CURRENT CONCEPTS FOR THE MANAGEMENT OF HAMSTRING INJURIES

Brett Guimard DC, DACBSP, CSCS, MAOM, LAc
Disclaimer and Discloser

■ Disclaimer
  – The opinions, viewpoints and recommendations contained in this presentation represent those of the author(s) alone and do not represent the opinions, viewpoints or recommendations of any organization in which the author(s) may be affiliated, including, without limitation, the USOC.

■ Discloser
  – Nothing to Disclose
Current Concepts for the Management of Hamstring Injuries

<table>
<thead>
<tr>
<th>Hamstring Overview</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Anatomy</td>
<td>Function</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hamstring Injuries</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview of Sport</td>
<td>Risk Factors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clinical Management of Hamstring Injuries</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis</td>
<td>Treatment</td>
</tr>
</tbody>
</table>
Hamstring Anatomy and Function

- Two main actions (hip extension, knee flexion)
- Not all hamstrings perform both (biceps femoris short head only performs knee flexion)
- Semitendinosus and biceps femoris (long head) share a proximal origin by way of a conjoined tendon in most people.
- Some studies have found that the semimembranosus also shares this same tendon (Neuschwander et al. 2015).
- When it does have a separate tendon, the proximal tendon of the semimembranosus is located anteriorly and laterally to the shared tendon of the semitendinosus and biceps femoris (long head) (Miller et al. 2007; Philippon et al. 2014; Feucht et al. 2014).
Hamstring Fiber Type

- Hamstring appears to be relatively balanced between type 1 and type 2 fibers
- Medial hamstring have a balance of type 1 and type 2 fibers
- Lateral hamstring may have greater percentage of type 1 fibers

Johnson (1973); Garret (1984); Pierrynowski (1985); Rah mane (2006)
Physiological Cross Sectional Area (PCSA) of the Hamstring Muscles

- PCSA best predictor of muscle strength
- Overall medial hamstring has the highest PCSA.
- Semimembranosus and Biceps femoris long head have the highest PCSA
  - (So both medial and lateral hamstring groups have one muscle with large PCSA and one with smaller PCSA)

Alexander (1975); Wickiewicz (1983); Woodley (2005); Ward (2009); Contreras; Beardsley S&C review (2012)
Normalized Fiber Length (NFL) of the Hamstring Muscles

- Best and most accurate measurement of muscle fiber length
  - (essentially a measurement of the number of sarcomeres in a series)
- Long muscle contract more quickly therefore NFL is a good measurement of how fast a muscle contracts
- Semitendinosus and biceps femoris short head have greater NFL
  - (so both medial and lateral hamstring groups have one muscle with longer NFL and one with shorter NFL)
- NFL and PCSA seem to be inversely related

Ward (2009); Kumazaki (2012); Contreras; Beardsley S&C review (2012)
Pennation Arrangement of the Hamstring Muscles

- Muscles with more complex pennation arrangements tend to have larger pennation angles and more fibers.
- Semimembranosus and biceps femoris long head are have larger pennation angles.
- Semitendinosus is fusiform (longitudinal muscle fibers that are intersected by an intramuscular, tendinous septum which separates the muscle into proximal and distal regions).
- Biceps femoris short head takes the form of a trapezoid with longer muscle fibers on the proximal side and shorter muscle fibers on the distal side.

Kumazaki (2012); Contreras; Beardsley S&C review (2012)
Summary of Structure

When looking at the hamstrings muscle architecture overall they have a relatively long NFL and lower PCSA compared with many other muscles in the body.

Semitendinosus and biceps femoris short head: High NFL, low PCSA – quick contractions over long distances.

Semimembranosus and Biceps femoris long head: Low NFL, High PCSA – Force production.

Architectural diversity allows for more consistent force output over the full hip extension ROM due to hamstring muscle subgroups displaying their peak contractions at different lengths.

- In contrast Quads have much greater architectural similarity.

Hamstrings are very different from each other architecturally and should be trained as such.

- Do to architecture and fiber type hamstrings must be train with a verity of exercise
- Hamstrings should be trained at both high and low velocity

- Research suggest that the two hemi-pennate muscles experience greater individual muscle fiber lengthening in repose to normal range of motion hamstring lengthening placing them at greater risk for strain.

