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Clinical Management of the Rock Climbing Athlete

Jennifer Sauers, PT, DPT

- Presenter Disclosure: Financial: Jennifer Sauers has received an honorarium for presenting this course. Non-financial: Jennifer Sauers has no relevant non-financial relationships to disclose.
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Jennifer Sauers, PT, DPT

Owner/Founder: Onsight Movement LLC, private PT practice in Las Vegas, Nevada specializing in rock climbers

DPT: University of Maryland, Baltimore

Adjunct Professor: College of Southern Nevada, Anatomy & Physiology

Member: Rock Climbing Special Interest Group (SIG), University of Southern California

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Learning Outcomes

After this course, participants will be able to:

- Describe at least three basic rock climbing terminology and styles of rock climbing.
- Outline at least three rock climbing movement techniques to human biomechanics.
- Identify at least three common injuries found in rock climbing.
- Outline at least two effective injury management strategies each for both the acute and chronic phases.

Why Rock Climbing?

Historically a niche sport, performed outdoors

Surge in indoor climbing gyms last 5 years

- US Gym, Health, & Fitness Club Avg. Growth: 3.0% (2015-2020)
- US Indoor Climbing Wall Avg. Growth: 3.6% (2015-2020)

Oscar-winning film “Free Solo” debuted in 2018

Rock climbing will make its first ever debut in upcoming Olympic games

- Speed, Bouldering, Sport Climbing disciplines

bisworld.com/united-states/market-research-reports/indoor-climbing-walls-industry

Rock Climbing Basics

Rock Climbing Basics

Many different ways to be a climber
- Analogous to field sport athlete vs goalkeeper, marathon runner vs. sprinter

1. The 'Climber Profile'
   - Key interview questions to ask a climber
     - Age, Discipline, Difficulty, Location

1. Climbing Biomechanics
   - Global movement strategies
     - static vs. dynamic
   - Local movement strategies
     - hold types

Rock Climbing Basics

The Climber Profile

Key questions to ask:

1. Age
   - Patient's age versus training age
2. Discipline
   - Bouldering, sport, trad
3. Difficulty
   - Roped climbing (YDS) versus bouldering (V-scale)
4. Location
   - Indoor vs. Outdoor

The Climber Profile

(1) Age

How old is the individual and how long has he/she been rock climbing?

1. Different injury prevalence in youth vs. adult
   - Epiphyseal growth plate fractures in youth vs. pulley injury in adult
2. Connective tissue adaptations with experience
   - Thicker annular pulleys and joint capsules at 15+ yrs
3. Time for technical skill/ motor control development
4. Time for habit formation. (Schreiber 2015)

The Climber Profile

(2) Discipline

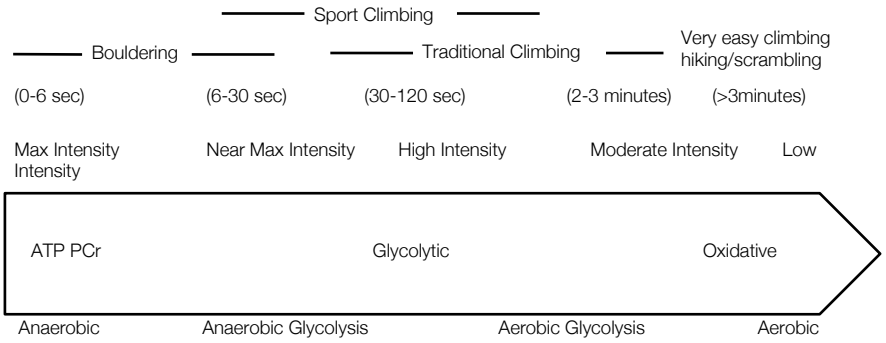
Three most commonly practiced disciplines:

1. Bouldering
2. Sport climbing
3. Traditional “trad” climbing

Difference in energy systems, training methods and technique involved

Can use this information to create sport-specific rehab plans

Energy Systems in Climbing



The Climber Profile

(2) Discipline

Bouldering:

- No ropes used, climbs are about 10-15 feet high
- Short, intense bouts with long rest periods
- Generally associated with greatest amount of power and anaerobic fitness required
- Pad placed on ground for protection when falling
- Can be performed in a gym or outdoors

Q3

The Climber Profile

(2) Discipline

Sport Climbing:

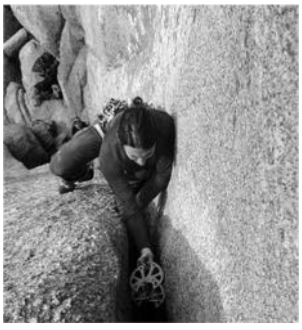
- Rope is required
- Continuous climbing (50 to 100+ feet) with short rest periods
- Rope is placed through carabiners which are clipped into permanently bolted hardware in the rock for protection when falling
- Can be performed in a gym or outdoors

The Climber Profile

(2) Discipline

Traditional “Trad” Climbing:

- Rope is required
- Continuous climbing (50 to 100+ feet) with moderate rest periods
- Individual places a device into the rock to protect when falling, and removes the gear when climb is complete
- More involved gear management
- Cannot be performed in a gym



The Climber Profile

(2) Discipline

Other:

- Top Roping
- Multipitch Climbing
- Speed Climbing
- Crack Climbing
- Aid Climbing
- Ice Climbing
- Free Soloing

The Climber Profile

(3) Difficulty

Yosemite Decimal System (USA)
Roped Climbing (sport and trad)

5.5----------5.15

5.5-5.8: Beginner
5.9-5.11: Intermediate
5.12-5.13: Advanced
5.14+: Elite

The Climber Profile

(3) Difficulty

Bouldering (USA)

V0----------V16

V0-V2: Beginner
V3-V6: Intermediate
V7-V10: Advanced
V11+ Elite

The Climber Profile

(4) Location

Indoor vs. Outdoor

Indoor-only (gym) climbers

- Susceptible to overtraining and increased volume

Outdoor-only climbers

- Logistical approaches may require more endurance/ hiking
- Potentially less volume outdoors

Rock Climbing Basics

The Climber Profile *Recap*

Key questions to ask:

1. Age
   - Patient's age versus climbing age
2. Discipline
   - Bouldering, sport, trad
3. Difficulty
   - Roped climbing (YDS) versus bouldering (V-scale)
4. Location
   - Indoor vs. Outdoor

Biomechanics of Rock Climbing

What Makes A Rock Climber Successful?

Journal of Exercise Science & Fitness
Determinants for success in climbing: A systematic review
(Saul et al. 2019)

Compared with non/novice climbers, advance/elite climbers have:

- Increased whole-hand grip strength
- Stronger and more efficient finger flexor muscles
- Better postural stability & control
- Low skinfold thickness, low body fat, & large forearm volume
- Psychological: "Iceberg Profile"

Global Movement Strategies:

- Unequal weight distribution side to side
- Usually 3 points of contact at any given time
- Series of isometric holds between movement:
  For slower, static climbers: ~7-9 seconds
  For faster, dynamic climbers: ~3-5 seconds
- Footwork techniques allows for conservation of energy & upper body capacity

Global Movement Strategies

Static vs. Dynamic

Static Climbers:

- Smooth, fluid weight shifting and movements
- Slow transitions
- Longer isometric hold in between movements (7-9 sec)
- Typically associated with sport/trad climbing, though not always the case

Dynamic Climbers:

- Choppy, quick movement
- Powerful transitions
- Shorter isometric hold in between movement (3-5 sec)
- Typically associated with bouldering

Global Movement Strategies

Static Climber

Global Movement Strategies

Dynamic Climber

Local Movement Strategies

Climbing Holds

Crimp: A small edge using only the fingertips

- Open hand
  - PIP joint >90° flexion with DIP joint in flexion
- Half crimp
  - PIP joint at 90° flexion with DIP joint in neutral
- Full Crimp
  - PIP joint < 90° flexion with DIP joint hyper-extended

(Cooper, 2019)

