Prevention and Rehabilitation of Hamstring Strains in Football Players

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Disclosure

I have nothing to disclose
Presentation Goals

- Hamstring strain incidence
  - NFL
- Identify risk factors
  - Evidence
- Prevention
- Rehabilitation principles
  - Yesterday
  - Today
- Our Data
Lost Time

- Lost game time means $$$$$$$$$
- Top players
- Hamstring strains
- 213 player games/year
Dallas We Have A Problem

"Ware is another Cowboy in a long line of players to be sidelined because of hamstring injuries during the team's three weeks of training camp practices. Starting wide receiver Miles Austin has also been out with a strained hamstring after missing six games last season with pulled hamstrings."
Background

- **Hamstring Strains**
  - Lengthened to greater than optimal lengths
    - Hip flexion and knee extension

- **12-15% of total injuries in sports**
  - Common in sports that require
    - Sprinting
    - Kicking
    - Acceleration
    - Change of direction
      - Friden & Lieber 2001
      - Woods 2004
      - Malliaropoulos 2002
Hamstring Strain Incidence

- High school football
  - 300,000 to 1,215,000 high-school football injuries each year in the United States
  - 38% muscle strains

- College
  - 155 injuries in 1 yr
  - 28% lower extremity muscle strains

- Australian Rules Football
  - HS strains most prevalent injury
  - 6.2 injuries per club/season

Bixler B & Jones RL, Fam Pract Med, 1992
Cross KM & Worrell T, J Athl T, 1999
Orchard J, Sweard H. et al. BJSM, 2002
Elliott MC et al., AJSM, 2011

Between 1989-98, injury data were prospectively collected by athletic trainers for every NFL team.

- 1716 hamstring strains
  - Injury rate of 0.77 per 1000 exposures
- 51.3% occurred in preseason
  - 23.1% defensive secondary
  - 20.8% wide receivers
  - 13.0% special teams
NFL Kicker Epidemiology

- Brophy RH et al., AJSM, 2010
- 20 years, injury data were prospectively collected by athletic trainers for every NFL team.
- 488 injuries in 264 punters & placekickers
- 20% hamstring strains
  - Days lost 16 (0-164)
- 62% occurred in games
Hamstring Strain Reoccurrence

- **Professional Soccer**
  - 16% hamstring reinjuries
  - Reinjuries caused significantly longer absences than did first time strains

- **Professional Australian Rules Football**
  - 33% hamstring reinjuries

- **Professional Baseball**
  - 20% hamstring reinjuries

- **Professional Football**
  - 22% hamstring reinjuries

Ekstrand J, AJSM, 2011
Orchard J, Sweard H. et al. BJSM, 2002
Ahmad CS et al., AJSM, 2014
Marcus CC et al., AJSM, 2011
Elliott MC et al., AJSM, 2011
Risk Factors

- Several hypotheses
  - Stiffness
  - Lack of proper warm-up
  - High quad:ham ratio
  - Fatigue
  - Weak hamstrings compared bilaterally
  - Poor lumbar posture and/or core stability
  - *Previous hamstring injury*  

*Zvijac JE et al. AJSM 2013*
Recurrence Evidence

- **Engebretsen et al 2010**
  - Prospective study examining potential risk factors for hamstring injury
  - 508 amateur soccer athletes
  - Hamstring muscle length, jumping ability, a simple eccentric strength test, or running speed were not sig.
  - Previous acute hamstring injury only significant risk factor
  - Previous HS injury more than doubles the risk of reinjury
Recurrence Evidence

- **Orchard and Best**
  - *2002*
  - One third of hamstring injuries will recur in first year
  - Greatest risk 2-4 weeks following return to sport

- **Marcus CC, et al**
  - *2011*
  - 22% reinjury rate during NFL regular season
PREVENTION
Strategy For Injury Reoccurrence Prevention

1. Identify the incidence of a specific injury reoccurrence
2. Identify risk factors for that injury
3. Design interventions to address the risk factors
4. Test the effectiveness of the intervention at reducing the reoccurrence of that specific injury
Preventing Hamstring Strains

Preventive Effect of Eccentric Training on Acute Hamstring Injuries in Men’s Soccer

A Cluster-Randomized Controlled Trial

Jesper Petersen, MD, PhD, Kristian Thorborg, PT, PhD,
Michael Bachmann Nielsen, MD, PhD, DMSc, Esben Budtz-Jørgensen,§ MSc, PhD,
and Per Hölmich, MD

Investigation performed at the University of Copenhagen, Copenhagen, Denmark

AJSM 2011
## RESULTS

Dramatic Reduction in Recurrent Injuries

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Allocation Group</th>
<th>No. of Injuries</th>
<th>Player Seasons at Risk</th>
<th>Injury Rate Per 100 Player Seasons</th>
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<tbody>
<tr>
<td>Total</td>
<td>Intervention (n = 461)</td>
<td>15</td>
<td>390</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>Control (n = 481)</td>
<td>52</td>
<td>396</td>
<td>13.1</td>
</tr>
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<td>348</td>
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<td>352</td>
<td>8.1</td>
</tr>
<tr>
<td>Recurrent&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Intervention (n = 49)</td>
<td>3</td>
<td>42.0</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>Control (n = 54)</td>
<td>20</td>
<td>43.7</td>
<td>45.8</td>
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Caveat to Petersen et al Results