Kellis (2012), Blazevich (2006), Kumazaki (2012); Contreras; Beardsley S&C review (2012)
Hamstring Injury Occurrence in Sport
In a group of national level sprinters from Hong Kong, hamstring injuries accounted for 50% of all injuries (Yeung et al. 2009).

In terms of hamstring injury rate, Yeung et al. (2009) found in their sprinter subjects that hamstring injuries occurred roughly 0.87 times per 1000 training and competition hours (sprinter training two hours a day, five times per week, will likely have a hamstring injury once every two years).

The IAAF reports that 48% of all injuries within the 2011 World Athletics Championships were hamstring injuries (Alonso et al. 2012).

Data from a 3-year injury surveillance study at the Penn Relays monitored acute injuries in large scale track and field competitions (Cohen, Drezner)
  
- Hamstring muscle injury was the most common orthopedic injury
- represented 74% of all muscle strains.

Re-injury rate for hamstrings in sprinters has been show in the literature to be 38%

Sprinters who had incurred previous hamstring injuries had significantly less hamstring flexibility when compared to uninjured sprinters (Johnhagen. 1994)
Incidents of hamstring strains over a 10 year period

- 1716 strains at a rate **0.77 injuries per 1000 hours** of sport exposure
- More than **half of the injuries (51.3%) occurred** during **7 week preseason**
- **Most commonly injured positions** were **speed positions** (defensive secondary 23.1%; wide receivers 20.8%, and running backs 12.3%)
- **16.5% of total** hamstring injuries **were re-injuries**
- During preseason re-injury rate was **12.7% for practice; 17.6% for games**
- **Main season re-injury rate rose** 22.0% for practice; 19.1% for games
- **Non-contact sprinting** was the most common mechanism of hamstring injury in NFL players; accounting for over **68% of all** hamstring strains.
- Statistics show that they occur in the NFL, on average, **176 times per season** (more than 5 injuries per team, per season)

Elliott (2011)
Rugby  (English Professional Rugby Union)

- Brooks (2006) reported incident of hamstring injury was 0.27 per 1000 player training hours
- 5.6 injuries per 1000 player match hours
- **68%** of the injuries were during running activity
- **23%** of all hamstring injuries were re-injuries
- Re-injuries estimated **25 days of lost time**
- New injuries estimated **14 days lost time**
Soccer
(or football in the majority of other countries)

- Hamstring strains accounted for 12% of all injuries over the two seasons
- 53% percent of the injuries were **long head of biceps femoris**
- 57% of the strain were **during running**
- Hamstring **re-injury rate** was **12%**
- In soccer hamstring strains are **1.7 times more likely to reoccur** then other injuries
- One study of elite soccer players reported a **50% prevalence** of hamstring strain
- Another study showed in professional soccer, **hamstring injuries account for roughly 1 in 5 of all injuries** (Petersen & Holmich 2005).
Australian Football

Orchard (2002) performed a study describing the epidemiology of injuries recorded in the Australian football league over 4 seasons.

- Hamstring strains represented 15% of all injuries.
- Averaged 6 injuries per club per season.
- Hamstring injuries had the highest reoccurrence rate of all injuries.
- 2x as likely to be recurrent than other injuries.
Long Term Effects

MRI Analysis of 14 athletes with a history of hamstring strain at least 5 mos prior, all fully rehabilitated and returned to sport for at least 1 month showed:

- 13/14 atrophy of long head biceps femoris with corresponding hypertrophy of biceps femoris short head
- 11/14 showed scar tissue at musculotendinous junction
- 2/14 had fatty infiltration of long head biceps femoris

Hypothesis:
“Scar tissue may increase the overall mechanical stiffness of the tissue it replaces, which may require the muscle fibers to lengthen a greater amount to achieve the same overall musculotendon length relative to a pre-injury state.”
Overview/Summery of Hamstring Injuries in Sport

<table>
<thead>
<tr>
<th>Prevalence among athletes ranges from 12%-50%, depending on the group studied</th>
<th>Biceps femoris most commonly injured</th>
<th>Semimembranosus relatively high rate, second to biceps femoris</th>
<th>57-68% of strains occur during running</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprinters and athletes in “speed positions” seem to have the highest incidence of hamstring injuries</td>
<td>Hamstring injuries tend to be more reoccurring then other injuries</td>
<td>Days lost due to strain range from 7-25, depending on severity &amp; location of injury</td>
<td>Long term effects of hamstring injuries</td>
</tr>
</tbody>
</table>
At Least Two Different Mechanism of Hamstring Strain Injury

