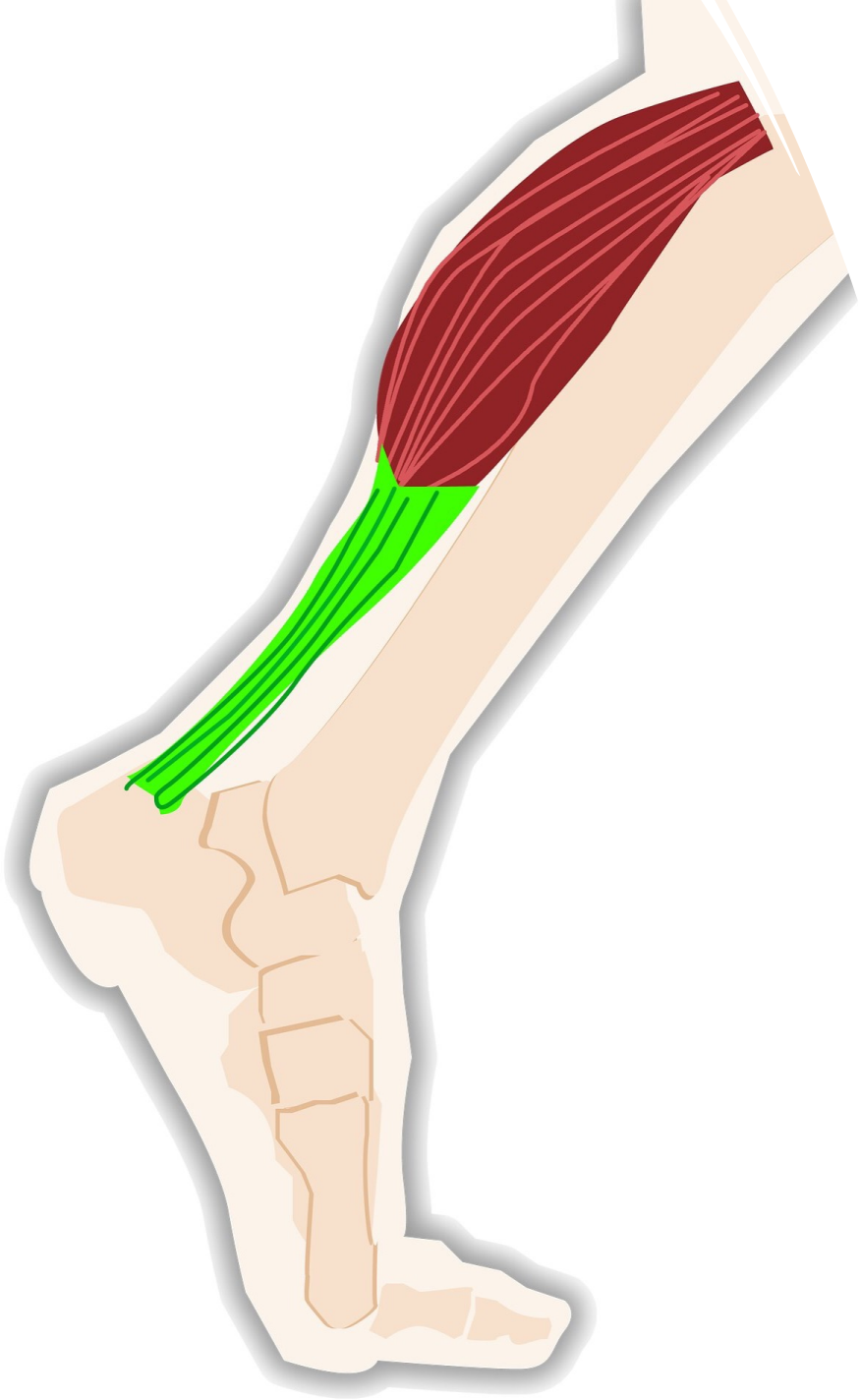




Structures of Tendon

Tenocytes





Tendon Functions

The tendon is a "mechanical bridge." It allows the transmission of muscle strength to the bones and joints, on the other it allows the contraction of the muscle to make the final tangible movement.

The muscle affects the tendon, and the tendon affects the functional expression of the muscle.

Tendon Functions

In the context of manual therapy, rehabilitation, or surgery, it is a mistake not to consider these close relationships of anatomy and function.

The tendon tissue can adapt its cellular structure under physiological (training) or pathological (trauma) stimuli, depending on the systemic hormonal environment and age.

Tendon Functions

The tendon plays an extraordinary role in mechanics and movement.

They transmit the force produced by the muscular contraction to the skeletal levers, thus allowing the movement and the maintenance of the body posture.

Tendon Functions

- The tendons allow the muscle to be at an optimal distance from the joint on which it acts without requiring an excessive length of the muscle between the origin and the insertion.

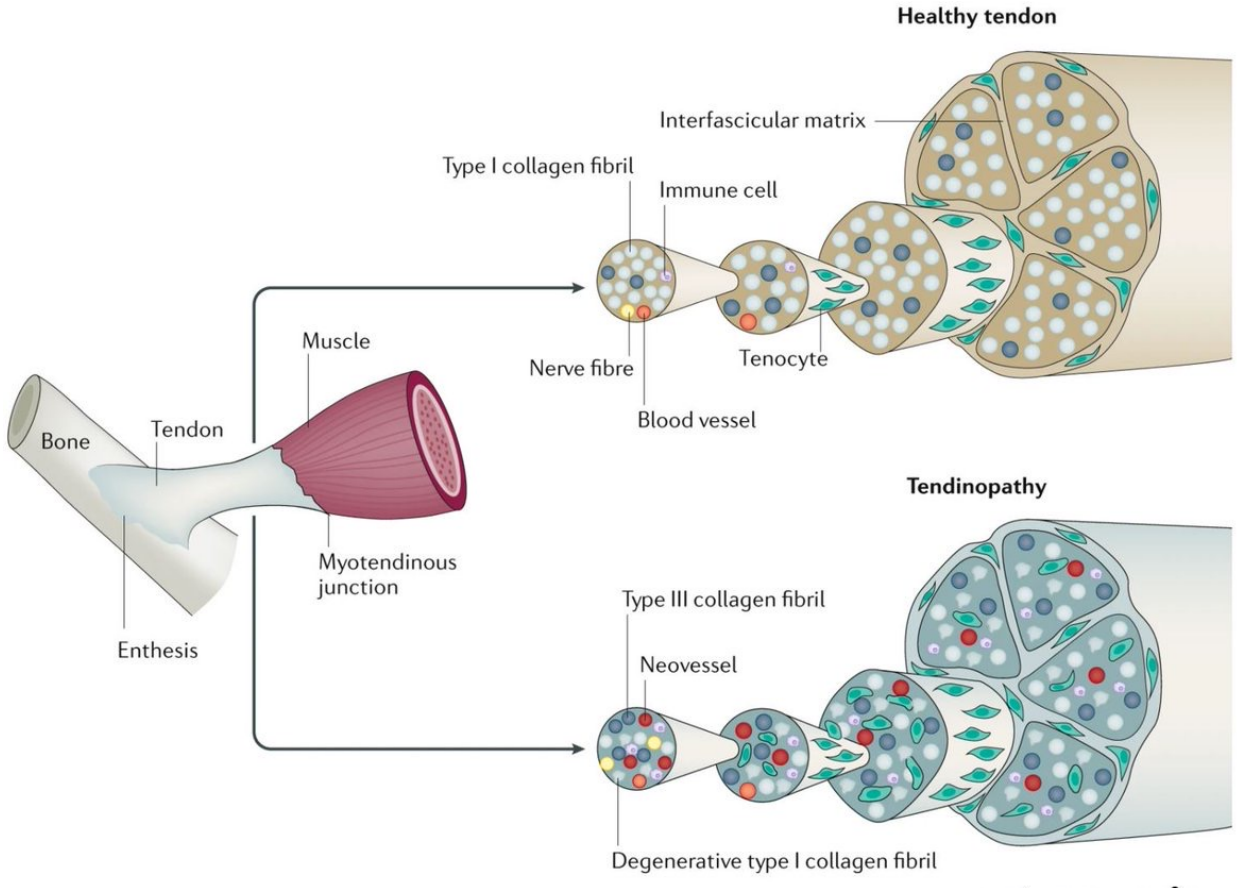
Tendon Functions

Tendons are stiffer than muscles, have greater tensile strength and can withstand very large loads with minimal deformations.

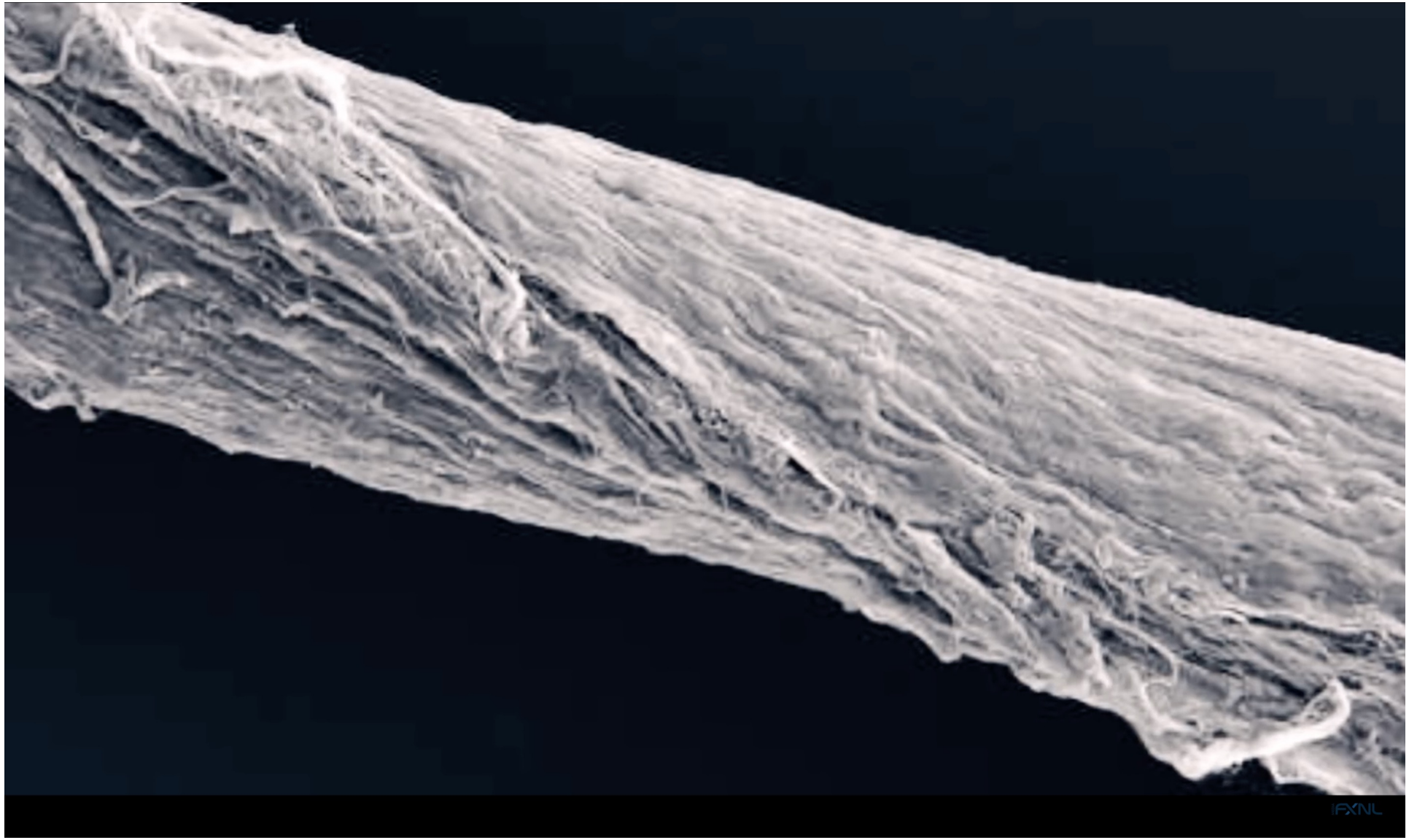
This property of the tendons makes the muscles capable of transmitting forces to the bones without losing energy to stretch the tendons.

For example, the flexor tendons of the foot can bear more than 8 times the body weight and store about 40% of this weight for an elastic hysteresis during the walk.

