Loading strategies and Chiropractic management for connective tissue injuries

Brian Healy, DC, MPT

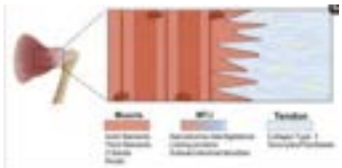
2025 GLOBAL SYMPOSIUM

Objectives

- Howcan chiropractors maximally benefit athletes for rehab and performance specifically of connective tissue?
  - Review the impact of CT injuries
  - Discuss common practices in rehab and performance
  - Review our understanding of connective tissue architecture and mechanical force propagation?
  - Howcan we match rehab and performance loading plans to produce specific adaptations?
  - Benefits ofthe Sports Chiropractor

Sports Injury Prevalence

- Connective Tissue Injury rates continue to rise
  - Ligament (ACL, UCL, PCL, MCL, ATFL)
  - Tendon (Achilles, Patella, RTC, Hamstring)
  - Muscle Strains
    - 1 in 8 strain injuries were of skeletal muscle
    - strain injuries occurred at junction to collagenous connective tissue with majority occurring at MTJ
    - Wilk et al 2019



Tong et al 2023

CT injuries plague athletes

- **Patella Tendinopathy**
  - **Basketball**: 18.9% of elite basketball players and 19.7% of nonelite basketball players have PT
  - **Volleyball**: 45% of elite volleyball players have PT
  - **Soccer**: 13.4% of young elite soccer players have PT
- **Achilles tendinopathy / tendon ruptures**
  - Competitive athletes have a 24% lifetime risk of Achilles tendinopathy.
  - In one study, 11.6% of male professional football players experienced Achilles tendinopathy.
  - In another study, 21.9% of university soccer players experienced Achilles tendinopathy.
  - In the NFL, the rate of Achilles tendon ruptures doubled from 2009 to 2016.
  - In a Finnish study, the incidence of Achilles tendon ruptures increased significantly over 30 years.

Hamstring Injury Trend

NFL – on average 176 per season

Most common injury

75% of injuries result in missed playing time

2021 NFL launched 4 million dollar research project with University of Wisconsin

MLB

2011 - 1 in ever 39 games

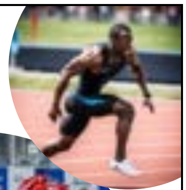
2016 - 1 in every 30 games

UEFA Elite Football Club

The proportion of injuries diagnosed as hamstring injuries increased from 12% in 2001/02 to 24% in 2021/22.

Around 18% of all reported hamstring injuries were recurrences with over two-thirds occurring within 2 months of the footballer's return to play

The Cost of Performance is Health



Common Practices Of Strength and Conditioning

Goals

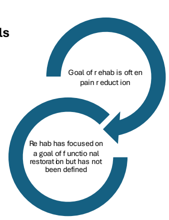
- Improve Strength
- Improve Power
- Improve Endurance
- Improve Mobility

Practices

- Target Muscle Groups
- Target Motion
  - (Hor Push/Pull, Vertical Push/Pull, Carry, Squat, Hinge, Lunge)
- Sport Specific

Common Practices of Rehab

Goals



Practice

- Common Exercises for Muscle Groups
- Functional Exercises
- Corrective Exercises
  - EMG based
  - Motor Pattern
- Protocols (ACL, RTCR, etc)

New Frame of Loading Practices

- Goal is balance of structural/architectural changes, neural changes, and tissue behavior changes
  - Connective Tissue architectural changes that occur following specific loading
    - Material - Composition, cross linking, etc
    - Morphological - CSA
  - Muscle changes
    - Sarcomeres in series or in parallel
  - Neural changes
    - Can occur at level of cortex, spinal cord, and NMJ
    - increased central motor drive, elevated motoneuron excitability, and reduced presynaptic inhibition

New Framing of Training

Skill is an emerging outcome and are dependent on the parts of the system

- Sports skills ie (shooting, dribbling, throwing)
- Movement
- Strength

Strength emerges from parts of the system

- Anatomy
- Neurology
- Endocrine
- Physiology
- Immunological
- Biochemical

Anatomical and Physiological Considerations

- **Continuity of connective tissue is beyond our previous expectations**
- **In series architecture**
- **Functional unit of the body**
- **Connective tissue is a rich source for afferent feedback**

van der Wal J. The architecture of the connective tissue in the musculoskeletal system-an often overlooked functional parameter as to proprioception in the locomotor apparatus. Int J Ther Massage Bodywork. 2009 Dec 7;2(4):9-23. doi: 10.3822/ijtmb.v2i4.62. PMID: 21589740; PMCID: PMC3091473.

