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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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Adjunct Professor: College of Southern Nevada, Anatomy & Physiology

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

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

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

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

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

<table>
<thead>
<tr>
<th>Disciplines</th>
<th>Duration</th>
<th>Max Intensity</th>
<th>Near Max Intensity</th>
<th>High Intensity</th>
<th>Moderate Intensity</th>
<th>Low Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bouldering</td>
<td>(0-6 sec)</td>
<td>ATP-PCr</td>
<td>Glycolytic</td>
<td>Oxidative</td>
<td>Anaerobic Glycolysis</td>
<td>Aerobic</td>
</tr>
<tr>
<td>Sport Climbing</td>
<td>(6-30 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional Climbing</td>
<td>(30-120 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very easy climbing</td>
<td>(&gt;3 minutes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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
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

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

(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?

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
Dynamic Climber

Local Movement Strategies
Climbing Holds

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

Climbing Holds

- Jug
- Sloper
- 3-Finger Pocket
- 2-Finger Pocket
- Mono Pocket

Climbing Holds

- Finger Pocket
- Mono Pocket

Local Movement Strategies

Climp Grip

- Open Hand
- Half Crimp
- Full Crimp
Local Movement Strategies

Climbing Holds

Gaston

Internal rotation and abduction of shoulder

Undercling

Engages biceps

Rock Climbing

Injury Considerations
Climbing Injury Trends

Acute vs. Chronic

1998-2001: 51% acute, 49% overstrain
2009-2012: 41% acute, 59% overstrain

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
Climbing Injury Trends

Injury by body part

1998-2001: (n=604) 2009-2012: (n=911)
41% Finger 52% Finger
5% Shoulder 17% Shoulder
13% Forearm and elbow 9% Forearm and elbow

Finger Injury

1998-2001: (n=604) 2009-2012: (n=911)
49% pulley injury 30% pulley injury
17% tenosynovitis 18% capsulitis
15% joint capsule strain 16% tenosynovitis
0.8% epiphyseal fracture* 3.4% epiphyseal fracture*

*seen in youth
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)
Annular Pulley Injury
Mechanism of Injury

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

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Symptoms

- May hear an audible “pop”
- Swelling, pain to palpation
- Bowstringing of flexor tendon in severe case of multiple pulley ruptures
Annular Pulley Injury
Grades 1-IV

<table>
<thead>
<tr>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury</td>
<td>Pulley Strain</td>
<td>Complete rupture of A4 or partial rupture of A2 or A3</td>
<td>Complete rupture of A2 or A3</td>
</tr>
<tr>
<td>Treatment</td>
<td>Conservative</td>
<td>Conservative</td>
<td>Conservative</td>
</tr>
</tbody>
</table>

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

Annular Pulley Injury
Surgical Intervention

Surgical Intervention for Grade IV Pulley Injury:

- Palmaris longus tendon graft
- Extensor Retinaculum graft
Annular Pulley Injury

Diagnostics

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

Annular Pulley Injury

Diagnostic Ultrasound

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

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

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

Diagnosis & Treatment Algorithm

[Diagram showing the algorithm for diagnosis and treatment of annular pulley injury, with decision points for acute trauma, chronic overuse, pain, swelling, tenderness, discrete bowstringing, high-grade injury, pulley sprain, and management options including surgical intervention, conservative management, and referral to orthopedics.]

Current Sports Medicine Reports
(Jones et al. 2018)
Elbow Injuries

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

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
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%)

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

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

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

Grade III/IV (Severe)
Im mobilize 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
Pulley Injury - Acute Phase
Pulley Protection Splint

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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Diagnosis</th>
<th>Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2 pulley (n= 24)</td>
<td>4.4 mm (±1.0)</td>
<td>2.3 mm (±0.6)</td>
</tr>
<tr>
<td>A4 pulley (n= 15)</td>
<td>2.9 mm (±0.7)</td>
<td>2.1 mm (±0.5)</td>
</tr>
</tbody>
</table>

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.
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

Taping Techniques

- 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

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

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
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
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)
**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)

**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

(Mullinars 2015)
Medial Elbow Tendinopathy

Isometric Exercise

- Isometric Wrist Flexion
- Isometric Wrist Pronation
- Isometric Bench Press
- Isometric Pull Up
- Modified Isometric Pull Up
**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
**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)

(Kungsgaard 2010) (Drew 2012)

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**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
Therapeutic Exercise for Climbers

Considerations for Climbers:
- Unilateral strengthening
- Closed kinetic chain with 3 points of contact
- Rotator cuff strengthening with arms overhead

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

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)
Putting It All Together

**Speed Drills for Dynamic Climbers**

- Assisted Pull Ups
- Quick Hangs

---

**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

References

- Lim HY, Wong SH. Effects of isometric, eccentric, or heavy slow resistance exercises on pain and function in individuals with patellar tendinopathy: A systematic review. Physiother Res Int. 2018;23(4):e1721.
References


Q & A

▪ Questions?