Clinical Background



- Injuries are caused by improper ability of the body to manage load intensity and volume
- **Strains- Acute overload/Inability to take intensity**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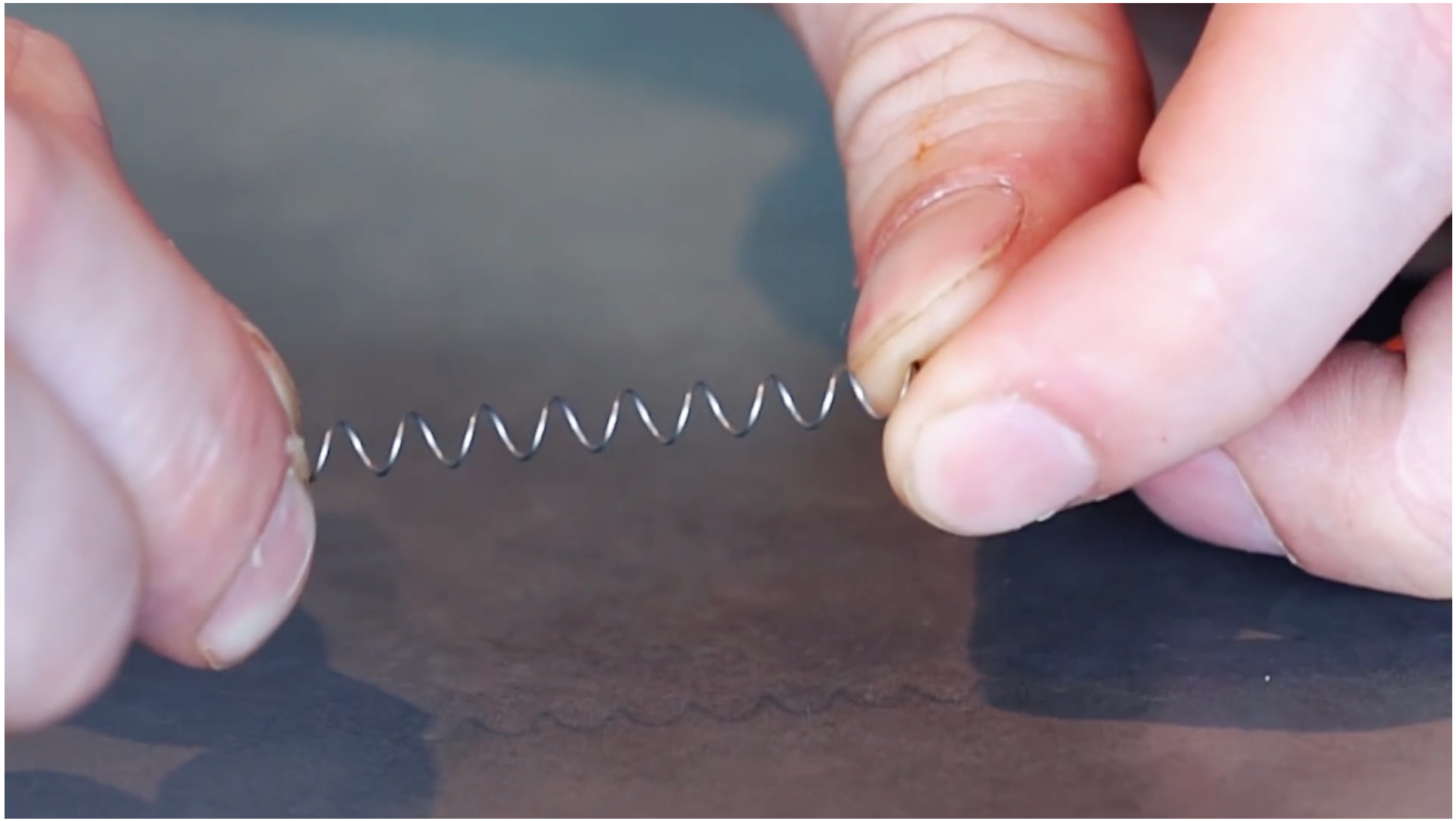
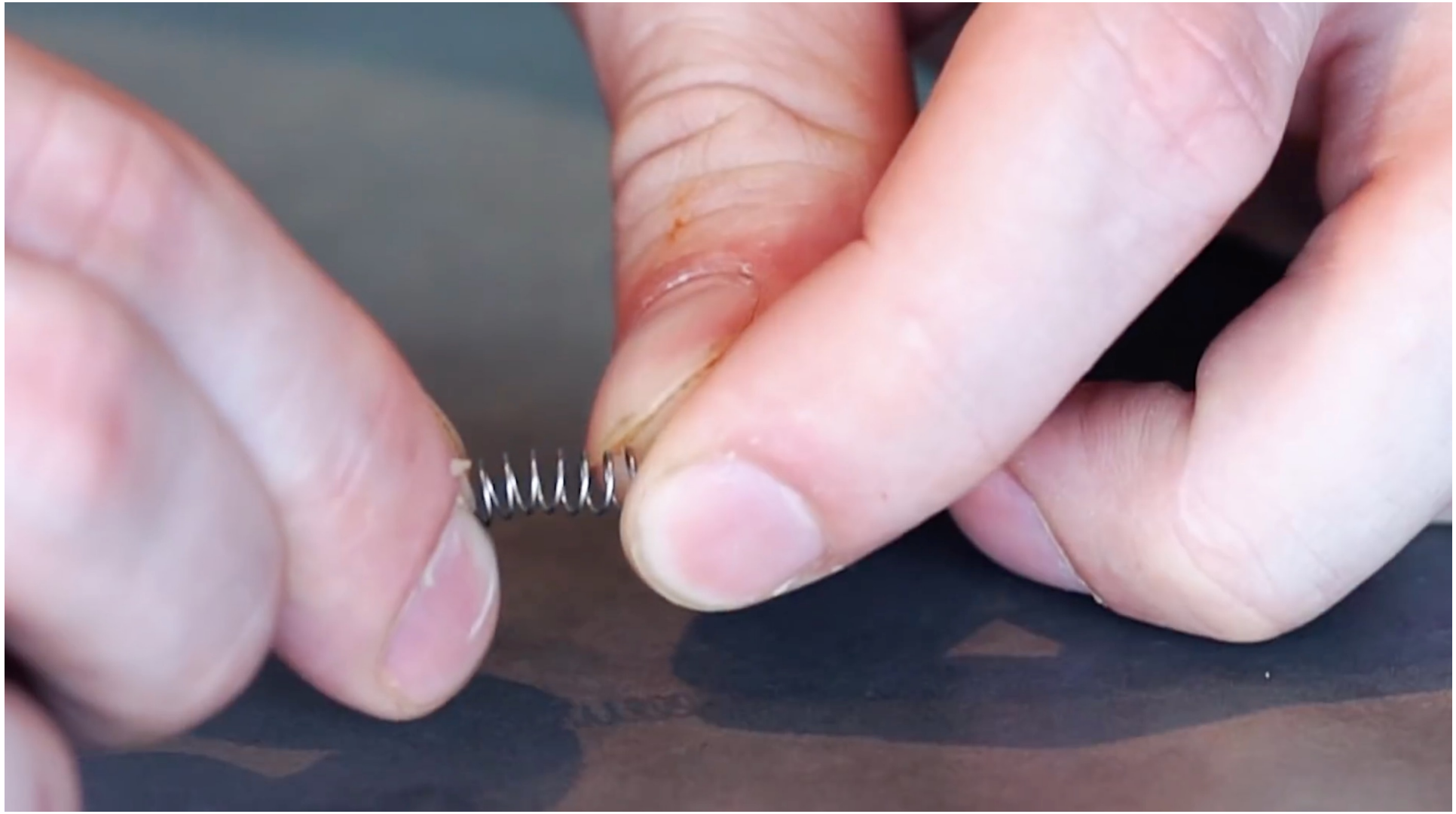
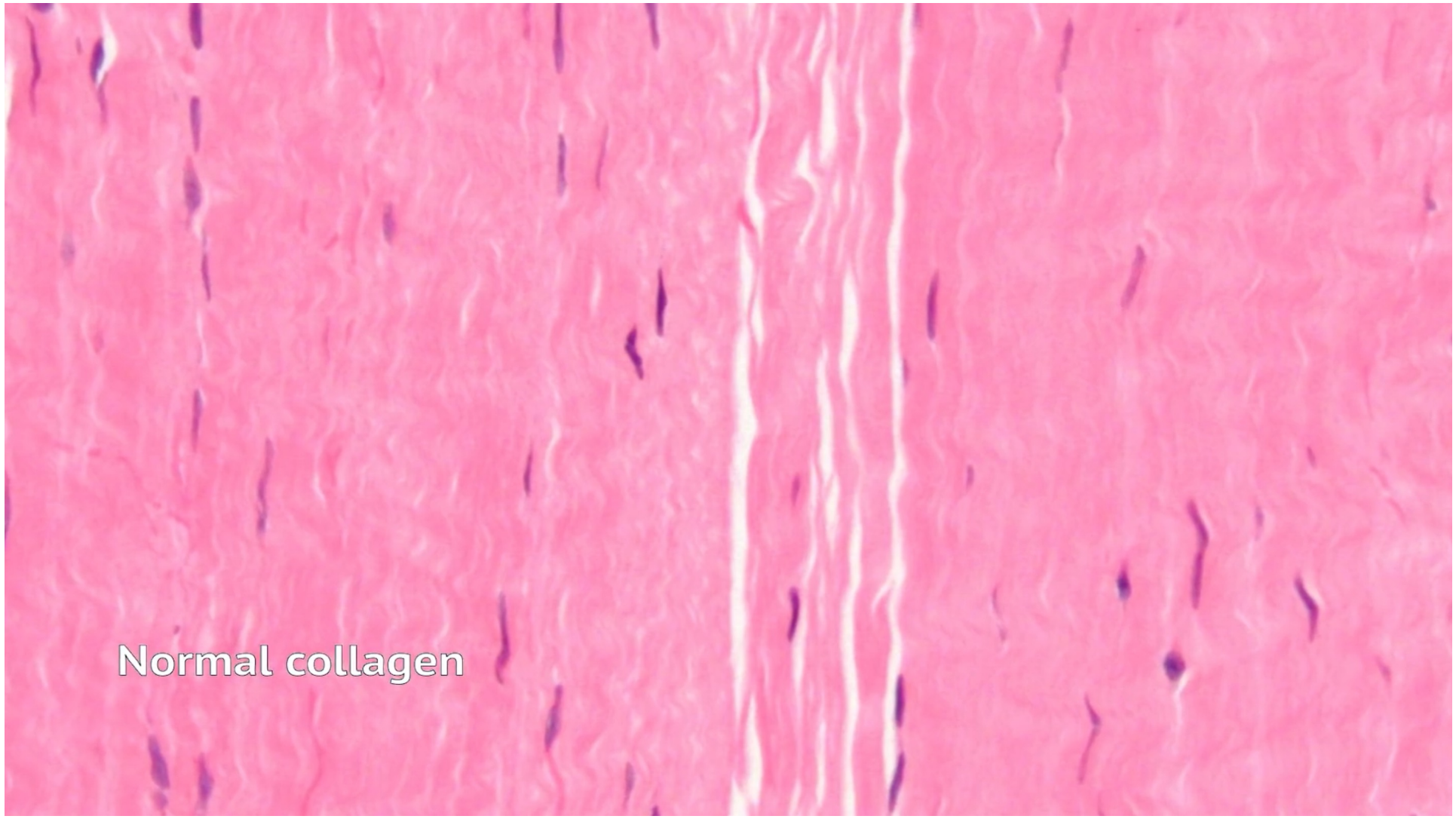
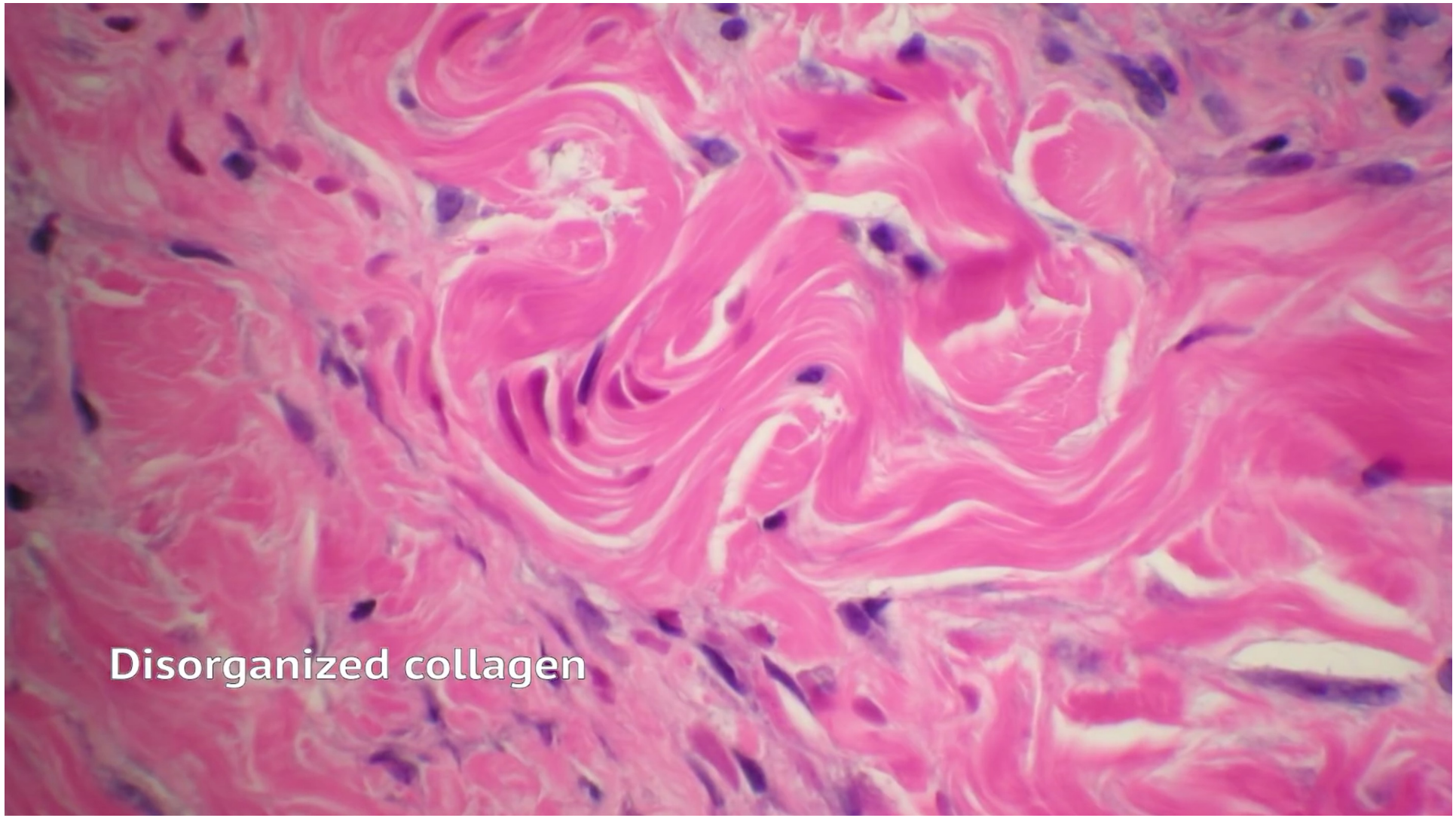
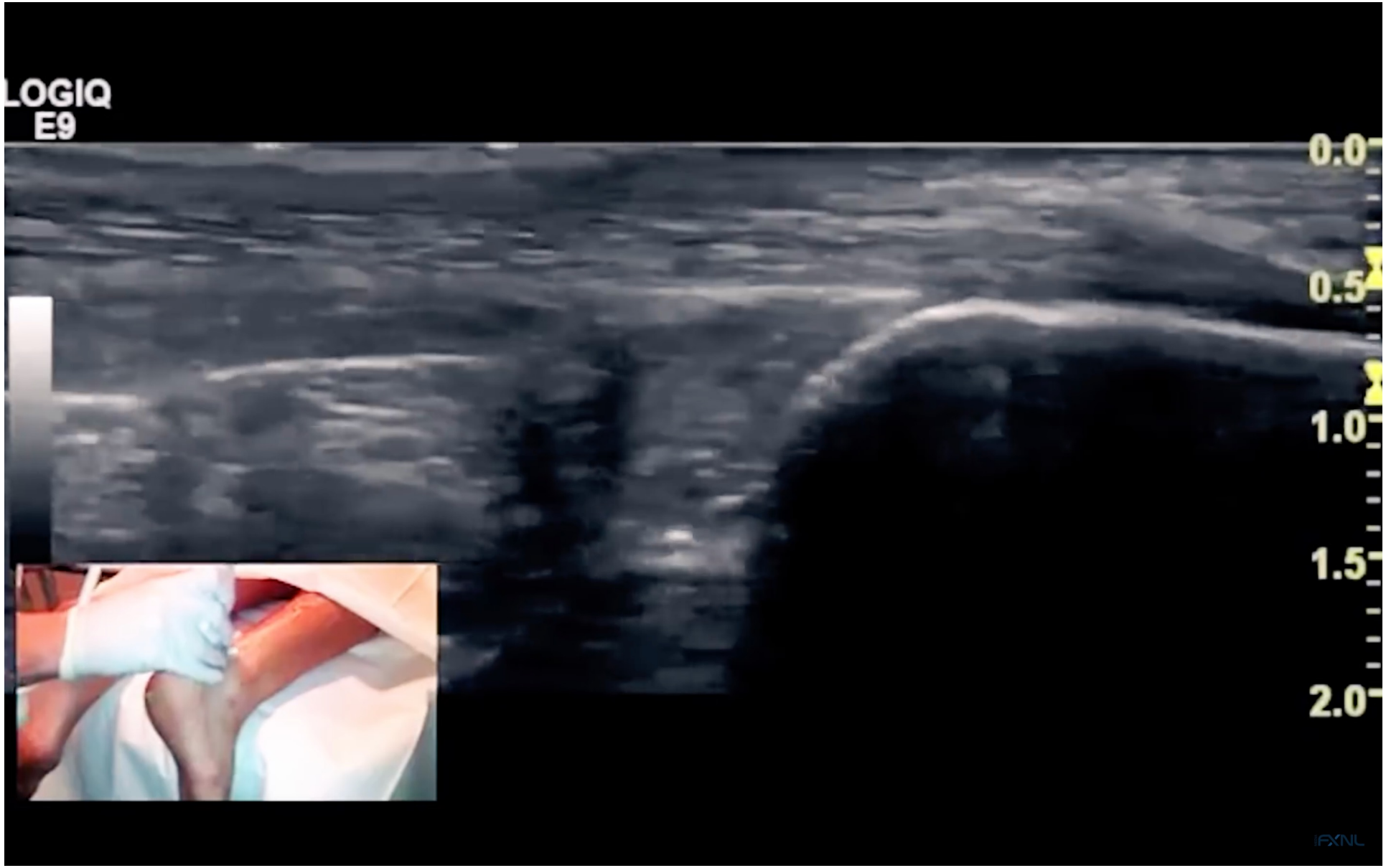