**Stretching Action**
- During excessive lengthening of the hamstring (kicking slide tackle, sagittal splitting)
- Occur close to the ischial tuberosity and typically involves tissue of Semimembranosus
- Reduction of knee flexion strength to 80% of pre-injury levels
- Dancers took a median of 50 weeks to return to preinjury performance levels

**High Speed Running**
- During high speed running
- Long head of the biceps femoris. Usually aponeurotic or muscle belly, proximal more common than distal
- Reduction of knee flexion strength to 40% of pre-injury levels
- Sprinters took a median of 16 weeks to return to previous performance levels

Hamstring More at Risk During Early Stance or Late Swing Phase?

**Stance**
- Strong concentric contraction to counter breaking forces to produce hip extensor movement for propulsion. Orchard (2012)
- Greater force

**Late Swing**
- Maximum hamstring length occurs during late swing phase
- Biceps Femoris increased in length more than other muscles (9.5-12.2% compared to 7.5-8.3%). Thelen (2005); Chumanov (2007); Riley (2010); Schache (2012)
- Energy absorbed in late swing increases with running speed (force during stance does not). Chumanov 2012
- Active lengthening with eccentric load produces more muscle damage. Liber (1993)
- Hamstring contributed to the majority of hip extension and knee flexion torques in late swing phase.
  - *Gluteus max contributed to majority of hip extension in stance phase.* Schache (2010)
- *(presenters note on stance vs late swing phase)*
Risk Factors for Hamstring Injury
(appear to be multifactorial)

- Previous Injury
  (#1 risk factor)
- Ethnicity
- Age
- Architecture
- Fatigue
- Flexibility
- Muscle Imbalance/Strength
Risk Factor for Hamstring Injury

- **Previous Injury** – Previous injury both within the hamstring muscles and surrounding muscles and structures increases the chance of injury.
  - *Previous hamstring strain is the #1 risk factor in a large number univariate and multivariate analyses*
  - *Koulouris et al. (2007) found that following anterior cruciate ligament (ACL) reconstruction surgery, the risk of a hamstring injury was significantly elevated.*
  - *Study on Australina Rules football showed previous calf injury significantly increased contralateral hamstring injury*

- **Architecture** - Research suggest that the two hemi-pennate muscles experience greater individual muscle fiber lengthening in repose to normal range of motion hamstring lengthening (placing them at greater risk for strain). Kumazaki (2012)

- **Muscle Fatigue** – Woods et al. (2004) found that significantly more hamstring injuries occur towards the end of a game, indicating that muscle fatigue plays a role in hamstring injury. Pinniger et al. (2000) demonstrated that repeated sprint bouts reduced hamstring function, meaning that the fatigued hamstring muscles could absorb less energy before reaching the level of stretch that caused injury.
Risk Factor for Hamstring Injury

- **Imbalance of Muscular Strength** – Orchard et al. (1997) found that if the quadriceps were much stronger than the hamstrings, this increased the risk of a hamstring injury. They found that a ratio of below 0.6 for hamstring:quadriceps strength increased the risk of injury.
  - *This ratio was mirrored in the Yeung et al. (2009) study on sprinters; the researchers found that if the ratio was below 0.6, then hamstring injury was seventeen times more likely to occur.*

- **Flexibility** – Harting et al. (1996) found that hamstring flexibility reduced the risk of injury in a group of military recruits. This finding is a little controversial, as there are also a some studies that illustrate that lack of hamstring flexibility does not increase the risk of injury and hip flexor length may be a better identifier as a risk factor.

- **Age** – One study showed risk increased annually by 30%
  - *Has only really been shown to be a risk factor in univariate analyses. Multivariable analyses did not identify age as a risk factor*

- **Ethnicity** – Higher incident of hamstring injuries and athletes of African and Aboriginal decent

Insufficient warm up, recovery period and hydration, core strength
Theories to Consider During Examination and Rehabilitation

Muscle Imbalance

Joint Position
Muscle Imbalance

Quadriceps to Hamstring Strength Ratio may be Significant

Comparing Eccentric Hamstring Strength to Concentric Quadriceps Strength Appears to be an Indicator of Injury Risk

Synergist weakness?
Joint Position Theory

Tight hip flexors pull pelvis into anterior tilt.