Local Movement Strategies

Crimp Grip

Open Hand

Half Crimp

Full Crimp

Local Movement Strategies

Climbing Holds

Jug

Sloper

3-Finger Pocket

2-Finger Pocket

Mono Pocket

CONTINUED

Local Movement Strategies

Climbing Holds

Gaston

Undercling

Internal rotation and abduction of shoulder

Engages biceps

CONTINUED

Rock Climbing Injury Considerations

Climbing Injury Trends

Wilderness & Environmental Medicine
Injury Trends In Rock Climbers: Evaluation of a Case Series of 911 Injuries Between 2009-2012
(Shoffl et al. 2015)

Acute vs. Chronic

1998-2001:
51% acute
49% overstrain

2009-2012:
41% acute
59% overstrain

Climbing Injury Trends

Wilderness & Environmental Medicine
Injury Trends In Rock Climbers: Evaluation of a Case Series of 911 Injuries Between 2009-2012
(Shoffl et al. 2015)

Body Region:

1998-2001: (n-=604)
67% upper extremity
12% lower extremity
20% other

2009-2012: (n=911)
91% upper extremity
6% lower extremity
2% other

CONTINUED

Climbing Injury Trends

Wilderness & Environmental Medicine
Injury Trends In Rock Climbers: Evaluation of a Case Series of 911 Injuries Between 2009-2012
(Shoffl et al. 2015)

Injury by body part

1998-2001: (n=604)
41% Finger
5% Shoulder
13% Forearm and elbow

2009-2012: (n=911)
52% Finger
17% Shoulder
9% Forearm and elbow

Q5

CONTINUED

Climbing Injury Trends

Wilderness & Environmental Medicine
Injury Trends In Rock Climbers: Evaluation of a Case Series of 911 Injuries Between 2009-2012
(Shoffl et al. 2015)

Finger Injury

1998-2001: (n-=604)
49% pulley injury
17% tenosynovitis
15% joint capsule strain
0.8% epiphyseal fracture*

2009-2012: (n=911)
30% pulley injury
18% capsulitis
16% tenosynovitis
3.4% epiphyseal fracture*

*seen in youth

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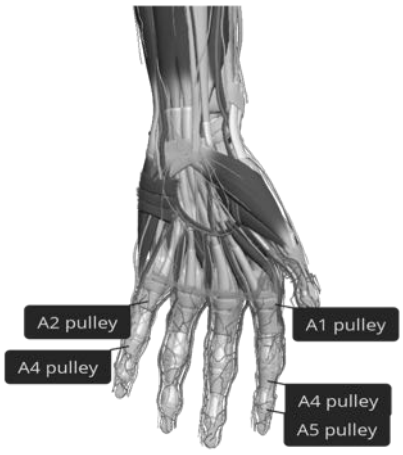
Annular Pulley Injury



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Journal of Hand Microsurgery
The flexor tendon pulley system
(Crowley 2012)

Annular Pulley Injury

Relationship between crimp grip position and annular pulley

- PIP Joint flexed >90 degrees of flexion with DIP joint in hyperextension
- Closed crimp position places the most biomechanical strain on A2 pulley than any other grip position
- A2 pulley is most affected, followed by the A4

(Crowley 2012)

Q1

Annular Pulley Injury

Mechanism of Injury

Journal of Biomechanics
The influence of concentric and eccentric loading on the finger pulley system (Shoffl et al. 2009)

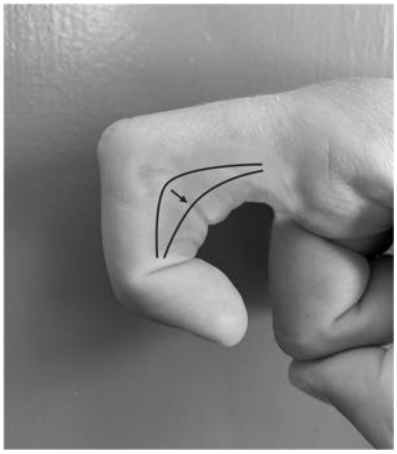
Most commonly caused by an eccentric load:

- Sudden increase in load due to a foothold slipping unexpectedly with hand on a small crimp
- Opening of the hand and fingers into extension
- Tiring of the forearms

Annular Pulley Injury

Symptoms

- May hear an audible "pop"
- Swelling, pain to palpation
- Bowstringing of flexor tendon in severe case of multiple pulley ruptures



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Annular Pulley Injury
Grades 1-IV

Wilderness & Environmental Medicine
Pulley injuries in rock climbers
(Shoffl 2003)

	Grade 1	Grade 2	Grade 3	Grade 4
Injury	Pulley Strain	Complete rupture of A4 or partial rupture of A2 or A3	Complete rupture of A2 or A3	Multiple ruptures (A2/3, A2/3/4) or single rupture (A2 or A3) combined with lumbrical muscle or ligament damage
Treatment	Conservative	Conservative	Conservative	Surgical Repair

CONTINUED

Annular Pulley Injury
Surgical Intervention

Wilderness & Environmental Medicine
Pulley injuries in rock climbers
(Shoffl 2003)

Surgical Intervention for Grade IV Pulley Injury:

- Palmaris longus tendon graft
- Extensor Retinaculum graft

CONTINUED

Annular Pulley Injury
Diagnostics

Wilderness & Environmental Medicine
Pulley injuries in rock climbers
(Shoffl 2003)

Ultrasound in Medicine & Biology
Diagnosis of complex pulley ruptures using ultrasound
(Shoffl et al. 2017)

Diagnostic Ultrasound: gold standard for diagnosing pulley injury

Measured as tendon-bone distance (TBD)

Pulley Strain: <2mm
Complete Pulley Rupture: >2mm

XRay: rule out volar plate avulsion fracture
MRI can be used if US diagnostics are unclear

Q8

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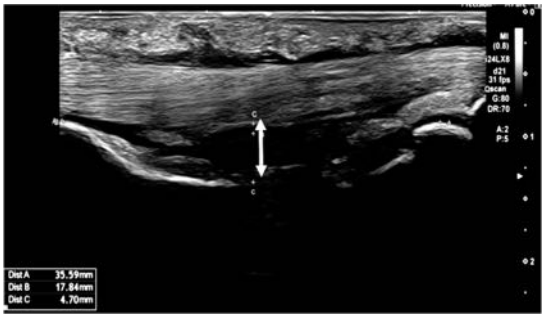
Annular Pulley Injury
Diagnostic Ultrasound



Diagnostics
Grip force measurement as a compliment to high-resolution ultrasound in the diagnosis and follow up of A2 and A4 finger pulley injuries
(Iruretagoiena-Urbieta et al. 2019)

Image: Xeber Iruretagoiena-Urbieta , Javier De la Fuente-Ortiz de Zarate , Marc Blasi, Felix Obradó-Carriedo, Andoni Ormazabal-Aristegi, and Elena Sonsoles Rodríguez-López

High-resolution ultrasound image of complete A2 pulley rupture. Arrow indicates tendon-bone distance at the midpoint of proximal phalanx (4.7mm)

CONTINUED

Annular Pulley Injury

Clinical Diagnostics

Journal of Hand Therapy
A potential classification schema and management approach for individuals with A2 flexor pulley strain
(Cooper 2019)

	Mild	Moderate	Severe
Pain	Daily Living: 0/10 does not limit activity Climbing: ≤2/10 after climbing, only crimp grip is painful	Daily Living: 3-5/10 does not limit activity Climbing: ≥5/10 that limits climbing in all grip positions	Daily Living: 5/10 limits activity Climbing >5/10 that severely limits climbing
Active Range of Motion (AROM)	No pain or ROM loss with AROM	Pain at end range finger flexion with ≤25 % AROM loss	Pain and ≥50% limited ROM with finger bending and straightening
Pain with Resistive Testing	Sloper: 0/10 Half crimp: ≤2/10 Full crimp: ≤2/10	Sloper: <2/10 Half crimp: 2-5/10 Full crimp: 6-8/10	Pain and weakness with any resisted flexor muscle test or grip hand position
Palpation	Minimal pain with full blanching palpation (maximal pressure)	Pain with mild blanching palpation (moderate pressure)	Pain with no blanching palpation (minimal pressure)