Normal collagen


10X
Normal Tendon

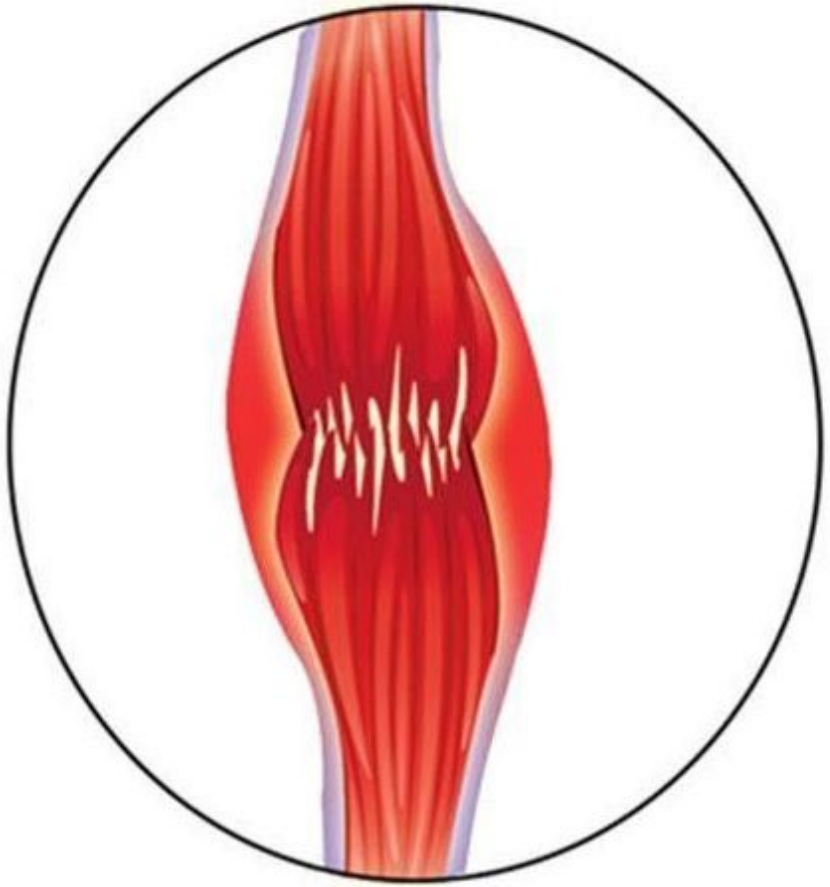

Disorganized collagen


LOGIQ
E9
0.0
0.5
1.0
1.5
2.0

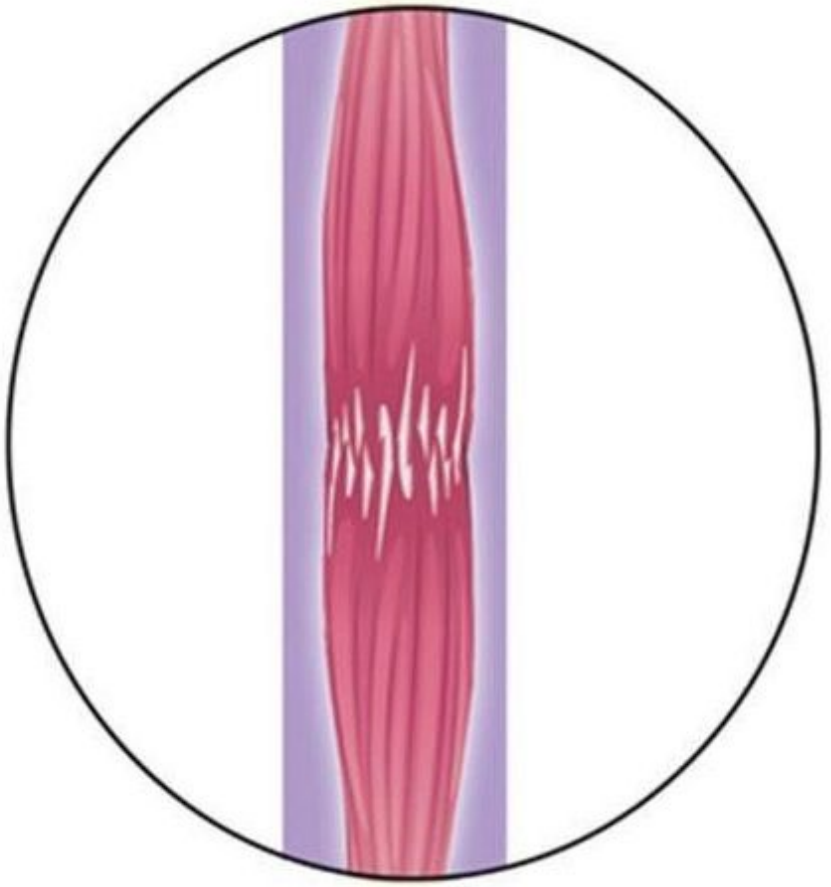
Tendon Injury

- **Tendinopathy- Chronic overload/Inability to take volume**
- Tendon Injuries estimated at 30-50% of all sports injuries
- 50% among endurance athletes
- 6% of sedentary individuals
- Achilles Tendinopathy estimated at 55-65% of all Achilles' tendon disorders

Tendonitis



Tendinosis



Tendinitis vs. Tendinosis

TENDINITIS

IRRITATION AND INFLAMMATION OF THE TENDON RESULTING FROM TINY MICROTEARS CAUSING PAIN, ACHINESS, AND SWELLING.

CAUSED BY INJURY FROM OVERLOAD OF THE TENDON'S TENSILE STRENGTH. COMMONLY OCCURS DURING WORK OR SPORTS ACTIVITIES.

TREATMENTS AIM TO REDUCE PAIN, SWELLING, AND INFLAMMATION TO ALLOW FOR PROPER HEALING TO TAKE PLACE. TREATMENTS INCLUDE REST, ICE, COMPRESSION, AND BRACING TO IMMOBILIZE THE AREA

VS

TENDINOSIS

DETERIORATION OF THE TENDON IN WHICH COLLAGEN PROTEINS ARE BROKEN DOWN CAUSING PAIN, STIFFNESS, AND DECREASED FUNCTION

CAUSED BY LONG-TERM OVERUSE AND REPETITIVE STRESS ON TISSUE LIMITING THE TENDON'S ABILITY TO PROPERLY HEAL.

TREATMENTS AIM TO BREAK DOWN RIGID TISSUES AND IMPROVE FUNCTION. TREATMENTS INCLUDE TISSUE MOBILIZATION, MASSAGE, STRETCHING, REHAB EXERCISES, AND RESTORATION OF MOBILITY AND PROPER MECHANICS.

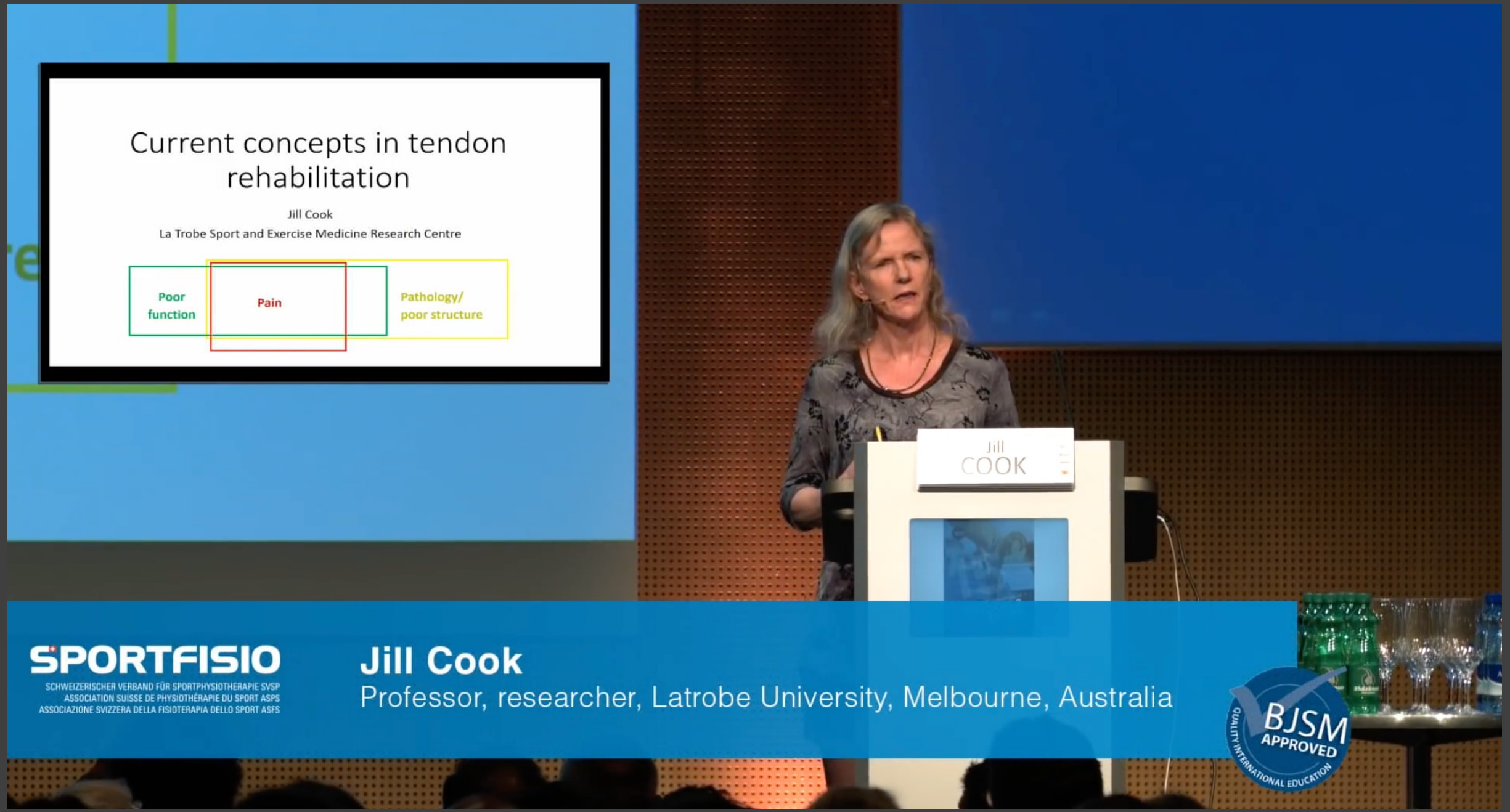
UNTREATED TENDINITIS MAY ULTIMATELY LEAD TO TENDINOSIS