Anterior tilt increases hamstring stretch at ischial attachment.

Altered length tension curve for hamstring group leading to higher risk of injury.

Cibulka 1986
One study demonstrated a 100% incidence of sacroiliac joint dysfunction in patients with hamstring strain.

Also showed that correcting SIJ dysfunction with manipulation resulted in immediate increase in peak hamstring torque.

Author concluded that the assessment of SIJ dysfunction should be part of the hamstring treatment approach.

A 1993 manuscript in the British Journal of Sports Medicine showed that increased lordosis was a better predictor of hamstring strain risk than hamstring flexibility.
Lower Cross Syndrome

- **Patient Presentation:**
  - Ant Pelvic Tilt
  - Compensatory Increased Lordosis
  - TL Junction Instability
Flexibility – quadriceps & hip flexor flexibility appears to be more important than hamstring flexibility

- Tight hip flexors may create higher potential energy.
- This generates increased forward propulsion during swing phase due to passive recoil.
- Effectively increases the eccentric load on hamstrings to decelerate the limb.

Petersen 2005
Summery of Theory and Risk Factors for Hamstring Injuries

Hamstring appears to be more at risk during late swing phase

Stretch related hamstring injuries have less functional deficit at initial injury however require longer RTS time.

Current theories for hamstring strain are supported by risk factors identified in the literature

Risk factors are multifactor
  - Modifiable risk factors include:
    - Muscle imbalances
    - Strength
    - Fatigue resistance
    - Joint position
Diagnosis of Hamstring Injury

- Max amount of pain on 1-10 VAS was associated with more significant findings on MRI and more days lost from sport
- It has been demonstrated in running athletes that the closer the pain on palpation to the ischial tuberosity the longer the time for recover
- Length of palpable tenderness did not correlate to prognosis
- Remaining strength defects on clinical exam had higher reinjury rate

Verrall (2003), Askling (2007), Malliaropoulos 2010
## Taking Off the Shoe Test

<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
<th>Positive Finding</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taking-off-the-shoe test</td>
<td>In standing, the patient is asked to take off the shoe on the affected side with the help of his/her other shoe. While performing this maneuver, the affected leg hindfoot must press the longitudinal arch of the noninvolved foot. The affected leg during the maneuver is in approximately 90° of external rotation at the hip and 20° to 25° of flexion at the knee.</td>
<td>The feeling of a sharp pain over the injured biceps femoris.</td>
<td></td>
</tr>
</tbody>
</table>

100% sensitive and specific for biceps femoris strain
Knee Active ROM Defect

- **Knee Active ROM Defect**
  - Athlete is supine knee of uninjured leg is brought to 90 degrees of hip flexion
  - Leg is actively straitened while ipsilateral glute remains on the table
  - Knee flexion angle is measured
  - Repeat on injured side

- Findings less then 20 degrees difference injured vs. uninjured had better prognosis
  - Less then 2 week RTS

- Greater then 30 degree difference injured vs. uninjured had much worse prognosis
  - Greater then 6 weeks RTS
Modified Thomas Test

- Knee extension → Rectus Femoris
- Hip Flexion → Iliopsoas
- Tibial Ext Rotation → TFL/G Max/ITB

Athletes who can achieve > 51 degrees knee flexion in modified Thomas position

*70% Decreased Injury Risk

Gabbe BJ, 2006
Diagnosis

Inspection

• Deformity in severe cases with visible retraction of muscle or tendon
• Bruising Presence of bruising indicative of at least a Grade 2 Strain

Palpation

• Palpate length of muscle belly for defects
• Palpate bony attachment sites for tenderness
• Avulsion more likely in adolescent population
• Important to differentiate adductor magnus from hamstring group ➔ different treatment & rehabilitation in adductor strains
Diagnosis

ROM
- Check hip flexion in adduction with knee extended for biceps femoris
- Check hip flexion in abduction with knee extended for medial hamstrings
- Pain with passive hip flexion with the knee flexed indicative of adductor strain