Anatomical and Physiological Considerations

- Mechanotransduction / Mechanobiology
  - **Longitudinal Force Transmission**
    - has been focus on many biomechanical models demonstrating collagen along with basal lamina create shear linkage between muscle fibers and tendon
  - **Lateral Force Transmission**
    - The ECM intramuscular connective tissue (IMCT) network allows forces to be distributed across the muscle, reducing stress on individual fibers Lateral force transmission also helps to:
    - Synchronize the contraction of fibers that may be activated at different times or to varying degrees.
    - Maintain fiber alignment and structural integrity.
    - Allow force generation even when some fibers are damaged or interrupted during growth.
- Zhang, C., and Gao, Y. (2012). Finite element analysis of mechanics of lateral transmission of force in single muscle fiber. *J. Biomech.* 45, 2001–2006. doi: 10.1016/j.jbiomech.2012.04.026

Behaviors and Structural Adaptation

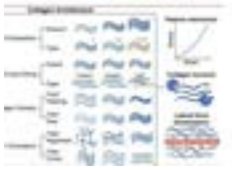
- Maximal Force Production
  - Neural drive
  - Muscle CSA
  - ECM architecture
    - Ability to transfer force efficiently
    - Afferent feedback can alter excitability of motoneurons at spinal/cortical level affecting force production

Behaviors and Structural Adaptation

- Rate of Force Production
  - Pennation angle
  - Long muscle length (sarcomeres in series)
  - Muscle Fiber Composition
  - Tendon Stiffness/Elasticity
  - Muscle CSA
  - Neural drive

Behaviors and Structural Adaptation

- Stiffness / Elasticity
  - Tendon
    - Structural Changes
      - Increase in cross-sectional area
    - Material Changes
      - Composition
      - Crosslinking
      - Fiber alignment
      - Hydration levels
  - IMCT
    - Increased collagen
    - density
    - Orientation



Wohlgemuth et al 2023

Loading Variables

Type
Isometric, Concentric, Eccentric

Intensity
% of 1RM

Direction
Angle Specific (Short vs Long Muscle Length)

Tempo
Repetition (example 3:1:3)
Power
Plyometric
Isometrics

Duration
TUT

Volume
Total for session
Total per tissue per session

Frequency
Stimulating, De training, retraining

Isometrics

- Highly versatile
- Pain modulation
- Control range of motion for specific tissue loading
- Muscle hypertrophy –
  - Stimulates collagen synthesis and sarcomerogenesis
  - Increased hypertrophy at longer muscle lengths
- Varying practical application based on type
  - HIMA vs PIMA
  - Ballistic Catches and Pulses
  - Neuromuscular adaptation for rate of force development through ballistic isometrics
- Load is distributed throughout the tissue (Baar 2019)

Oranchuk DJ, Storey AG, Nelson AR, Cronin JB. Isometric training and long-term adaptations: Effects of muscle length, intensity, and intent: A systematic review. Scand J Med Sci Sports. 2019 Apr;29(4):484-503. doi:10.1111/sms.13375. Epub 2019 Jan 13. PMID: 30580468.

Plyometrics

- Increase tendon stiffness
- Increase fascicle length
- Increase muscle CSA
- No difference in muscle stiffness

- Ramírez-delaCruz, M., Bravo-Sánchez, A., Esteban-García, P. *et al.* Effects of Plyometric Training on Lower Body Muscle Architecture, Tendon Structure, Stiffness and Physical Performance: A Systematic Review and Meta-analysis. *Sports Med - Open* 8, 40 (2022). https://doi.org/10.1186/s40798-022-00431-0

Longer Muscle Length

- Sarcomerogenesis in series
- Increased fascicle length
- Increased tendon stiffness
- Increased titan stiffness
- Increased motor unit efficiency recruitment

Oranchuk DJ, Storey AG, Nelson AR, Cronin JB. Isometric training and long-term adaptations: Effects of muscle length, intensity, and intent: A systematic review. Scand J Med Sci Sports. 2019 Apr;29(4):484-503. doi: 10.1111/sms.13375. Epub 2019 Jan 13. PMID: 30580468.

Internal Attention Focus

- Evidence to support activating specific muscle tissue
- Consciously creating loading in specific areas of the tissue
- Can be improved by various feedback mechanisms (verbal and manual cueing

Attentional Focus Cueing: How and When to Use Internal and External Focus Cues to Optimize Exercise Performance, November 2021, ACSM's Health & Fitness Journal 25(6):33-41

Tempo

- Slow tempo creates shear stress near the MTJ
- Slow loading provides strain, reduces cross bridging, can promote loading into tissue that are stress shielded

Wilk M, Zajac A, Tufano JJ. The Influence of Movement Tempo During Resistance Training on Muscular Strength and Hypertrophy Responses: A Review. Sports Med. 2021 Aug;51(8):1629-1650. doi: 10.1007/s40279-021-01465-2. Epub 2021 May 27. PMID: 34043184; PMCID: PMC8310485.

