Spine Pain in Athletes

Kenneth Vitale, MD
Physical Medicine & Rehabilitation
Associate Clinical Professor, UCSD

Disclosures & Conflicts of Interest:
None
Outline

1. Background & Epidemiology
2. Common Lumbar Conditions: Adult
3. Common Lumbar Conditions: Adolescent
4. Common Cervical Conditions

Part 1: Background
Low Back Pain

- 2/3 up to 85% of adults have lifetime LBP prevalence
- Evidence of excessive imaging & surgery for LBP in US
- Many believe LBP has been overmedicalized
- LBP is a symptom, not a diagnosis
- If 85% of adults have LBP, can consider it part of life, not a disease
- There are wide variations in treatment suggesting professional uncertainty about optimal approach

Epidemiology in Athletes

- LBP in athletes however, range from 1-30% in literature
- 10-15% of all sports injuries are low back
- Highest reported in wrestling, gymnasts (up to 59-79%)
- Also soccer, tennis, football, golf, weightlifting (30-40%)
Etiology

- Experimental research suggests many pain generators:
  - Paraspinal muscles & fascia
  - Ligaments
  - Facet joints
  - Disc annulus fibrosus
  - Spinal nerve roots
  - Vertebral periosteum
  - Blood vessels

- 85% chronic LBP cannot be given precise pathoanatomical diagnosis
- Correlation b/w symptoms & imaging is weak
- Differential Diagnosis is vast in general population
  - Somewhat more focused in athletes


Part 2: Common Lumbar Conditions

Adults
Most Common in Adult Athletes

1. Degenerative Disc Disease (DDD)
2. Spondylolysis

DDD Pathophysiology

- Stress at annulus fibrosus leads to tears
- Circumferential tears first, progress to radial tears
  - HIZ on MRI
- Continued stress & leakage of nucleus pulposus
  - Loss of disc height on x-ray
- Subsequent increased load on facet joints
  - Degeneration & osteophyte formation at disc and facet
  - Attempt at autostabilization
  - Arthrosis on x-rays
DDD in Athletes

- Overall, athletes in general:
  - DDD (including HNP) up to 58% of athletes (vs. 38% controls)
  - 75% of elite gymnasts (vs. 31% controls)
- Type & intensity of sport may accelerate disc degeneration
  - More common in volleyball players with improper technique vs. good form (62% vs 21%)
- In some studies, playing sport itself is probable risk factor for DDD

Future studies: more studies in different types of sports (more athletes in different types of sports)


Treatment of DDD in Athletes

- **Nonsurgical**
  - Numerous treatments; outside of scope to review
  - PT, pain medication, activity modification

- **Surgical**
  - No consensus on indications or procedure
  - Main indications in athletes:
    - Pain correlated with imaging studies
    - Failure of conservative therapy
    - ? Duration, >4-6 months

- **Fusion:** Anterior, posterior, interbody fusion (ALIF, TLIF, PLIF, XLIF), 360 degree
  - Fusion rate with interbody fusion may be higher
  - Since pathology presumed discogenic, some surgeons prefer interbody fusion

Return to Play with DDD

- This is main concern for athletes
  - Regardless of conservative or surgical treatment
  - No clear consensus regarding optimal RTP
  - Mostly based on expert opinion

- From expert opinions RTP criteria (conservative therapy):
  - Achieve full lumbar ROM
  - At least 80% of strength before RTP

- From expert opinions RTP (lumbar fusion):
  - Wait 6-12 months
  - Often 1 year (until radiographic union)
  - Avoid contact sport
  - Avoid torsion sport
  - Some surgeons allow RTP after 6 months
  - Some allow contact if 1 level fusion


14
Lumbar Disc Herniation in Athletes

- Disc herniation (HNP) more correlation with symptoms
- Prevalence of up to 58% in the adult athletic population
- Only 11% of younger athletes
- Both DDD and HNP both have similar pain patterns
  - Pain with lumbar flexion/sitting
  - Relieved with lumbar extension/standing
  - HNP often has radicular symptoms
- Nonsurgical treatment
  - DDD and HNP treatments similar
- Surgical treatment
  - May involve discectomy without fusion

Return to Play with HNP

- RTP conservative vs discectomy:
  - 79% conservative (4.7 mth)
  - 85% discectomy (5.2-5.8 mth)
- 2016 systematic review & meta-analysis:
  - ~81% RTP following surgical treatment
  - No statistical difference RTP surgical (pooled proportion 84% RTP) vs.
    conservative (pooled proportion 76% RTP)
Return to Play with HNP