CONTINUED

Annular Pulley Injury

Resistive Testing

Open Hand (Top)
Half Crimp (Bottom Left)
Full Crimp (Bottom Right)

Annular Pulley Injury

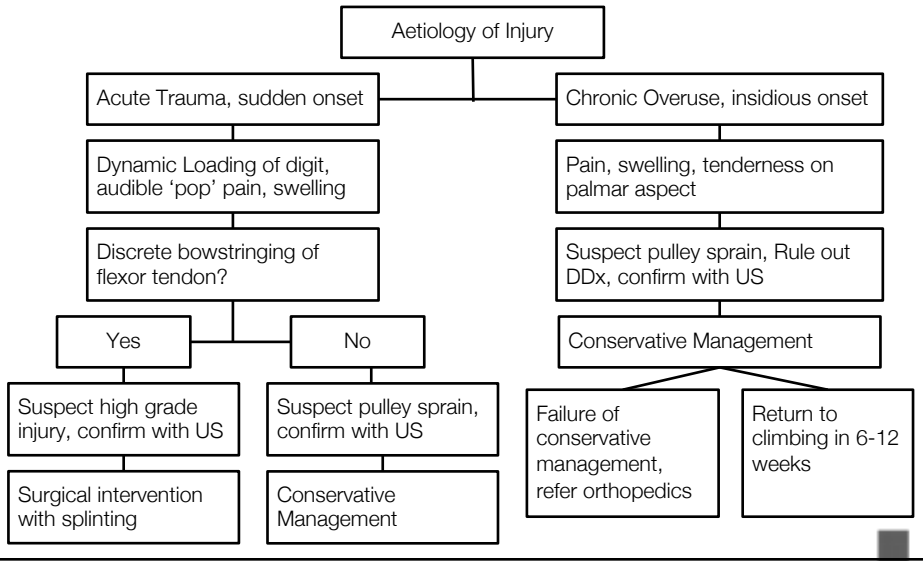
Limitations of Clinical Diagnosis:

- Difficult to rule out differential diagnoses without imaging
- Differential diagnosis of finger pain in climbers:
  - Flexor tendon strain (FDS/FDP)
  - Collateral Ligament Strain
  - Tenosynovitis
  - Volar Plate injury
  - Epiphyseal Fracture

- Climbers may have a combination of injuries

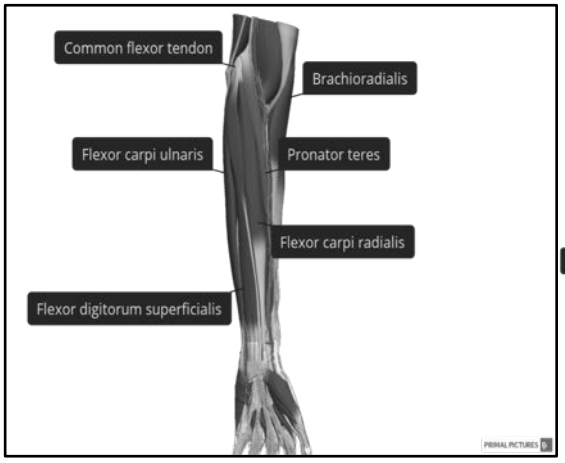
Current Sports Medicine Reports
(Jones et al. 2018)

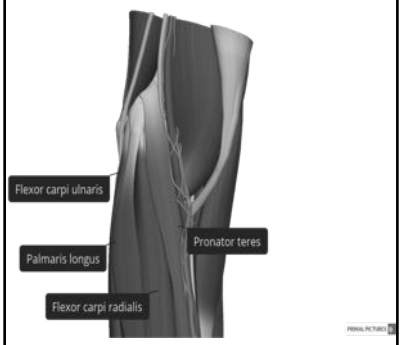
Diagnosis & Treatment Algorithm



Elbow Injuries

- Elbow injuries account for approximately 9% of all injuries (Shoffl et al. 2015)
- Tendinopathies of the elbow:
  - Medial Epicondylosis (sometimes referred to as "climbers elbow")
- Lateral Epicondylosis