Tendonitis vs. Tendinopathy

- It's an inflammation of the tendons that causes deep, nagging pain.
- Common treatment: rest, ice, compression, and elevation

- It refers to tendon injuries.
- Common treatment: physical therapy, medication, or bracing/splinting

Tendon Recovery & Rehabilitation



SPORTFISIO
SCHWEIZERISCHER VERBAND FÜR SPORTPHYSIOTHERAPIE SVSP
ASSOCIATION SUISSE DE PHYSIOTHÉRAPIE DU SPORT ASPS
ASSOCIAZIONE SVIZZERA DELLA FISIOTERAPIA DELLO SPORT ASFS

Jill Cook

Professor, researcher, Latrobe University, Melbourne, Australia

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How do we develop tendon pathology?

- Inflammation (Scott and Rees)
    - Few inflammatory cells
    - Some inflammatory mediators
- Collagen tearing
    - Impossible
    - Cannot tear normal collagen (Screen et al)
- Cell-mediated pathology
    - Cells Intimately attached and sensitive to matrix load
    - Respond to load

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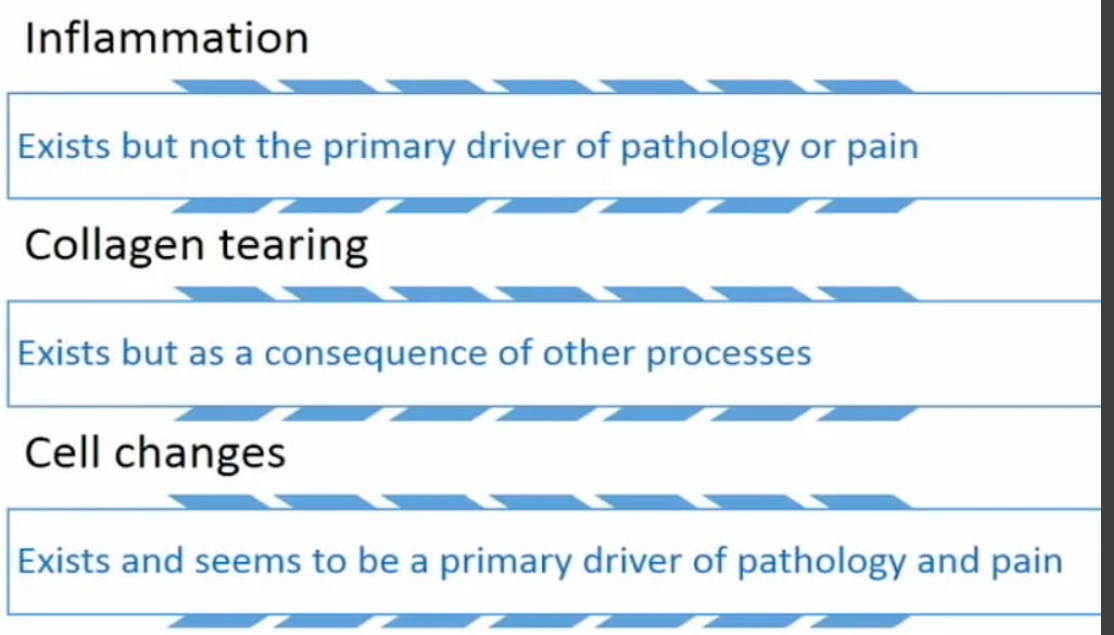

Why is this important?

- Does pathology help direct rehabilitation?
  - Inflammation
    - REST, ice, anti-inflammatory medication
  - Collagen tearing
    - REST to allow healing
- We know that rest is bad for a tendon
  - Tendons need load to maintain structure
- A cell based model allows treatment that can incorporate load
    - If it is not provocative to the cell

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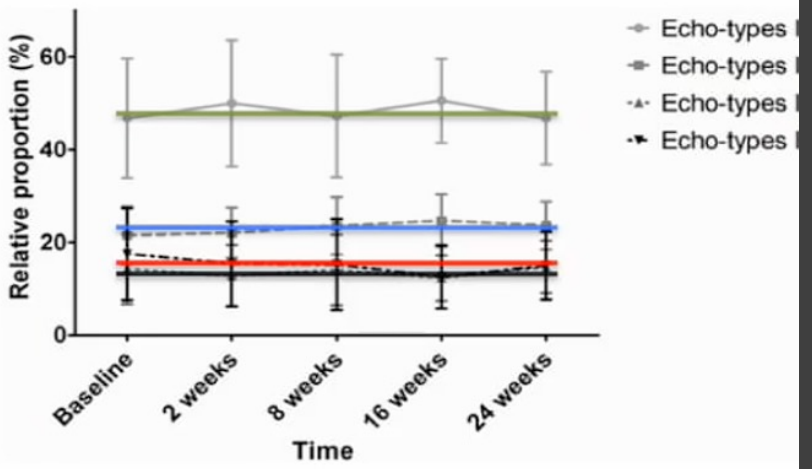
- A cell based model allows treatment that can incorporate load
    - If it is not provocative to the cell
- Even with all this knowledge, can we change structure?
    - Evidence suggests not
    - Exercise does not, injection therapies do not



Making decisions about tendon rehabilitation

- Where does the pain come from?
  - Not related to structure
    - Not vascularity, echogenicity
      - You can't image pain
  - Nociceptive driver unknown
    - How might we change it then?
  - Not evidence of central sensitisation in the lower limb

    Pilsinga et al

Can we change pain?

- Sensory nerves in tendon pathology are peripheral (peritendon)
  - No sensory nerves in the tendon (Danielson et al)
    - Pathology not correlated to pain
- To change pain we need to direct treatments at the nerves
  - What do they do and how long do they last?
    - Induce neuropraxia, lasting days to months
      - Not a long term solution
  - What interventions do this?
    - ESWT, sclerosing injections, filleting surgery

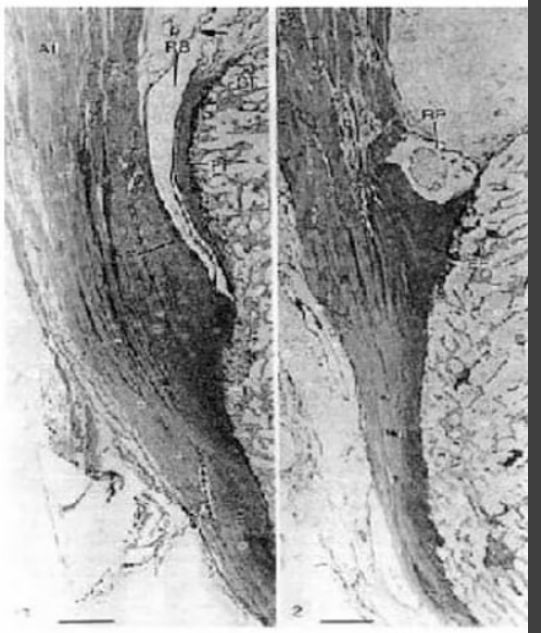
What is the link between pain and function?

- Tendon pain causes profound dysfunction
    - Destroys performance

So what about function?

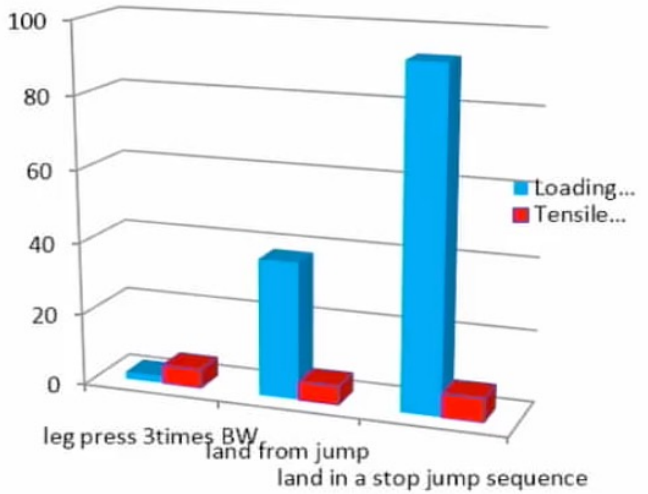
- What loads must we rehabilitate a tendon to deal with?
  - Energy storage
  - Compressive
  - Friction

- Achilles
  - Mid tendon = **Energy storage load**
    - Achilles is the only tendon with midsubstance pathology
  - Insertion = **Compressive load**
    - Just before the tendon insertion
  - Peritendon = **Friction load**
    - Posterior gliding membranes and anterior fat structures



So what about function?

- How do we define this?
  - Must be related to tendon function
    - Ability to store and release energy in your tendon
      - Spring-like behaviour of tendon
        - Must be fast
      - Able to deal with compressive loads
- How do we treat dysfunction?
  - Restore the highest level of function
    - BUT there are many things you need before you can use your tendon springs
      - Address the tendon, muscles and the kinetic chain



What are the rehabilitation protocols with evidence?

- Eccentric exercise
  - What it does
    - Loads the series elastic component of the tendon
      - Ie the spring
  - What it does not do
    - Strengthen the muscle, kinetic chain or change brain
    - Adapt the tendon to energy storage loads
    - Compressive loads

(Alfredson et al)

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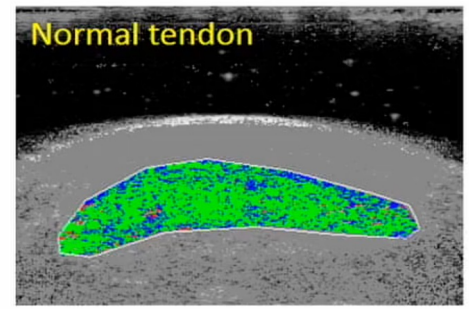
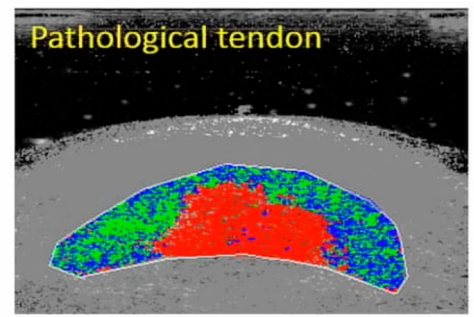
    (Alfredson et al)

- Heavy slow resistance
  - What it does
    - Muscle strength
    - Loads tendon
      - Slow loads improve mechanical strength
  - What it does not do
    - Adapt the tendon to energy storage loads
    - Compressive loads
    - Fully address kinetic chain and brain