- Unfortunately, percentage of athletes actually returning to same level of sport prior to surgery much lower
  - Range 38% - 65%, pooled estimate of 59%
- High risk of bias
- Overall low-moderate quality of studies
- True discectomy efficacy for RTP remains unknown
- Authors suggest may be overstated

Spondylolysis and Spondylolisthesis

- Bony defect of pars interarticularis
- Three subtypes:
  - Stress fracture
  - Acute traumatic fracture
  - Elongated pars (recurrent microfractures, subsequent micromotion then union)
- Most common
  - L5 (85-95%)
  - L4 (5-15%)
- Many detected incidentally
- 25% of symptomatic patients may develop spondylolisthesis
- In athletes:
  - Gymnasts 17%
  - Rowers 17%
  - Throwing athletes 27%
  - Weightlifters 23%
  - Wrestlers 30%
  - Diving 43%
Spondylolysis/Spondylolisthesis Signs & Symptoms

- Axial LBP without radicular symptoms
- Hamstring tightness common
- Midline point tenderness
- Hyperlordosis (if spondylolisthesis)
- Exaggerated pelvic incidence (higher grade spondylolisthesis)
- Step off lower lumbar spine
- Hyperextension increases pain
- Positive SLR due to either hamstring tightness or nerve root tension

Spondylolysis/Spondylolisthesis Diagnosis

- High clinical suspicion needed
- X-ray: Oblique & coned-down lateral LS junction
  - Many discourage routine use of obliques
  - Increased radiation (caution in adolescents)
  - Only ~1/3 of stress fractures identified
- If negative $\rightarrow$ single photon emission CT (SPECT) bone scan
  - SPECT can help differentiate symptomatic from asymptomatic pars defects
- If SPECT positive $\rightarrow$ CT
  - CT can help differentiate acute (fresh fracture edges) vs. chronic pars defect (sclerotic blunt edges), and healing
  - Some reserve CT only if not improving $2^\circ$ increased radiation
- MRI
  - Added soft-tissue assessment
  - Less sensitive than SPECT bone scan
Spondylolysis/Spondylolisthesis Treatment

- Most improve with conservative treatment
- Initial rest, +/- brace, then PT
- Avoid extension, strengthen abdominals, stretch HF & HS
- Bracing controversial, most frequently cited reference:
  - Boston brace 23hr/day; up to 3 months
  - Compliance to any brace likely more important than brace type
  - However often slower return to sport once out of brace
- Best outcome is if just avoid sport 3 months
- RTP if fully pain-free during activities
- Can follow every 6-12 months until skeletal maturity to monitor for spondylolisthesis
- If continued symptoms, can refer to surgery
  - Pars repair, in situ posterolateral fusion, interbody fusion


Part 3:
Common Lumbar Conditions

Younger Populations
Most Common in Adult Athletes

1. DDD
2. Spondylolysis

Adolescents:

1. Spondylolysis
2. Posterior Element Overuse Syndrome
3. Ring Apophyseal Avulsion Fracture
4. Lumbar Scheuermann's
5. Sacroiliac pain and Sacral Stress Fracture
6. Lumbar Disc Herniation

Adolescent Athlete LBP

- Adolescents with LBP much more likely to have structural injuries
- Should be investigated fully
- Idiopathic LBP, “muscle strain” should be diagnosis of exclusion
- LBP ~10-15% of young athletes
  - College football 27%
  - Artistic gymnasts 50%
  - Rhythmic gymnasts 86%
- Spondylolysis much more common (up to 47%)
- Disc pathology much less (11% compared to 48% adults)
Adolescent Athlete LBP Etiology

- May be due to trauma
  - However overall less contact & less intensity training than adults
- More likely to overuse
  - Training volume & intensity
- Injuries more often when young athlete in sport longer time periods
  - Tournaments, sports camps
- Difficult to determine appropriate training amount
  - Not all athletes tolerate same training volume
- Overuse injuries present more often during rapid growth
  - 11-13 girls
  - 12-14 boys

Adolescent Athlete Biomechanics

Additional risk factors:

- Increased thoracic kyphosis
- Thoracolumbar fascia tightness
- Abdominal muscle weakness
- Hip flexor & hamstring tightness
- Increased femoral anteversion & genu recurvatum