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Journal of Bone & Joint Surgery
The role of mechanical loading in tendon development, maintenance, injury and repair
(Galloway 2013)

Elbow Injury

Tendinopathy Concepts

What the research suggests:

- Normal, physiologic loads are required for tendons to maintain homeostasis
- Healthy adaptation occurs when tendons are placed under loads greater than ~70% MVC
- Tendinopathies often result from excessive (overuse) *or* insufficient mechanical loading, impairing the ability of cells to maintain normal tendon function

CONTINUED

Elbow Tendinopathy

Mechanism of Injury

1. Over-gripping and repetitive gripping of climbing holds, leading to strain of common flexor tendon
2. Large volume of climbing - usually indoor - contributes to overuse
3. Constantly bent elbows/ poor technique leads to excessive loading of tendon
4. Routes greater than vertical places more load on upper extremities

Q10

Elbow Tendinopathy
Common Strategies That Lead To Elbow Pain

Climber with Improved Technique

Shoulder Injuries

Shoulder injuries account for approximately 17% of all injuries (Shoffl et al. 2015)

1. SLAP tear (32%)
2. Impingement syndrome of shoulder (25%)
3. Shoulder sprain (10%)

Q4

Shoulder Injury

Mechanism of Injury

SLAP tear
- Traumatic event, fall onto shoulder

Impingement
- Poor rotator cuff strength combined with awkward climbing movements (gastons), disengaged shoulders

Shoulder sprain
- Overuse/degeneration
- Performing overhung/dynamic movement with inadequate strength

Rehabilitation Strategies for Rock Climbers

- Injury Management for Fingers, Elbow, Shoulder
- Therapeutic Exercise For Climbers
- Progressions and Return to Sport Considerations

Pulley Injury - Acute Phase

Immobilization

Wilderness & Environmental Medicine
Pulley injuries in rock climbers
(Shoffl 2003)

Grade I (Mild)
No immobilization needed
Tape finger for 12 weeks, full climbing 6 weeks

Grade II (Moderate)
Immobilize 10 days
Tape finger for 12 weeks, full climbing 6-8 weeks

Grade III/IV (Severe)
Immobilize 10-14 days (or post-surgery for grade IV)
Pulley protection splint until 6 weeks post injury/surgery
Tape finger for 6-12 months, full climbing 3-6 months

Q2

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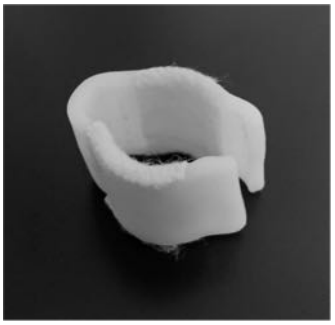
Pulley Injury - Acute Phase

Pulley Protection Splint



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Pulley Injury - Acute Phase

Pulley Protection Splint

Wilderness & Environmental Medicine
Pulley ruptures in rock climbers: outcome of conservative treatment with the pulley-protection splint- a series of 47 cases
(Sneeberger 2016)

Tendon-phalanx distance (mm) before and after treatment using pulley protection splint

Variable	Diagnosis	Follow-Up
A2 pulley (n= 24)	4.4 mm (±1.0)	2.3 mm (±0.6)
A4 pulley (n= 15)	2.9 mm (±0.7)	2.1 mm (±0.5)

Conclusion: The pulley protection splint is an effective conservative treatment modality for pulley ruptures, which reduces tendon-phalanx distances and enable the patient to regain previous finger function

CONTINUED

Pulley Injury - Acute Phase

Therapeutic Exercise

Goals:

- Restore range of motion of the digit
- Ensure proper movement of FDS and FDP tendon through annular pulley