Dramatic Reduction in Recurrent Injuries

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WHAT ARE WE MISSING?
75 soccer players randomized to lengthened rehab (L) or conventional (C) groups

- Return to sport
  - L Protocol 28d
  - C Protocol 51d

- 2 Reinjures in both group

- Lengthened state exercises facilitates quicker return to sport
Despite the Best Prevention Programs, Hamstring Strains Do Occur
Hamstring Strain

- Askling CM et al. Acute first time hamstring strains during high speed running: A longitudinal study including clinical and MRI findings. BJSM 14, 1980
- Primary Muscle- involve long head biceps femoris injury
- Secondary Muscle- involve semitendinosus injury
Differential Diagnosis

- Adductor strain
- Hip joint etiology
  - Labral tear
- Lumbar spine pathology
- Stress fracture
- Nerve compression syndrome
  - Sciatica
- Ischial tuberosity avulsion
REHABILITATION
Our Philosophy

- Early contraction of the muscle
  - Isometric- (midRange-short-long)
  - Isotonic against gravity
  - Isotonic against resistance
  - Isolated Eccentrics
  - Lengthened State Eccentrics
  - Functional eccentrics
Repair of Muscle Strain: Basic Science

- **Central Zone**
  - Gap between fiber stumps
  - Hematoma fills gap
  - Connective tissue scar replaces hematoma
  - Scar holds stumps together
  - Regenerating fibers must penetrate scar

- **Mediating Factors**
  - Lateral adhesion of endomysium protects scar from rerupture
  - Up to 10 days post injury scar is weak link (thereafter it’s the fiber stump)
  - Early mobilization reinforces lateral adhesion
  - Myoblast proliferation accelerated by cyclic strain
  - New myotendinous junction formed by 10 days

Kjaer et al 2003
Physiological Evidence

- **Day 0 – Start PROM & Isometric contractions**
  - **avoid immobilization**
    - Facilitates myoblast regeneration (Vandenburgh 1982)
    - Maintains fiber alignment at the site of injury (Kjaer et al 2003)

- **Day 3 – Start Submaximal Isotonics**
  - Limit scar formation without reinjuring fibers (Vandenburgh 1982)

- **Day 10 – Start Eccentrics**
  - Prevent atrophy during fiber regeneration
    - By Day 10-14 post injury, Scar is actually stronger than the fibers (Kaariainen et al 1998)

Early isometrics, Maintain available ROM, BUT DON’T STRETCH
Rehabilitation Phase I (Acute)

- RICE first ~48 hours after injury
- Modalities
- Submaximal Multi-Angle isometric flexion
  - Hip PROM pain-free
  - Nonweight-bearing hip PRE’s
  - Bilateral balance board
- Concentric Flexion with weight
  - Seated
  - Standing
- Theraband/Kettle Bell Dead Lifts
- NO STRETCHING!

*Schmitt B et al., IJSPT 2013*
Rehabilitation

- **Phase 1 - Clinical Milestones**
  - PAINFREE
  - Isometric & isotonic contractions at short and intermediate length

- **Timeframe**
  - Depends on grade
  - ? 3 days to 2 weeks
Rehabilitation Phase II (Subacute)

- Dynamic warm-up
- Isolated Eccentrics at short and intermediate lengths
- Nerve glides
- Windmills without weights
- SLS with ball toss
- Weighted dead lifts
- STM/IASTM
- Shuttle jumps
- Lateral and retro bandwalks
- Nordic hamstring curls
Rehabilitation

- Clinical Milestone
  - PAINFREE
  - Maximal resisted Eccentrics at short and intermediate lengths

- Timeframe
  - Our objective criteria for return to light practice
    - FeedForward Activities
    - NOT FeedBack Activities
Mechanics of the Human Hamstring Muscle during Sprinting

It is recommended that hamstring injury prevention or rehabilitation should be preferentially biased towards strengthening exercises that primarily involve eccentric contractions performed with high loads at longer musculotendon lengths!

Rehabilitation
Phase III (Return to activity)

- Phase II exercises with increase in load, intensity, speed and volume
- **ECCENTRIC TRAINING IN THE MAXIMUM LENGTHENED STATE**
  - ANY WAY YOU CAN
Length Tension Curve

  - Hx of multiple HS strains within last 4-5 years
  - Full participation at time of testing
  - Examined muscle length effect on torque
  - Create angle torque curves using
    - isokinetic dynamometer
      - Compared to uninjured other leg
      - Compared to healthy subjects
Length Tension Curve

Found strong correlation between optimum angle for peak torque and a previous history of hamstring strain.

TABLE 1. Mean values for various parameters (± SEM), for hamstrings and quadriceps of 18 uninjured athletes and 9 athletes with a previously history of unilateral hamstring strains (injured).