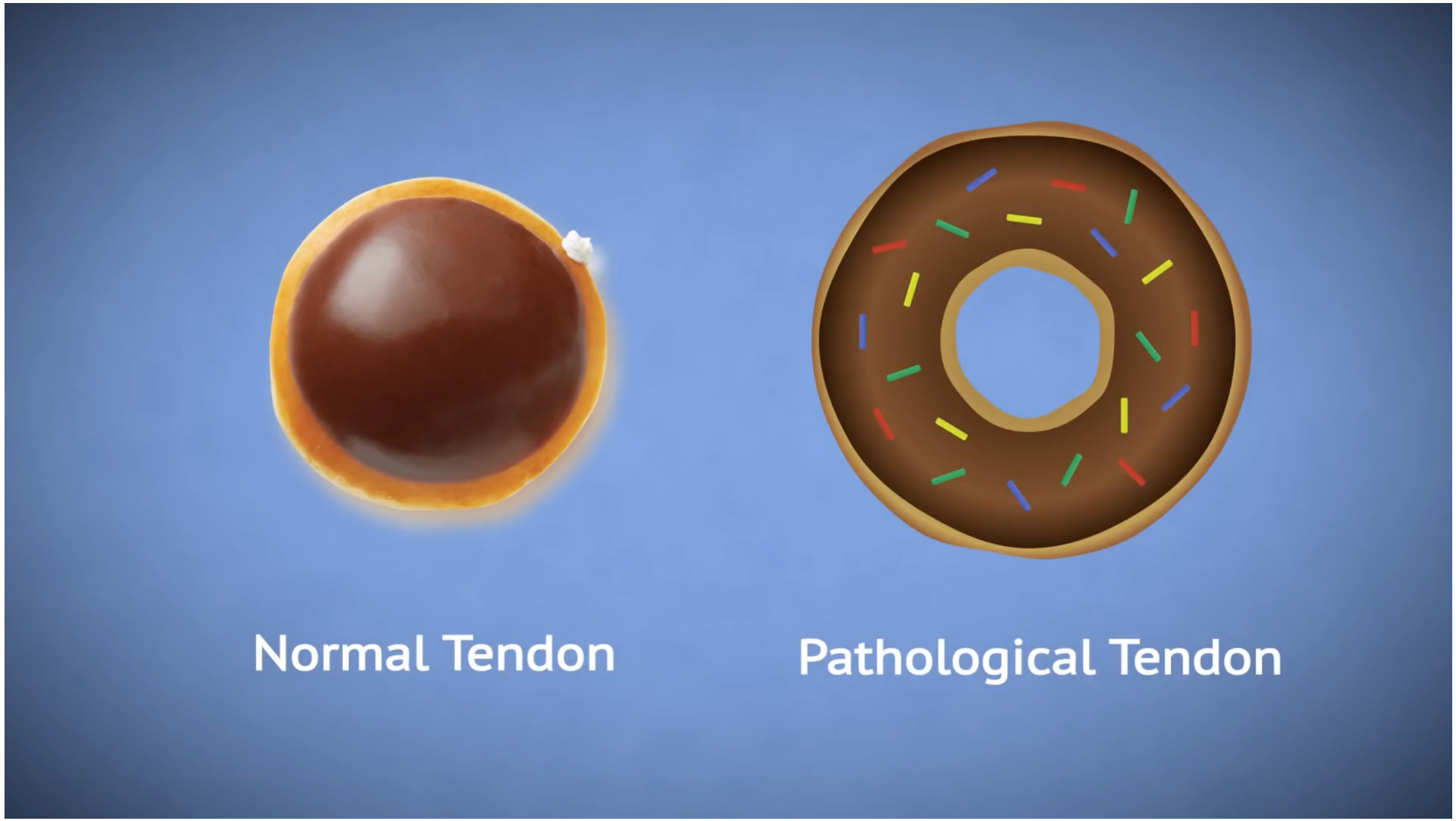
    (Kongsgaard et al)

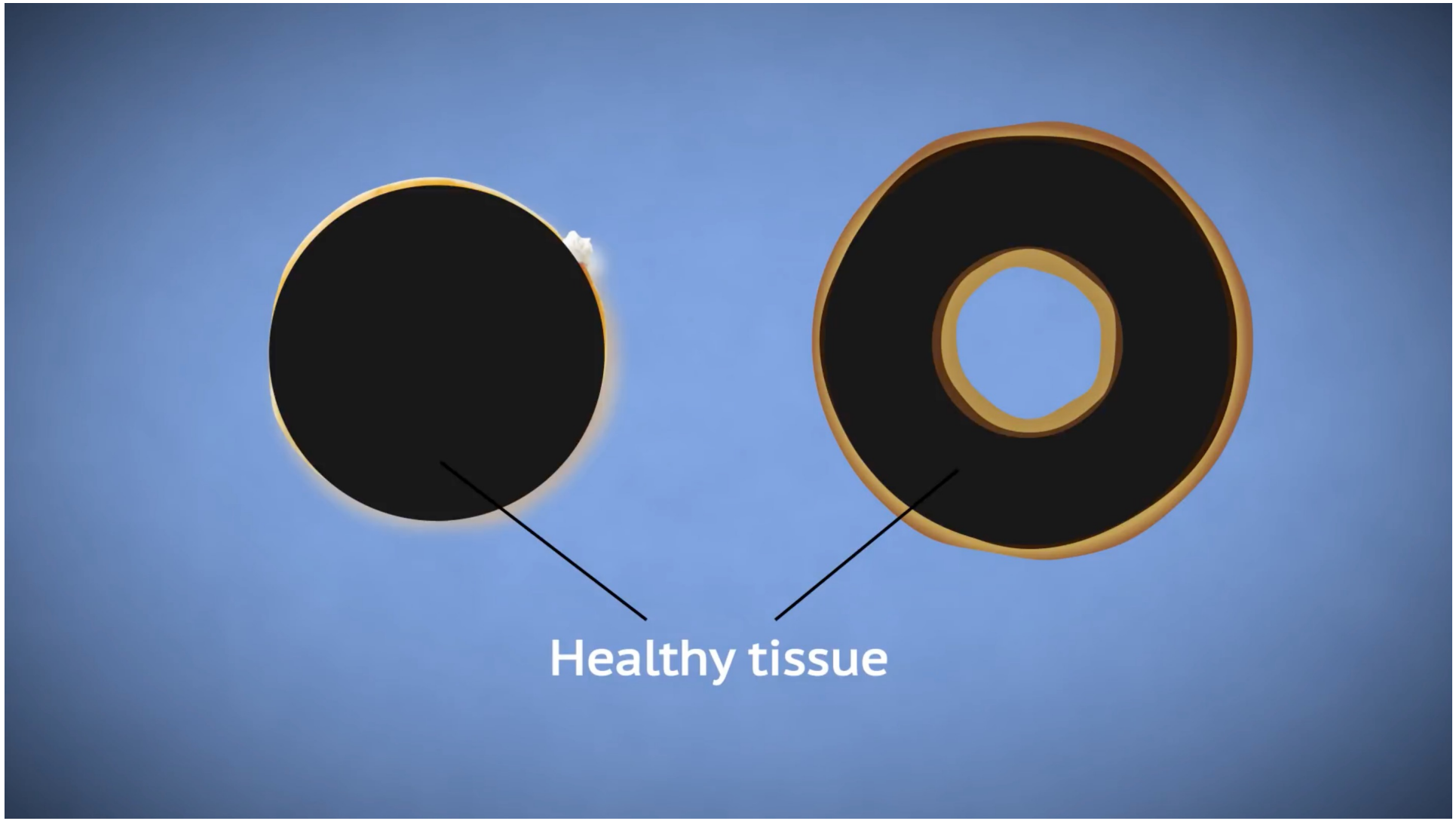
	Normal	Pathological
Achilles tendon		
AP diameter (mm)	6.5 ± 0.5	8.4 ± 1.5
mCSA of poor structure(mm^2)	1.4 ± 1.4	4.7 ± 8.3
Patellar tendon		
AP diameter (mm)	6.0 ± 0.6	7.8 ± 2.6
mCSA of poor structure (mm^2)	4.5 ± 3.4	17.1 ± 22.3

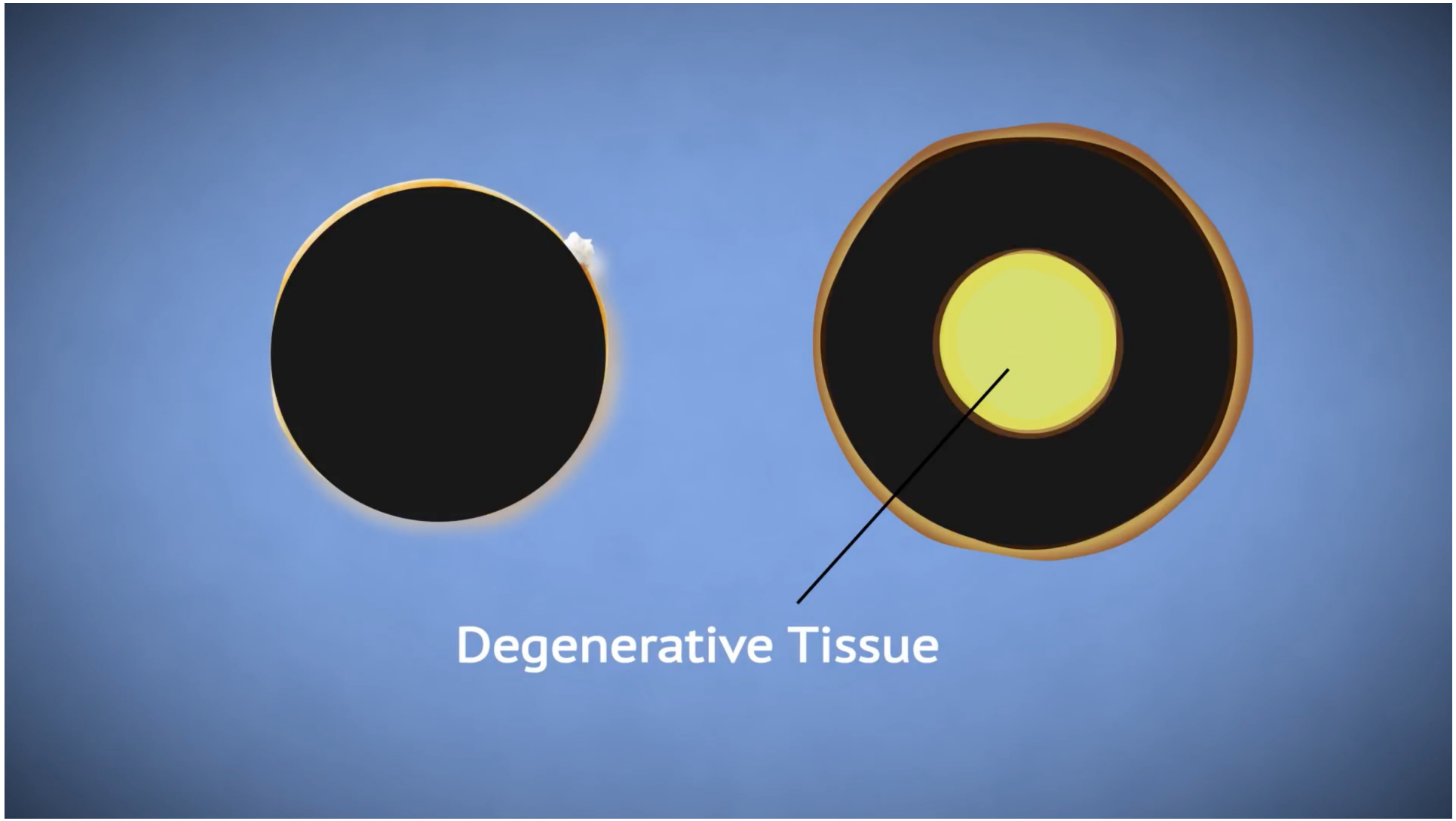




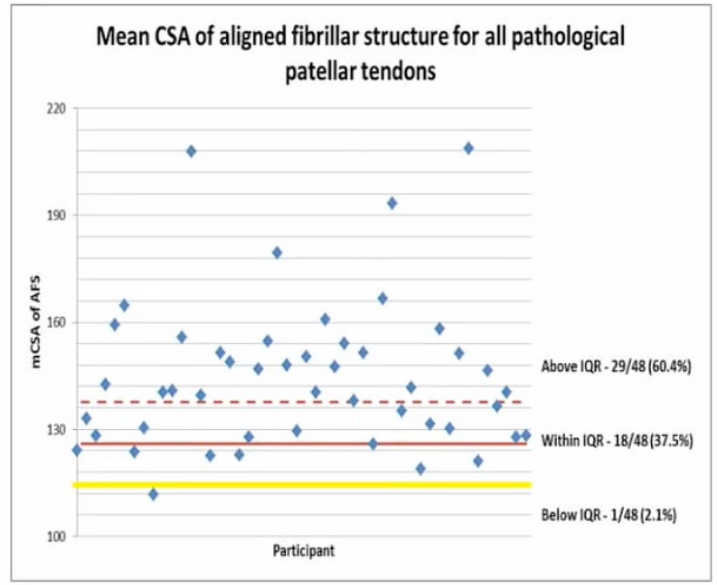
Docking and Cook 15


Normal Tendon
Pathological Tendon


Healthy tissue


Degenerative Tissue

- Any therapies for tendon pathology are not necessary
  - Docking and Cook 15



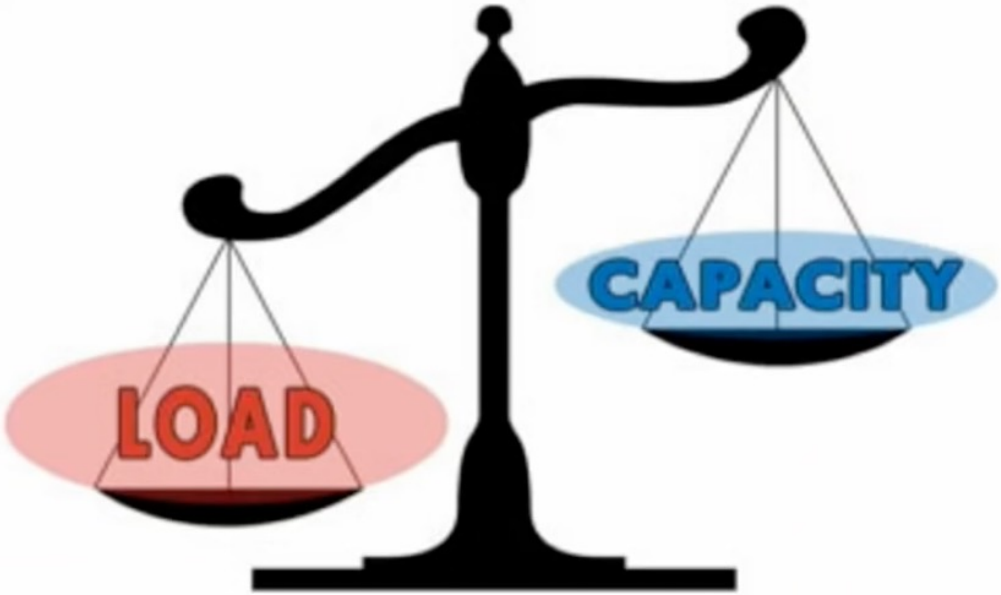
Treat the doughnut not the hole

So what do these have in common?