Resisted ROM
- Should be performed with the patient prone
- Begin with isometric contractions at neutral position
- Test at different angles of knee flexion in hip internal rotation (medial group) and external rotation (biceps femoris)
- If symptoms cannot be elicited with isometric contractions, add eccentric contractions at various knee flexion and hip rotation angles
- Also check adductor and gluteal groups
Diagnosis

Lumbar/SI Exam

• Biomechanical assessment of sacroiliac joint
• Ranges of Motion
  • Hyperextension testing (Kemp’s or Stork) for facet and posterior element referral
• Neurological Assessment of Lumbar Nerve Roots
  • Sensory
  • Motor
  • Reflexes
• Biomechanical assessment of sacroiliac joint
• Straight Leg Raise/Slump
  • It is not uncommon for a chronic radiculopathy to be mistaken for a chronic hamstring strain
  • Nerve entrapments/adhesions in the posterior thigh have been identified as a cause of pain after hamstring injury
Diagnosis - Imaging

Plain Film Imaging
- Usually not indicated
- Should be performed in skeletally immature individuals with tenderness or deformity at site of attachment
- Plain film only useful to rule out suspected avulsion injury or apophysitis

MRI
- Preferred modality in United States
- More sensitive than MskUS for subacute and chronic strains
- 19 -32% of posterior thigh injuries (suspected hamstring strains) are indetectable on MRI
- In elite athletes, may be used to guide RTP management
Useful MRI Findings for the Diagnosis and Prognosis of Hamstring Muscle Strain Injuries

- **T2 signal hyper-intensity**: Negative suggest injury below threshold to detect and prognostically suggest earlier RTP

- **Injury involving some disruption of the central tendon**: Demonstrates higher grade injury and longer RTS

- **Isolated free tendon end injuries**: Longer rehabilitation time

- **Greater than 50% of muscle involvement on transvers image and a volume of injury greater than 20cm**: Poorer prognosis and higher reoccurrence

- **Crano-cadual length of signal change shown on T2 MRI**: Related to prognosis

Summer for Diagnosis of Hamstring Injuries

Clinical evaluation should include:
- Inspection/ Palpation
- ROM/ RROM
- Lumbar/ SI Exam
- Orthopedic Assessment/ Functional Assessment

There are a few special test shown in the literature that may be useful as part of a hamstring evaluation:
- taking off shoe test
- Knee AROM deficit
- Modified Thomas

MRI may be useful for injury prognosis.
Rehabilitation for Hamstring Injuries

There very few randomized controlled studies in the area of hamstring injury rehabilitation

There are several article with suggested best practices for hamstring injury management

Petersen & Holmich
Rehabilitation (has not changed much since the 50’s)

**Acute**
- RICE
- Short Immobilization
- Pain free motor control
- Address Muscle Imbalance

**Sub-Acute**
- Strengthen In Pain Free Range
- Gradual Lengthening to full ROM
- Myofascial release
- Pain free stretching

**Sport Specific**
- Multi-planar Movement in Full ROM
- Gradually Increase Rate of Force Development
- Gradually introduce dynamic eccentric activity
- Jog → Run → Sprint

**Return to Sport**

Hamilton (2012), Lorenz (2011), Comfort 2009
Acute – Immobilization

- A brief period of immobilization (3-7 days) optimizes scar formation over acute injuries.
- Immobilization for the first few days (3-7) allows the scar to reach a tensile strength that will not allow for re-rupture due to contraction induced forces.
- After a short period of immobilization, gradually mobilizing the tissue allows for scar extensibility, limits fibrosis, and allows for strengthening within a larger functional range.

- Stretching during this period is controversial:
  - Mild stretching (no pain) 4 times a day for the first 3 days has shown to lead to good functional outcomes.
  - Some feel stretching in the acute phase leads to denser scar formation, which may predispose athlete to future injury.

[Figure 2: A schematic illustration of the healing skeletal muscle. Day 2: the necrotized parts of the transsected myofibers are being removed by macrophages while, concomitantly, the formation of the connective tissue scar by fibroblasts has begun in the central zone (CZ). Day 3: satellite cells have become activated within the basal lamina cylinders in the regeneration zone (RZ). Day 5: myoblasts have fused into myotubes in the RZ, and the connective tissue in the CZ has become denser. Day 7: the regenerating muscle cells extend out of the old basal lamina cylinders into the CZ and begin to pierce through the scar. Day 14: the scar of the CZ has further condensed and reduced in size, and the regenerating myofibers close the CZ gap. Day 21: the interfacing myofibers are virtually fused with little intervening connective tissue (scar) in between.]