<table>
<thead>
<tr>
<th></th>
<th>Uninjured</th>
<th>Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right Side</td>
<td>Left Side</td>
</tr>
<tr>
<td>Hamstrings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimum angle</td>
<td>30.1 (1.5)</td>
<td>27.3 (1.2)</td>
</tr>
<tr>
<td>Difference in angles</td>
<td>2.7 (1.2)</td>
<td>114 (8.1)</td>
</tr>
<tr>
<td>Peak torque (Nm)</td>
<td>130.2 (5.3)</td>
<td>133.5 (4.7)</td>
</tr>
<tr>
<td>Torque ratio (*)</td>
<td>103.1 (2.8)</td>
<td>94.1 (4.4)</td>
</tr>
<tr>
<td>Quadriceps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimum angle</td>
<td>71.3 (1.7)</td>
<td>67.7 (1.3)</td>
</tr>
<tr>
<td>Difference in angles</td>
<td>3.8 (1.0)</td>
<td>67.2 (1.9)</td>
</tr>
<tr>
<td>Peak torque (Nm)</td>
<td>239.2 (7.9)</td>
<td>237.6 (8.4)</td>
</tr>
<tr>
<td>Torque ratio (*)</td>
<td>99.8 (2.2)</td>
<td>98.8 (3.1)</td>
</tr>
<tr>
<td>C:H Torque Ratio</td>
<td>1.8 (0.03)</td>
<td>1.8 (0.03)</td>
</tr>
</tbody>
</table>

Take Home Message

Clinical Relevance

• It’s the **optimum angle of peak torque** and not **absolute peak torque value** that is the difference

• Rehabilitation focused on strengthening HS in lengthened state

• GOAL: strong at end range (ie lengthened state) to prevent reinjury
Purpose

Examine if a progressive eccentric strengthening program with the muscle in a maximally stretched position restores strength and results in a low reinjury rate.
Subjects

- 50 patients
  - 30 men
  - 20 women
  - Age 36 ± 16 yrs
  - Diagnosed with Hamstring strain
    - 3 G1, 43 G2, 4 G3
    - 25 recurrent injuries
    - Site
      - 27 proximal
      - 14 mid
      - 9 distal

- Sports/ Mechanism
  - 37 Sprinting cases
    - 6 football
    - 4 Gaelic football
    - 2 soccer
    - 4 softball
    - 6 track
    - 11 recreational running
    - 2 lacrosse
    - 2 field hockey
    - 1 basketball
  - 13 Non-sprinting
    - 4 stretch cases
    - 2 karate
    - 2 plyometrics
    - 1 squash, waterskiing, skiing, weight training, hill running
Isometric Hamstring Strength Prior to Return to Sport

Angle-Torque Relationship (Length-Tension)

- **Strength throughout ROM**
  - Short 80° knee flexion
  - Intermediate 60° knee flexion
  - Intermediate 40° knee flexion
  - Long 20° knee flexion
  - 130° thigh flexion

**Discharge Criteria**
- Painfree maximum contractions in the lengthened state, Sports specific testing

**Example of Athlete Testing at 60° Knee Flexion**
Stats & Power

- **Data Analysis**
  - Reinjury rates were compared between compliant and noncompliant athletes using Fisher exact tests.
  - Strength through the ROM assessed by ANOVA
RESULTS
Hamstring Rehabilitation

OUR DATA

Compliant Athletes
- 43 athletes completed all 3 phases
  - 17±7 Physical Therapy Visits
- Follow-up 23±14 mos
  - 22 athletes > 2yrs
  - 11 athletes 1-2yrs
  - 10 athletes <1yr (min 3 mo)

Non-compliant Athletes
- 8 athletes did not complete rehabilitation
  - 12±7 Physical Therapy Visits
    - 3 completed Phase 1
    - 5 completed Phase 2
- Follow-up
  - All <1yr (min 3 mo)
Isometric Hamstring Strength Prior to Return to Sport

43% weaker in lengthened state

P<0.01
Knee Flexion Strength Deficits

![Graph showing knee flexion deficits with percentages and p-values.]

- **15%** (P=.07) for compliant group at 80 degrees.
- **23%** (P<.05) for non-compliant group at 60 degrees.
- **31%** (P<.01) for non-compliant group at 40 degrees.
- **43%** (P<.001) for non-compliant group at 20 degrees.
Hamstring Strain Reinjuries

- Compliant Athletes
  - 0 of 43 reinjured

- Non-compliant Athletes
  - 4 of 8 reinjured
    - 2 within 3 months
    - 1 at 4 months

- Fisher Exact Test
  P<0.01
Return To Play Special Tests

H-Test

Lengthened state manual muscle test
Keys to Success

- Prevention
  - Identify players at risk
  - Demand intervention program
  - No Hx

- Nordic Hams
  - Previous injury

- Lengthened State Ecc
  - ESP! WR,DB,RB
  - No Deficit @ End ROM

- Rehabilitation
  - 1-2 days rest MAX
  - Early active therapy
  - Use objective measures to guide progression
  - Don't return to play too early
  - COMPLETE REHABILITATION