- Exercise and correct loading
- Where does exercise fail?
  - It is not new
  - It is slow
  - It is not expensive

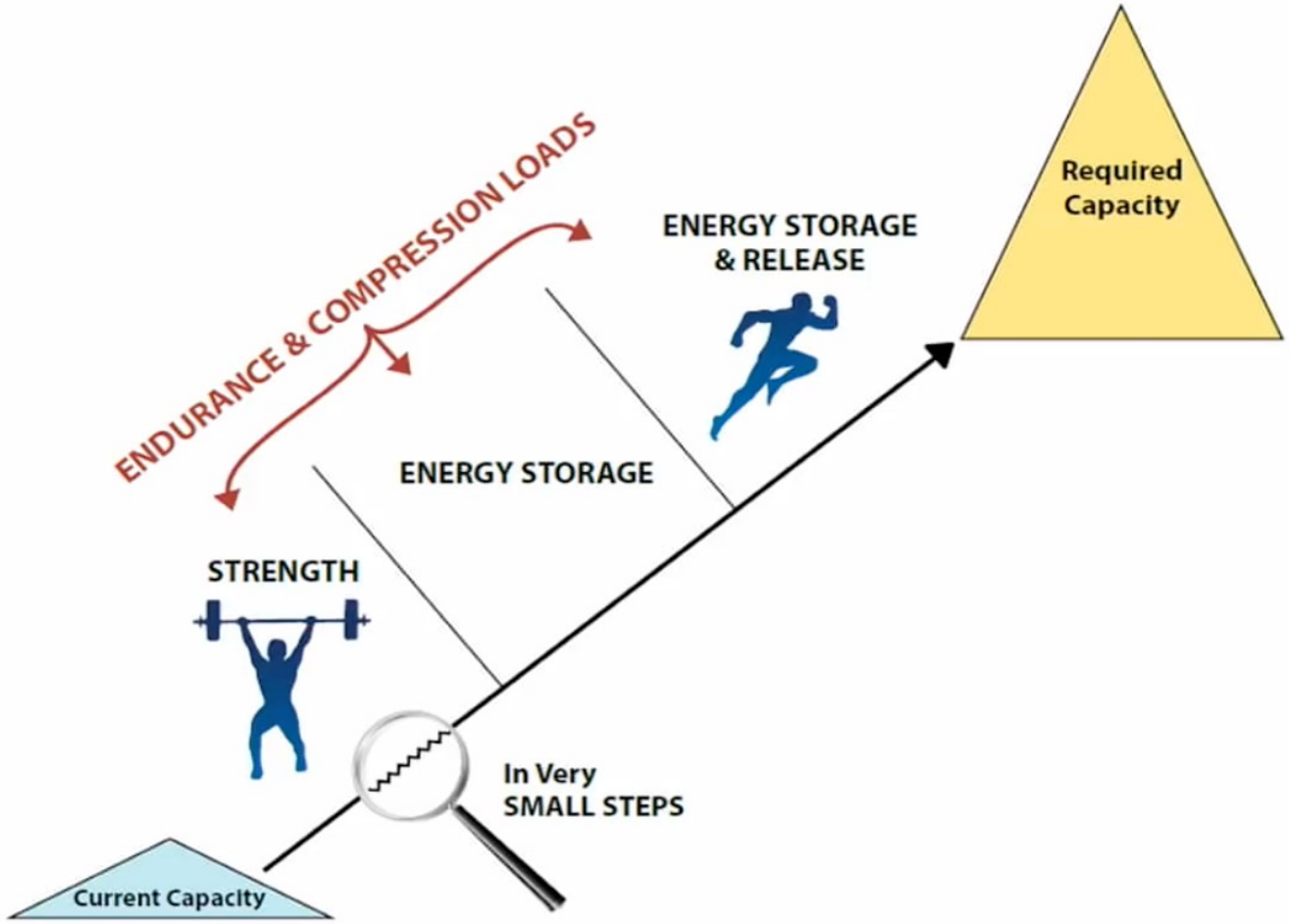
How can we make exercise ideal for tendons?

- Make the tendon, the muscle tendon complex and the kinetic chain tolerant to the imposed loads
  - Pain will improve
- Do not try and fix structure
  - Unfixable
- Do not rely on quick fixes
  - Short term gain, no long term improvement



How do we rehabilitate lower limb tendons?

- A staged loading program
  - First unload to settle pain and tendon
    - Decrease energy storage loads, frequency and volume and intensity of training
    - Add isometrics for pain and brain
  - Then <u>gradually</u> reload
    - To the level they need for their activity
      - Strength, energy storage and release loads
      - Add endurance and compression as needed



Four stages of rehabilitation

Stage 1

- Isometrics
  - To reduce pain
  - No compression

Stage 2

- Strength
  - Muscle/ kinetic chain strength
  - Functional strength
  - Strength endurance
  - No compression

Stage 3

- Energy storage
  - Faster
  - End of range eccentric
    - Add compression

Stage 4

- Energy storage and release
  - Sport specific loading
  - Compression

How do we rehabilitate lower limb tendons?

- Take the staged program and fit it to the person and the tendon
  - Individuals vary markedly
    - Elite jumping athlete
    - Older sedentary person
    - Copers versus non-copers
  - The rehabilitation must be different

  - The tendons vary markedly
    - Achilles tendinopathy can occur across the lifespan
    - The patellar tendon occurs in young, jumping men
    - Gluteus medius tendinopathy occurs in post-menopausal women

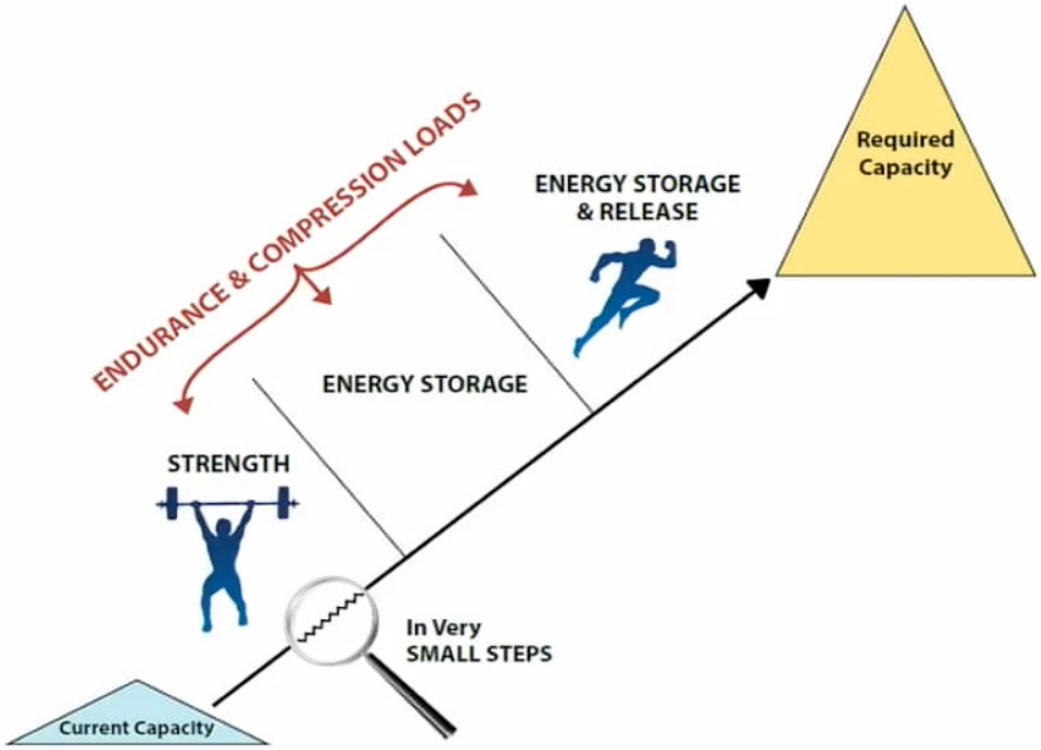
What about rest?

- Catabolic to tendon
  - Tendon tissue loses structure
    - Becomes pathological
  - Musculotendinous strength drops
    - Mechanical strength of tendon decreases in 2 weeks
  - Kinetic chain function deteriorates
    - Anti-gravity muscles
  - Motor drive changes
    - Luckily our brains don't turn to mush as well

- The strength of any tissue will only be as great as the load placed on it
  - Decrease the load = decrease the tissue capacity

Summary

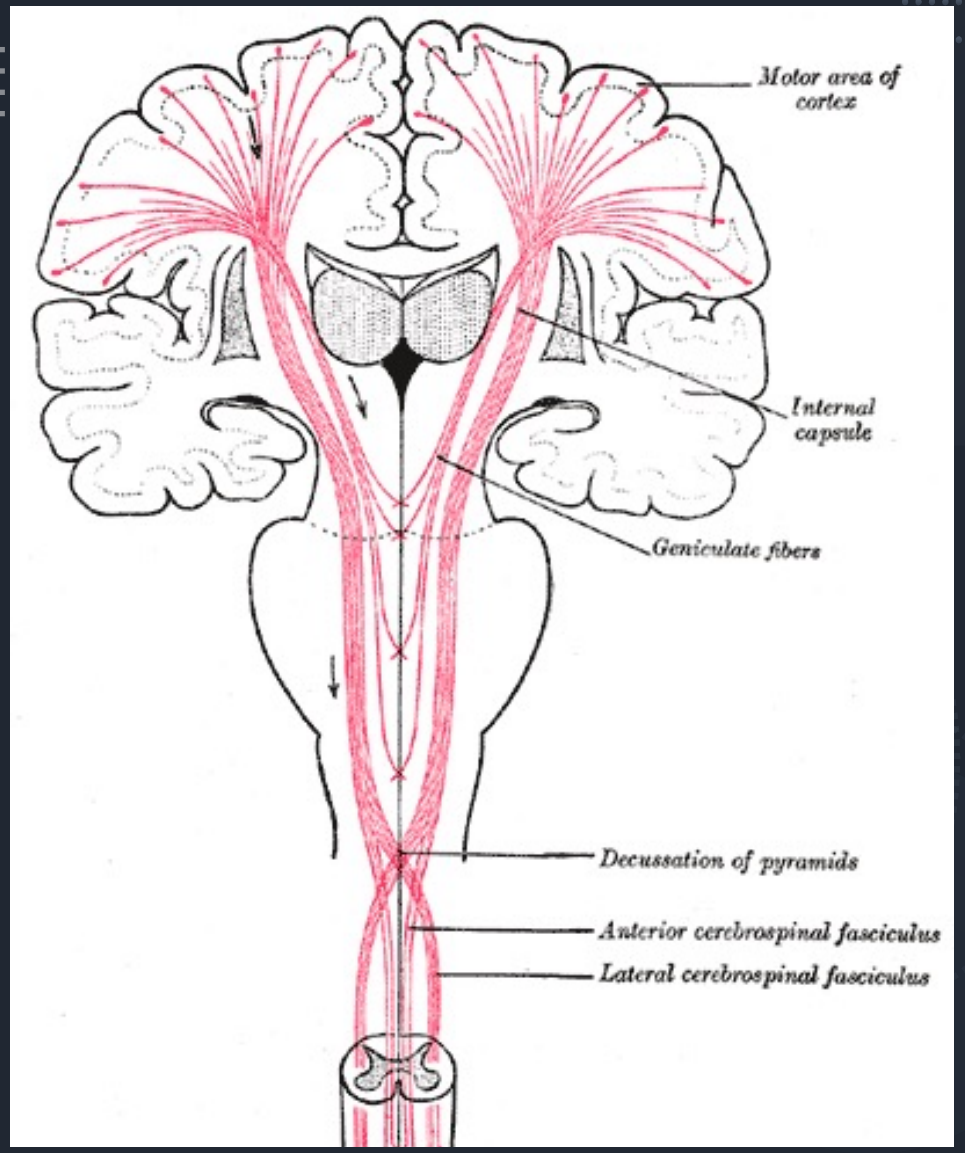
- Tendons and tendon pathology and pain are complex
  - They are often managed simplistically
- Recipe treatment programs will not address the complexity of presentations
  - Outcomes will be poorer
- Clinicians need to be thoughtful
  - Need to understand the issues



Learning from Ebonie Rio

Neurological Complications of Tendon Problems

- Corticospinal and neuromuscular adaptations
- Corticospinal excitation and inhibition



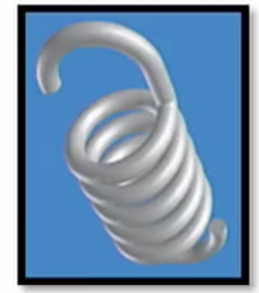
Motor Control Issue with Tendon Problems