  - All increase lumbar lordosis
  - All increase stress on posterior elements
Adolescent Athlete LBP Pathophysiology

- During periods of rapid growth
  - Muscles & ligaments unable to keep pace with rate of bone growth
  - Muscle imbalances & decrease in flexibility
- Growth cartilage and secondary ossification centers vulnerable
  - Weakest link of force transfer
  - Susceptible to compression, distraction, torsion injury

Spondyloysis

- Posterior column:
  - Pedicles
  - Pars interarticularis
  - Facet joints
  - Spinous processes
- Ossification of posterior column progresses from anterior → posterior
- May be congenitally incomplete at pars, notably L5
- Spina bifida occulta at lumbosacral junction may be additional risk factor for spondyloysis
- Symptoms & Treatment on previous slides

References:

Purcell & Micheli. LBP in Young Athletes. Sports Health: A Multidisciplinary Approach May/June 2009 vol. 1 no. 3 212-222
Posterior Element Overuse Syndrome

- After spondylolysis, probably most common adolescent LBP
- Constellation of conditions involving muscle-tendon, ligaments, facet joints, joint capsules
- Posterior column structures subject to excessive stress
  - Traction from tight dorsolumbar fascia
  - Impingement 2° increased lordosis
- Presentation similar to spondylolysis but workup negative
- Management is conservative
  - Similar to spondylolysis, strengthen abs, stretch HF and HS
  - Better to retrain biomechanics & avoid excessive posterior element stress

Adolescent Athletes

- Anterior column:
  - Anterior 2/3 vertebral body
  - Anterior 2/3 intervertebral disc
- Epiphyseal growth plates at ends
- Cartilaginous endplates over epiphysis
- Ring apophyses attached to annulus fibrosus
- Disc may herniate through ring apophysis with repetitive flexion
  - Limbus vertebrae (smooth sclerotic margins)
- Injury to the ring apophysis can result in avulsion fractures
  - Limbus fracture (rough margins, hematoma)
Atypical Scheuermann’s

- Scheuermann’s thoracic kyphosis (juvenile kyphosis)
- Osteochondrosis of ossification centers of thoracic vertebral bodies
- Pathogenesis remains unknown, likely hereditary and multifactorial
- Parents bring in due to thoracic kyphosis deformity
- ~20% kids report pain (thoracic)
- Natural history is generally benign, some need no treatment, other treat with brace, surgery if severe

If occurs in lumbar area, up to 80% can have LBP
If aggressively load spine with rapid flexion & extension, can get endplate fractures, Schmorl’s nodes, apophyseal avulsions
Treat symptoms as needed, often with bracing in 15° lordosis, PT to stretch tight thoracolumbar fascia, core stabilization
**Vertebral Body Apophyseal Avulsion Fracture**

- Rapid flexion & extension during sport can injure cartilaginous ring apophysis
- More common in gymnasts, wrestling, volleyball, weightlifting
- Pain with lumbar flexion, resembling disc herniation in adults
- Can displace posteriorly with disc into spinal canal
- Lateral x-ray shows fragment in canal
- MRI less sensitive
- CT can better characterize injury
- Typically can recover with rest, conservative measures
- If neurological symptoms, may need surgery

**Sacroiliac Pain, Sacral Stress Fracture**

- Sacroiliac (SI) joint disperses forces trunk ↔ lower extremities
- Can be source of pain if either excessive or reduced motion
- May be spondyloarthropathy in appropriate clinical situations
- Treatment is activity modification to improve biomechanics & symmetry
- Sometimes SI joint manipulation, SI belt
- Can also get stress fracture of sacrum
- Treatment generally involves rest from offending activity, retraining biomechanics
Lumbar Disc Herniation in Adolescents

- Uncommon
- If present, pain with lumbar flexion
- May have radiation into buttocks and hamstrings
- Radicular symptoms often not present
- SLR variable
- MRI
- Treat similarly to adults

Prevention?