Jarvinen 2005.
NSAIDS and Soft Tissue Injury

- NSAIDS have not been shown to be beneficial, and may in fact delay healing in soft tissue injury.
Acute Strain Treatment – Strengthening

Hamstring rehab/strengthening beginning with light isometrics on day 3 to 5, and advancing to pain free isotonics

• Low levels of contraction
• Pain is the guide
Acute Strain Rehab - Address Muscle Imbalance

Quad/Hip Flexor Length

- Stretching
- Manual Therapy
- Incorporate new length into functional movements

Synergist Activation

- It has been proposed that hamstring strains can occur due to suboptimal synergist contribution during hip extension.
- Gluteus Maximus is a major synergist to the hamstring during hip extension in sprinting.
- The Adductors function as a hip extensor when the hip is flexed past 70 degrees.
Neuromuscular Control - Low Intensity Balance & Agility Drills

**MUST BE PAIN FREE!**

- Pelvic Control
- Balance and Proprioception
- Carioca Walks
- Lateral shuffles
- Functional Reach
- Squat & Lunge Matrices
Sub-Acute Phase

Primary goal is to regain strength through full pain free range of motion

- Continue to address muscle imbalances while increasing intensity of agility drills
- Manual therapy to help increase scar extensibility
- Use slow eccentrics to stimulate tissue remodeling
- Gradually increase
  - Length
  - Speed
  - External resistance
Manual Therapy

- Functions of Soft Tissue Mobilization
  - Increase scar mobility
  - Decrease inter and intramuscular adhesions
  - Decrease fascial fibrosis
  - Increase local circulation to facilitate exchange of nutrients, oxygen, metabolites

From Meltzer 2010
Eccentric is King

- Use Slow Eccentrics
  - >3 sec eccentric
  - Time under tension theory = greater time under tension gives greater stimulus for muscle remodeling
  - Risk - Eccentrics increase DOMS

- Track and Field – Group of elite Swedish sprinter had significantly better outcome using rehab program with eccentric exercise vs stretch and concentric (Askling 2015)

- Soccer - Effects of eccentric strength training in Elite soccer teams from Iceland and Norway
  - Incidence of hamstring strain was lower in teams who used eccentric training however did not note any effect on teams using stretching program. (Arnason 2008)

- Soccer - Effects of intervention program of eccentric training vs control group for Elite English soccer players
  - Occurrence of hamstring strain in eccentric intervention group was significantly lower than control group. (Askling 2003)

- Rugby - Athletes who performed eccentric hamstring exercises along with stretching had lower incidence and severity of injury during training and competition. (Brooks 2006)

- Large RCT study with Danish soccer athletes showed eccentric exercise significantly decreased injury rates vs. control group
Body Weight

Elastic Resistance

Physio Ball Hamstring Curl

Slide Board Hamstring Curl

Bridge Walk Outs

Romanian Dead Lift

SL Romanian Deadlift

Russian Leans /Glute Ham Raise

RTS / Injury Prevention
Sport Specific Training

- Increase Rate of Force Development
- Retrain Stretch-Shortening Cycle
- Gradually increase external resistance to pre-injury levels
- Gradually increase sprint intensity

*presenters note – hill sprint before flat ground sprints
Overview of EMG Studies of the Hamstrings

Lying leg curls, Nordic/Russian curls and glute-ham raises produce overall high hamstring activation in comparison with squats, good morning and stiff leg deadlifts (exercises which involve knee flexion in hip extension)

Squat do not activate the hamstring significantly (quad activation is much greater than the hamstring)

Medial hamstring has higher activation with kettle bell swings, Romanian deadlifts and razor curls

Lateral hamstrings have a higher activation with leg curls, hip extensions with barbell, and step up variations