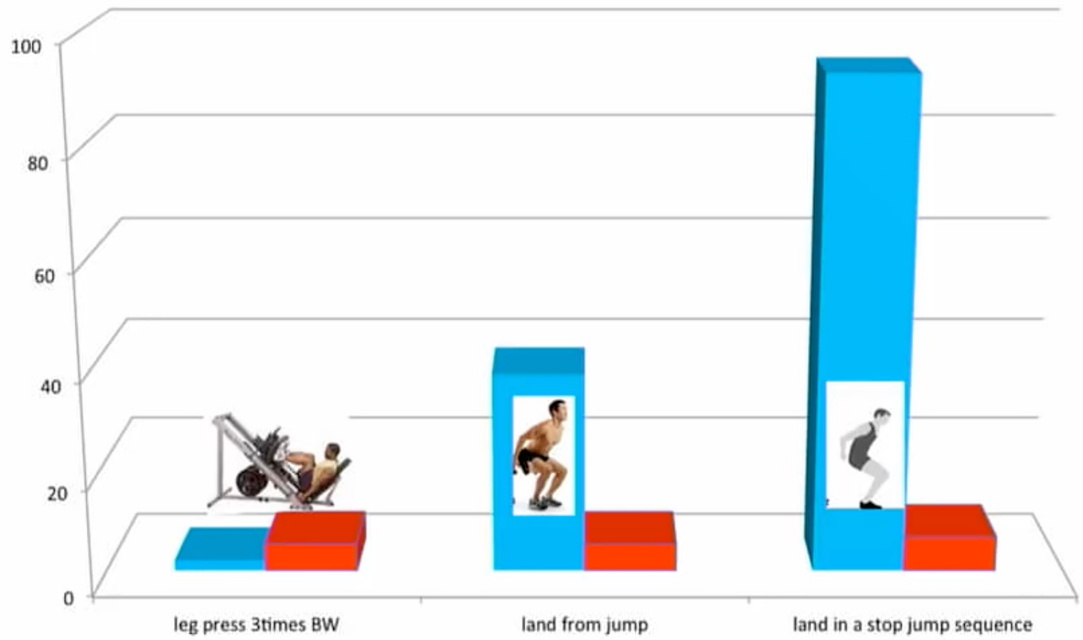
- Strength deficit deception
- Not only deficit, also CES occurs!
- Motor control deficit to normal side
- Upper limb vs. lower limb

MORE ON MOTOR CONTROL

- Maximal strength’s susceptibility to injury
- Maximal strength’s role in sub maximal motor task
- Imbalance between CSE and CSI around the painful tendon
- Movement variability
- Jumper’s knee paradox

Do we address athletic demands?
Loading rate for the patellar tendon

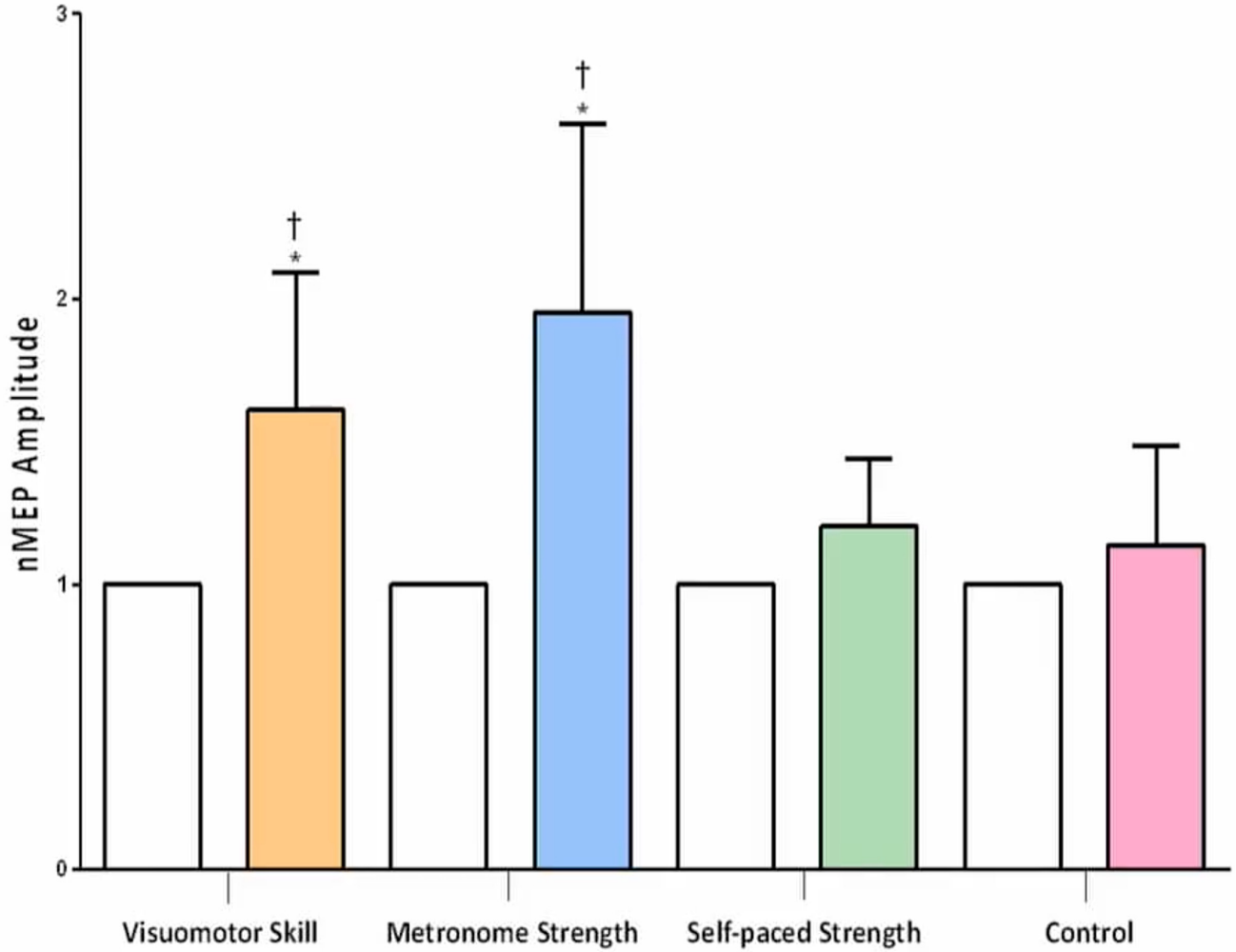




Reeves 2003, Janssen 2013, Edwards 2012

Sincere thanks to Adjunct Prof Craig Purdam for this slide

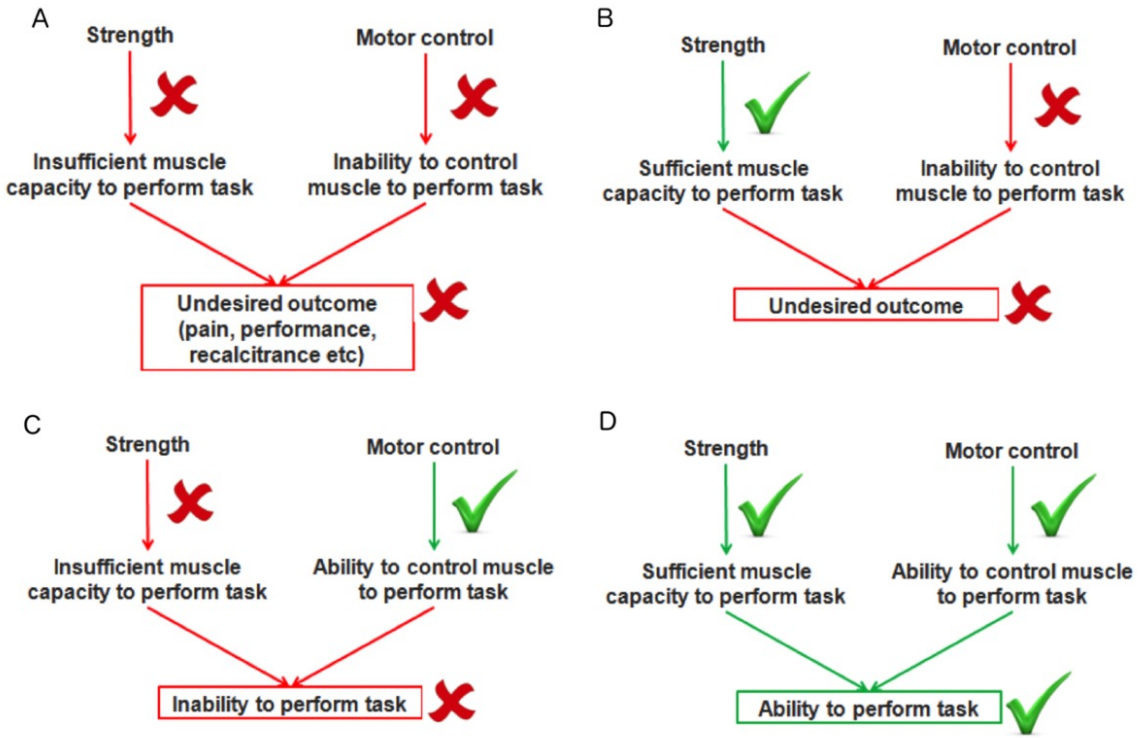
MOTOR CORTEX PLASTICITY



† Indicates significant difference ($p \leq 0.05$) from pre-training values

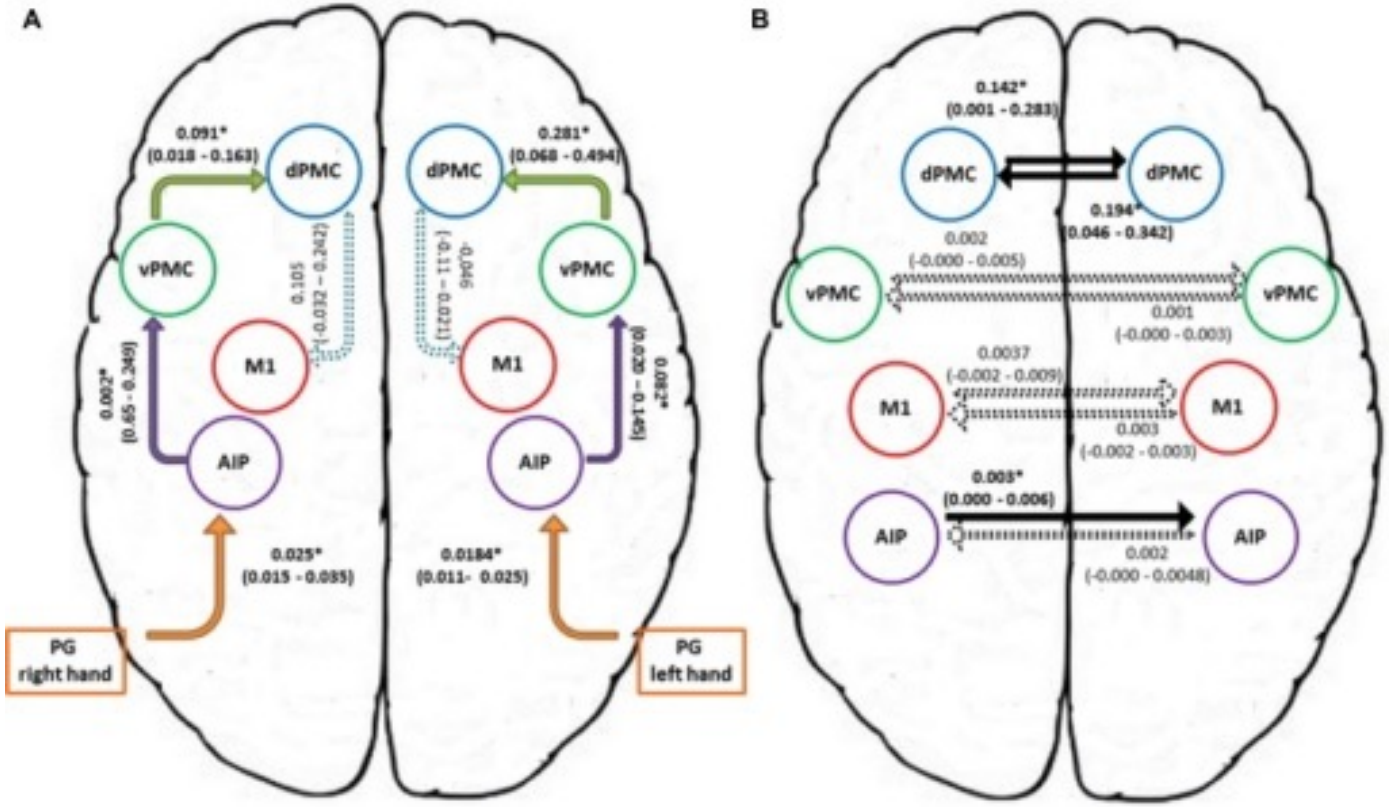
* Indicates significant difference ($p \leq 0.005$) from control

More Than Strength



MOTOR CONTROL BILATERALLY AFFECTED

- Interhemispheric connections
- CSE out of control



Can you self-pace?

No evidence it is effective – frequency and predictability is important

Subliminal levels of processing – projections between auditory cortex & motor cortex

Can you use music?

Probably – needs to be rhythmic not a distraction

External rhythm has to be relevant to movement – no effect in trained runners (Browley 1992)

Can negatively affect weights performance (Errol 1996) can increase arousal (Gluch 1993, Brownley 1995)

Can you use visual cues?

Auditory cues had greater benefit than visual cues in PD (stride length and cadence)

Mirror? Visuomotor?