Flexor Tendon Glides

CONTINUED

Pulley Injury - Acute Phase

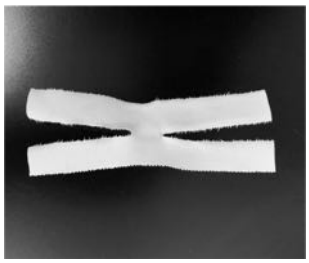
Taping Techniques

Journal of Applied Biomechanics
Impact of taping after finger flexor tendon ruptures in rock climbers
(Shoffl 2007)

- H-Taping has been shown to reduce tendon-bone distance by 16% (using leukotape) compared with circumferential taping
- Prophylactic taping is generally not recommended as it can reduce tendon adaptation for strength

H Taping

H Tape



Circumferential Taping

Q9

Pulley Injury - Late Stage/Chronic

Flexor Tendon Remodeling

- Progress patient to loading of the finger flexors once full finger mobility is restored
- Loading of finger flexor tendons is important for improved capacity and return to sport

Pulley Injury - Late Stage/Chronic

Using A Hangboard

- Allows for longitudinal loading of finger flexors for optimal reorganization of collagen fibers in climbing-specific position
- Commonly used piece of training equipment for climbers
- Modifications are possible based on individual's experience level

CONTINUED

Pulley Injury - Late Stage/Chronic

Determining Load Tolerance

- Start with using body weight, body weight added/removed, or externals weights from ground
- Load tendons slowly for 5-10 seconds, eliciting a low-grade amount of symptoms
- If no symptoms present- add weight
- If pain is intolerable- subtract weight

CONTINUED

Weight Added

Weight Removed (Via Pulley System)

CONTINUED

Pulley Injury - Late Stage/Chronic
Using Tech To Determine Load Tolerance

CONTINUED

Pulley Injury - Late Stage/Chronic
Using Tech To Determine Load Tolerance

Pulley Injury - Late Stage/Chronic

Initial Loading

Purpose: Introduce finger flexor tendons to load

Example Protocol:

- Begin with an open hand grip
- Hang for 5-10 seconds, rest 2-3 minutes
- Repeat 3 sets
- Perform 2-3 times per week

Gradually increase intensity over time as tendon adapts

Pulley Injury - Late Stage/Chronic

Loading Progression

Purpose: Hang/Rest times mimic demands of climbing

Example protocol:

Slow/Static Climber
- 3 sets: 7 second hang, 3 second rest x 5 reps

Fast/Dynamic Climber
- 3 sets: 5 second hang, 3 second rest x 5 reps

Rest 2-3 minutes between sets, 2-3x/week

7 second hang, 3 second rest

Elbow Injury Management

Medial Elbow Tendinopathy- Acute Phase

Activity Modification

Relative Rest

- Decrease climbing volume
- Improve technique: intermittently straightening elbows, movement of hips/focused footwork, refrain from over-gripping
- Climb less than vertical terrain

Medial Elbow Tendinopathy- Acute Phase

Addressing Climbing Technique

Medial Elbow Tendinopathy

Tendinopathy Treatment

What the research suggests:

- Effects of exercise on tendon structure are mixed:
  - Exercise may increase number of collagen cross-linkages (Galloway 2013)
  - Exercise has little to no effect on structural changes (van Ark 2018) (Drew 2012)
- Pathological portion of tendon may not 'heal' or return to normal, but still may be sufficient amount of healthy tissue and aligned fibril structure (Docking et al 2015)

"Focus on the doughnut, not the hole!"