Contreras; Beardsley S&C review (2012)
# Exercise Selection

<table>
<thead>
<tr>
<th>Plyometric</th>
<th>Power Development</th>
<th>Strength Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agility Ladder</td>
<td>RDL + Pull</td>
<td>Leg Curl's</td>
</tr>
<tr>
<td>Hops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skips (Form Drills)</td>
<td>Pulls</td>
<td>Lunge &amp; Split Squat</td>
</tr>
<tr>
<td>- A</td>
<td>- From Floor</td>
<td></td>
</tr>
<tr>
<td>- B</td>
<td>- From Blocks</td>
<td></td>
</tr>
<tr>
<td>- C</td>
<td>- From Hang</td>
<td></td>
</tr>
<tr>
<td>Power Skip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral Skip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jumps</td>
<td>Olympic Lifts (Snatch &amp; Clean)</td>
<td>Step Up Variations</td>
</tr>
<tr>
<td>- Onto Box</td>
<td>- From Floor</td>
<td></td>
</tr>
<tr>
<td>- Onto Ground</td>
<td>- From Blocks</td>
<td></td>
</tr>
<tr>
<td>- Repeat Jumps</td>
<td>- From Hang</td>
<td></td>
</tr>
<tr>
<td>- Depth Jumps</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Gradually Increase Sprint Intensity

Acceleration – 10m

Modifiable Intensity

30%
40%
50%

Deceleration – 10m

0.0m

40.0m
Gradually Increase Sprint Intensity

- Acceleration - 30m
- Modifiable Intensity: 60%, 70%, 80%, 90%, 100%
- Deceleration - 30m
Return to Sport
Currently there is no consensus guideline for return to sport following hamstring injury

Consider Clinical Findings
- Pain Free ROM
- Remaining Strength Loss

May be variables in RTS
- Sport
- Athlete Position
- Level of Play

Sims (2015)
**Askling H-test**

- clinical examination – no signs of remaining injury
- knee brace to keep the leg in extension
- straps stabilizing the upper body/contralateral leg
- perform SLR as fast as possible to the highest point
- 3 trials per leg/uninjured leg first/no warm-up
- if experienced any insecurity (VAS) - extended rehab.
Prevention of Hamstring Injuries

Large scale RCT from Danish Football strongly suggest that hamstring injuries can be significantly reduced

942 male soccer players (amateur and professional)

Eccentric Hamstring Prevention Program VS. Control

Injury rate was 71% lower for eccentric group

Even lower for athletes with previous injury (86% lower)

<table>
<thead>
<tr>
<th>Week</th>
<th>Sessions/Week</th>
<th>Sets</th>
<th>Reps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
<td>6 to 8</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>3</td>
<td>8 to 10</td>
</tr>
<tr>
<td>5 to 10</td>
<td>3</td>
<td>3</td>
<td>12, 10, 8</td>
</tr>
</tbody>
</table>

Increase load when athletes can control fall forward.

When Athlete can achieve 12 reps increase load by:

a) Adding speed to starting phase of motion.
b) Have partner push back of shoulders
Summery of Rehab, RTP, and Prevention of Hamstring Injuries

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Immobilization</th>
<th>NSAIDS Usage</th>
<th>Rehabilitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamstring rehabilitation recommendations in the literature have not change much since the 50’s</td>
<td></td>
<td></td>
<td>Immobilization for the first 3-7 is important</td>
</tr>
<tr>
<td>Muscle imbalances need to be addressed</td>
<td></td>
<td></td>
<td>NSAIDS should not be used in the acute stage of injury</td>
</tr>
<tr>
<td>Train power development with Olympic lift variations and jumps to increase eccentric→concentric capacity</td>
<td></td>
<td></td>
<td>Rehabilitation should be progressive, pain free, include neuromuscular control, strength, power, plyometric training</td>
</tr>
<tr>
<td></td>
<td>Manual therapy is important for proper tissue healing</td>
<td>Prevention programs do work <em><strong>A program of Russian Leans/Nordic Hamstrings appears to be one of the most effective methods of decreasing hamstring strain incidence</strong></em></td>
<td></td>
</tr>
</tbody>
</table>
Hamstring strains are a common injury in sport

Re-injury rates suggest that rehabilitation is not adequate

Several risk factors for hamstring strain have been identified and are modifiable with treatment and active care

Muscle function, architecture, and fiber type should be considered when developing a rehab plan

Rehabilitation which involves eccentric loading and muscle lengthening appears to have the best outcomes

Injury prevention of hamstring injury appears to be possible with appropriate exercise intervention