Frequency and Volume

Tsai et al 2024

5 protocols varying in frequency (sessions per week) and volume (TUT) - 90% MVC, 4.5-6.5% strain

- Low Frequency, Low Volume – 2.5 sessions, 3 min per session
- Low frequency, High Volume
- Moderate Frequency, Moderate Volume
- High Frequency, Low Volume
- High Frequency, High Volume – 5 sessions, 5 min per session

All protocols produced increased tendon stiffness, no superior protocol, most change happened in first 8 weeks due to material changes in tendon

Practical Loading of Tendon (IMCT?)

- Tendon rehab and conditioning research is more robust than IMCT
- A significant amount of muscle strain injuries are related to IMCT – (Wilke et al 2019)
- Tendon adapts best to high load high strain
  - Material/Modulus changes occur in weeks/months
  - Morphological/CSA changes occur in months/years
  - Lower load/strain should be considered to match injured tendon healing stage
- Tempo
  - Isometric/slow isotonic exercises improve material/modulus and CSA
    - Joint angle can aid in specific tissue loading
  - Rapid exercise/plyometrics increase stiffness and improve elastic/storage property of CT
  - Rate of Force production should match tendon quality to reduce injury risk through jerk

Lazarczuk SL, Maniar N, Opar DA, Duhig SJ, Shield A, Barrett RS, Bourne MN. Mechanical, Material and Morphological Adaptations of Healthy Lower Limb Tendons to Mechanical Loading: A Systematic Review and Meta-Analysis. Sports Med. 2022 Oct;52(10):2405-2429. doi: 10.1007/s40279-022-01695-y. Epub 2022 Jun 3. PMID: 35657492; PMCID: PMC9474511.

Practical Loading of Tendon (IMCT?)

- Tendon can be stimulated in 5-10 min
- Load magnitude can vary
- Refractory period of ~6-8 hours before another stimulus (paxton et al 2012)

Tendon vs Muscle Training

- Coordination muscle strength tendon stiffness - Arampatzis et al 2020
  - ~200 athletes performed MVIC (average of 5 reps)
  - Achilles and Patella strain %
  - 4.5-6.5% was suggested as ideal tendon strain during MVIC
- Individualized tendon loading protocol - Domroes et al 2024
  - 14 handball athletes and provided %MVC target based on tendon strain of 4.5-6.5%
  - Incorporating a specific tendon loading protocol to induce tendon strain may benefit tendon stiffness and provide protection of athletes

Connective Tissue Injuries

Load > Capacity

Excessive Loading (Overuse)

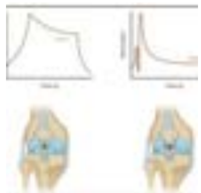
- Force propagated through tissue > tissue loading bearing capacity
  - Imbalance of force generation (neurological drive) to biological tissue ability to absorb and dissipate force
- Not enough recovery time

Unbalanced Loading

- Stress Shielding
  - Inadequate degrees of freedom
  - Microinjuries in tissue

Stress Shielding

- Stress shielding in tendons occurs when weaker tissue regions are protected from mechanical stress by surrounding, stronger tissues.
- **Cellular Level:**
  - Stress shielding causes the fibroblast density in the mid-substance of the tendon to rapidly increase, suggesting an attempt at tissue repair under reduced mechanical load.
- **Molecular Level:**
  - Tenocytes under reduced load downregulate genes related to matrix synthesis, such as those encoding collagen I and decorin. This weakens the extracellular matrix (ECM) and contributes to the progressive loss of mechanical properties
  - Stanczak et al 2024.



Chiropractic Management of Connective Tissue Injuries

- Manual assessment of tissue
  - Soft tissue findings –
    - Abnormal relative gliding
    - Abnormal tension to length
      - Abnormal afferent feedback
      - Decrease efficiency to absorb/transfer force
- Soft tissue manual inputs
  - Create specific submaximal external load on tissue
  - Provide afferent feedback for cueing of subsequent exercise

Chiropractic Management of Connective Tissue Injuries

- Facilitate loading of specific tissue by
  - Reducing guarding
  - manual blocking during loading
  - Verbal and manual cueing during loading

Thank you

Drbrianhealy@outlook.com