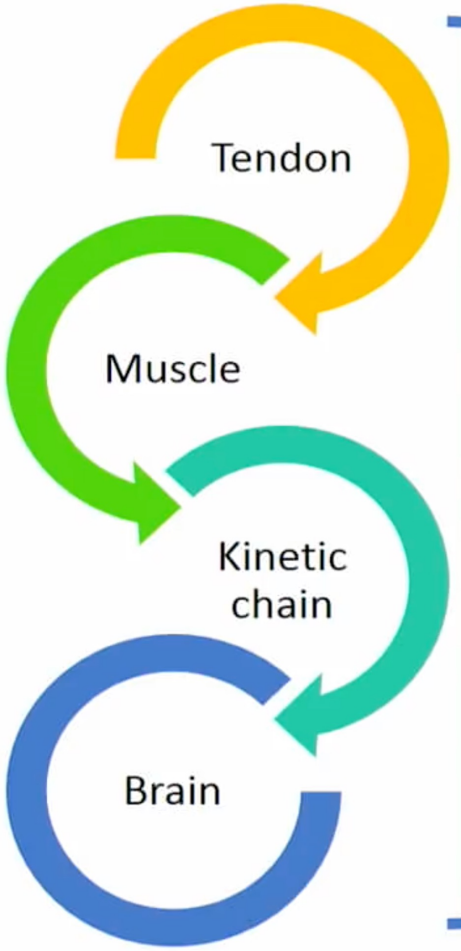
Auditory cues create faster reaction times than visual or tactile cues (Spidalleri 1983, Chapman 1986)

Tips and tricks for clinicians?
More gifts from neuroscience

- Cross education (Scripture 1894)
  - Training one limb results in improvement in the untrained limb
  - Changes to both excitability and inhibition (Kidgell 2015, Goodwill 2012)
  - Needs to be high force (Hortobagyi 2003)

- Tendons?
  - Strength train the other side – don't punish the good side!
  - Recommend single leg
    - Great – most athletic activity is single leg
    - Motor changes occur bilaterally (Rio 2015)

TNT: Tailoring evidence based loading for the person in front of you



Changing the way we **think** about rehabilitation

- Use analgesic loads, cross education & external pacing / visuomotor training during loading
- Progressive loading
  - isometric, concentric, eccentric, energy storage & release
- Education & expectations

Evidence Based Tendon Rehab Protocols

OPEN ACCESS

Effectiveness of progressive tendon-loading exercise therapy in patients with patellar tendinopathy: a randomised clinical trial

Stephan J Breda [1,2] Edwin H G Oei,[1] Johannes Zwerver,[3,4] Edwin Visser,[5] Erwin Waarsing,[2] Gabriel P Krestin,[1] Robert-Jan de Vos [2]

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[1]Department of Radiology & Nuclear Medicine, Erasmus MC, Rotterdam, Zuid-Holland, The Netherlands
[2]Department of Orthopaedics and Sports Medicine, Erasmus MC, Rotterdam, Zuid-Holland, The Netherlands
[3]Centre for Human Movement Sciences, University Medical Centre Groningen, Groningen, The Netherlands
[4]Sports Valley, High Performance Medical Centre, Gelderse Vallei Hospital, Ede, Gelderland, The Netherlands
[5]Department of Physical Therapy, Sportgeneeskunde Rotterdam, Rotterdam, Zuid-Holland, The Netherlands

Correspondence to
Stephan J Breda, Department of Radiology & Nuclear Medicine, Erasmus MC, 3015 GD Rotterdam, Netherlands; s.breda@erasmusmc.nl

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ABSTRACT

Objective To compare the effectiveness of progressive tendon-loading exercises (PTLE) with eccentric exercise therapy (EET) in patients with patellar tendinopathy (PT).

Methods In a stratified, investigator-blinded, block-randomised trial, 76 patients with clinically diagnosed and ultrasound-confirmed PT were randomly assigned in a 1:1 ratio to receive either PTLE or EET. The primary end point was clinical outcome after 24 weeks following an intention-to-treat analysis, as assessed with the validated Victorian Institute of Sports Assessment for patellar tendons (VISA-P) questionnaire measuring pain, function and ability to play sports. Secondary outcomes included the return to sports rate, subjective patient satisfaction and exercise adherence.

Results Patients were randomised between January 2017 and July 2019. The intention-to-treat population (mean age, 24 years, SD 4); 58 (76%) male) consisted of patients with mostly chronic PT (median symptom duration 2 years). Most patients (82%) underwent prior treatment for PT but failed to recover fully. 38 patients were randomised to the PTLE group and 38 patients to the EET group. The improvement in VISA-P score was significantly better for PTLE than for EET after 24 weeks (28 vs 18 points, adjusted mean between-group difference, 9 (95% CI 1 to 16); p=0.023). There was a trend towards a higher return to sports rate in the PTLE group (43% vs 27%, p=0.13). No significant between-group difference was found for subjective patient satisfaction (81% vs 83%, p=0.54) and exercise adherence between the PTLE group and EET group after 24 weeks (40% vs 49%, p=0.33).

Conclusions In patients with PT, PTLE resulted in a significantly better clinical outcome after 24 weeks than EET. PTLE are superior to EET and are therefore recommended as initial conservative treatment for PT.

suggested, a direct cause–effect relationship is currently unknown.[5] The nomenclature 'tendinitis' has been replaced by 'tendinopathy',[1] since histopathological studies confirm structural degenerative changes of the tendon tissue as the key feature, with minimal presence of inflammatory cells.[6 7] Anti-inflammatory treatment options are, therefore, discouraged and these have proven ineffective for tendinopathy.[8]

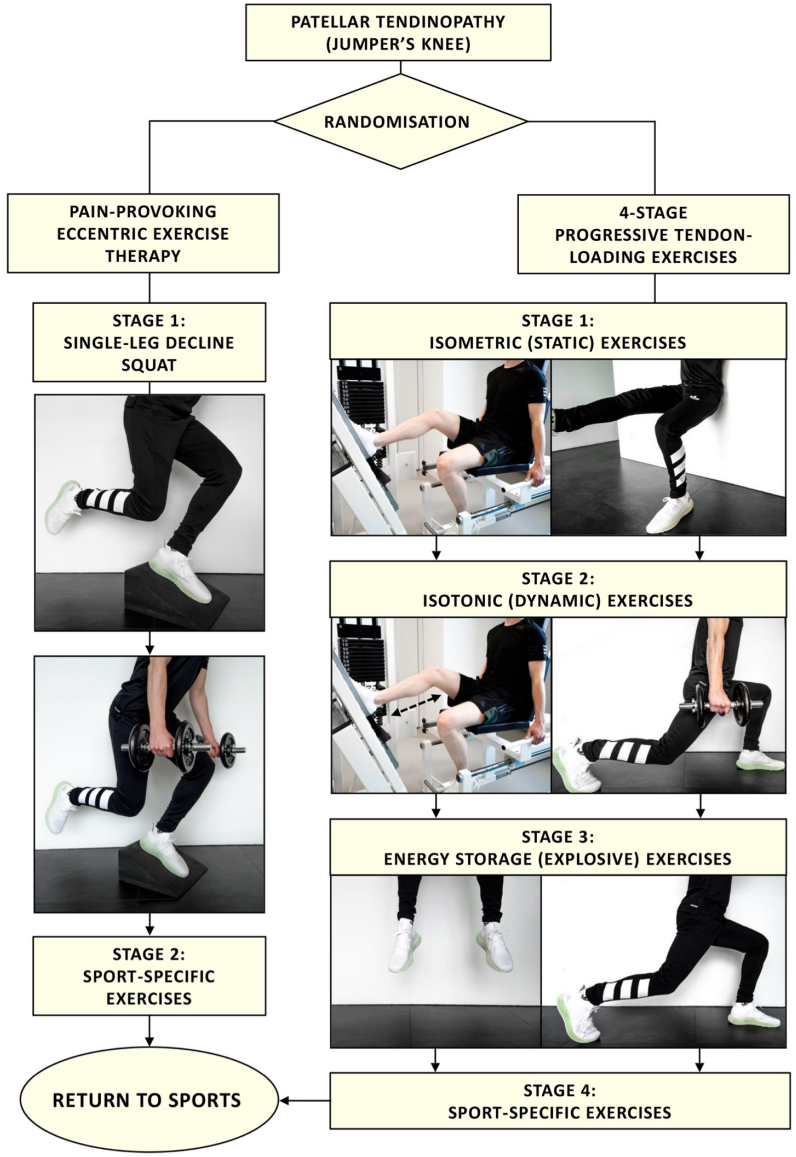
Eccentric exercise therapy (EET) has strong evidence of effectiveness for PT and is also supported in guidelines by the National Institute for Health and Care Excellence (NICE), London, UK.[9 10] However, EET is pain-provoking and the therapeutic effects on pain and functional outcome are debated when applied during the competitive season.[11] A recent review proposed an alternative exercise therapy for PT consisting of progressive tendon-loading exercises (PTLE) within the limits of acceptable pain.[3] To date, it is unknown how the effectiveness of PTLE compares to EET.

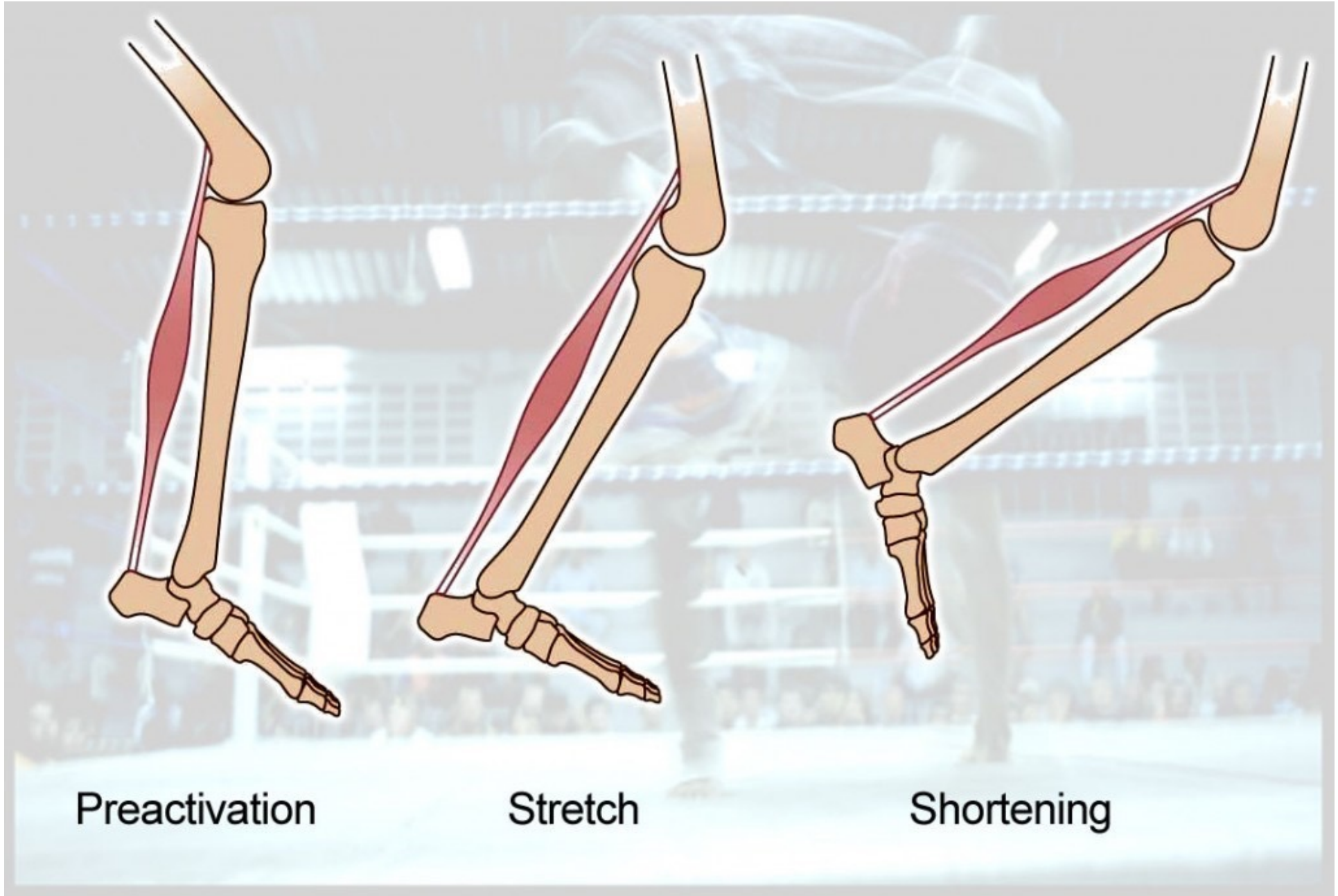
The aim of our stratified, single-blinded, block-randomised controlled trial was to compare PTLE and EET based on clinical outcome after 24 weeks in patients with PT.

METHODS

Trial design

The JUMPER study was a stratified, investigator-blinded, block-randomised controlled trial that included recreational, competitive and professional athletes with PT. The trial was conducted at a university medical centre in The Netherlands. The study protocol was registered on ClinicalTrials.gov (ID: NCT02938143) prior to recruitment. All patients provided written informed consent.


PATELLAR TENDINOPATHY
(JUMPER'S KNEE)
RANDOMISATION
PAIN-PROVOKING
ECCENTRIC EXERCISE
THERAPY
4-STAGE
PROGRESSIVE TENDON-
LOADING EXERCISES
STAGE 1:
SINGLE-LEG DECLINE
SQUAT
STAGE 2:
SPORT-SPECIFIC
EXERCISES
RETURN TO SPORTS
STAGE 1:
ISOMETRIC (STATIC) EXERCISES
STAGE 2:
ISOTONIC (DYNAMIC) EXERCISES
STAGE 3:
ENERGY STORAGE (EXPLOSIVE) EXERCISES
STAGE 4:
SPORT-SPECIFIC EXERCISES


Preactivation
Stretch
Shortening

Strengthening

- Eccentric only
- Partial ROM
- Velocity adding
- Freezing
- Amortization

PERFORMANCE ENHANCEMENT

- Tendon loading sequence
- Skill training
- Visual and Auditory cues
- Running
- Dual task
- Image training

Redefine ‘Plyometrics’

- eccentric muscle action suddenly terminated in an explosive isometric contraction
- a powerful myotatic reflex
- a sharp extension of the passive components of the muscle complex
- a subsequent explosive concentric contraction

Here is How We Apply Them to Training