Medial Elbow Tendinopathy- Late Stage/Chronic

Therapeutic Exercise Strategies

- Isometric
- Eccentric
- Heavy Slow Resistance (HSR)

CONTINUED

Medial Elbow Tendinopathy

Benefits of Isometric Loading

- Analgesic effect
- Less fatiguing compared to dynamic strength training
- Optimal when mobility is limited due to pain and/or injury
- Can mimic body positioning during climbing
- Can avoid compressive force on tendons
- Has demonstrated carryover into improved dynamic performance

(Rio 2015) (Lim 2018) (Lum 2019)

CONTINUED

Medial Elbow Tendinopathy

Isometric Exercise

Commonly suggested protocol:

45 second hold x 5 times, 2-3 times per day
Rest 2 minutes between

Progress intensity to 70% MVC as pain allows

(Malliaras 2015)

Medial Elbow Tendinopathy

Isometric Exercise

Isometric Wrist Flexion

Isometric Wrist Pronation

Isometric Bench Press

Isometric Pull Up

Modified Isometric Pull Up

CONTINUED

Medial Elbow Tendinopathy

Eccentric vs. HSR Exercise

- Eccentric exercise has been shown clinically to reduce pain and improve function for those with tendinopathies
  (Alfredson 1998) (Galloway 2013) (Lim 2018)

3 sets of 15 reps, 2x/ day for 12 weeks; increasing intensity over time

- Heavy slow resistance (HSR) exercises have demonstrated good clinical outcomes: correlation to neovascularization of tendon, fibril density & greater long term patient satisfaction

  (Drew 2012) (Beyer 2015) (Kongsgaard 2010)

4 sets of 15 reps, 3x/week; decreasing volume and increasing intensity over time

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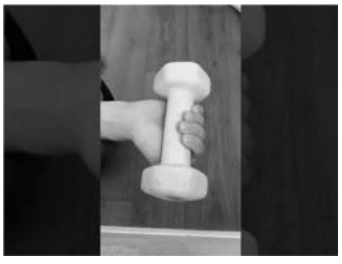
Medial Elbow Tendinopathy

Eccentric Exercise

Eccentric Pronation (top)

Eccentric Finger Flexion (bottom)

Eccentric Wrist Flexion



Medial Elbow Tendinopathy

Heavy Slow Resistance

Exercise in which each rep is performed slowly (~6 seconds total) for both eccentric and concentric phase

Exercise intensity is 70%-85% 1RM, 2-3 times per week

Example:

- Heavy wrist flexion/extension
- Pronation/Supination
- Barbell finger curls

Q7

(Kongsgaard 2010) (Drew 2012)

Shoulder Injury Management

Shoulder Injury- Acute Phase

Activity Modification

Relative Rest

- Consider engaged versus disengaged shoulder
- Decrease overhung climbing
- Limit awkward movements like gastons

Shoulder Injury- Acute Phase

Activity Modification

Engaged shoulders

Non-engaged shoulders

Shoulder Injury

Therapeutic Exercise for Climbers

Considerations for Climbers:

- Unilateral strengthening
- Closed kinetic chain with 3 points of contact
- Rotator cuff strengthening with arms overhead

Shoulder Injury

Therapeutic Exercise for Climbers

Quadruped Shoulder Taps

Turkish Roll Up

Putting It All Together

Exercise Progression + Return To Sport

- Incorporate full body function into upper limb dominant rehab plans
- Collaborate with climbing coach to address technique driven issues
- Dynamic and plyometric upper extremity exercises for return to sport

Putting It All Together

Exercise Progressions To Address Full Body Function

Turkish Get Up

Turkish Sit Up with dual kettlebell

Putting It All Together

Exercise Progressions To Address Full Body Function

Plank Spread

Hanging Alternating Leg Lifts

Q6

Putting It All Together

Exercise Progressions For Return To Sport

Increasing speeds/dynamic training:

- Assisted pull up for speed
- Quick load to finger flexors on hangboard
- Upper extremity plyometrics (advanced)

CONTINUED

Putting It All Together

Speed Drills for Dynamic Climbers

Assisted Pull Ups

Quick Hangs

CONTINUED

Putting It All Together

Upper Extremity Plyometrics for Advanced Athletes

Summary

- Rock climbing is a skill-based sport with different sub-disciplines
- Both acute and overuse upper extremity injuries are prevalent
- Use Climber Profile to assist in diagnosis, injury management, and progression to late stage rehab
- Assess climbers on the wall to address technique issues that may be contributing to their problem

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Q & A

- Questions?