- Avoid intense training and flexion/extension during growth spurts
- Avoid extreme lumbar extension: layback and walkovers
- Stretch hip flexors and hamstrings
- If team sport, match athletes in size & strength to avoid contact injuries from larger, stronger kids
- Back pain is part of life
- Back pain is not part of sport
- “Muscle strain” should be diagnosis of exclusion
Part 4: Common Cervical Conditions

Neck pain

- Many kinds of cervical trauma from sport
- High risk sports:
  - Diving (hitting bottom of pool)
  - Football (defensive player & tackling)
  - Gymnasts (dismounting)
  - Soccer (goalie)
  - Ice hockey (checked from behind, hitting boards)
- Catastrophic spinal cord injuries 2° sport ~10% of all SCI in US
  - (Outside of scope to review complex cervical trauma/fracture/SCI)
Neck pain

- Sports injuries 2nd only to MVA as reason for neck pain ED visits
- Large ROM of cervical spine
- This ROM comes at cost of stability
- Cervical spine little intrinsic bony stability
  - Stability from muscle & ligamentous restraints
  - Muscular envelope functions as dynamic splint
  - Ligaments function as checkrein (limits end range)

Cervical Spine Injuries in the Athlete Bulletin of NYU Volume 64, Numbers 3 & 4, 2006

Common Cervical Injuries

1. Stingers/Burners
2. Spear Tacklers’ Spine
3. Transient Quadriplegia
4. Cervical Disc Herniation
5. Strain/Sprain
6. Cervical Spinal Stenosis
7. Unique Populations
Stingers/Burners

- Traction/compression of brachial plexus
- Unilateral arm numbness, burning/dysesthesia, +/-weakness
- If bilateral, consider SCI (“burning hands” Central Cord Syndrome)
- Can be up to 50% contact/collision sports
  - Often underreported
  - Usually C5 and C6
- Traction without degenerative changes (younger)
  vs.
- Compression with degenerative changes (older)

Stingers/Burners

- Often can RTP when symptoms resolve (minutes); can be weeks
- Typical RTP exam includes assessment of grip strength
  - Should include pain-free neck ROM and negative Spurling's
- If continued symptoms:
  - EMG
  - Brachial plexus MRI
- Prevention?
  - Properly fitting shoulder pads, cervical neck roll may possibly help
  - Correct blocking & tackling techniques
Spear Tackler’s Spine

• Uses crown of head as initial point of contact
• Spear Tackler’s Spine: constellation of radiographic & clinical findings
  • Neck pain, stiffness & limited ROM
  • Radiographic cervical stenosis
  • Straightening or reversal of cervical lordosis
  • Posttraumatic spondylosis
• When cervical lordosis lost, impact to top of head can transmit extreme axial forces, risking injury


Bulletin of NYU • Volume 64, Numbers 3 & 4, 2006
Cervical Spine Injuries in the Athlete

Spear Tackler’s Spine

• Once bony changes present:
  • Risk of neurologic injury
  • Consider retirement from contact sport
• Torg: Spear tackler’s spine absolute contraindication to contact sports
• Treatment tries to maximize ROM, posture/alignment
• 1975 football rules changed to ban spear-tackling

Bulletin of NYU • Volume 64, Numbers 3 & 4, 2006
Cervical Spine Injuries in the Athlete
The subject of this page is "Transient Quadriparesis," a condition affecting the cervical spine. Here are the key points extracted from the page:

- **Transient quadriparesis (TQ), transient quadriplegia, cervical cord neurapraxia (CCN), spinal cord concussion**
- Sensory and motor symptoms, at least 2 limbs
- Sensory usually burning; motor variable weakness
- Duration 10-15 min; residual symptoms can persist 2 days
- Football, hockey, wrestling, boxing, basketball
- Often preexisting congenital stenosis, kyphosis, congenital fusion, instability, disc herniation

The page also includes references to medical journals and publications by Allen CR, Kang JD, Torg J, Ramsey-Emrheim J, and others, discussing the management and implications of cervical spine injuries in athletes.
Transient Quadriparesis RTP

- Asymptomatic and no h/o TQ, canal/vertebral body (Torg) ratio of <0.8
  - No contraindication
- 1 episode of TQ and Torg ratio <0.8
  - Relative contraindication
- >1 episode and degenerative changes/DDD
  - Relative contraindication
- 1 episode and MRI cord pathology/edema
  - Relative/absolute contraindication
- 1 episode, ligament instability, neurologic symptoms 2 days, or multiple episodes
  - Absolute contraindication

Cervical Spine Injuries in the Athlete Bulletin of NYU Volume 64, Numbers 3 & 4, 2006

Cervical Disc Herniation

- Cervical DDD & herniation less common than lumbar
  - Usually affects older athletes
  - Uncommon neck pain in adolescent athletes
- Football, wrestling higher prevalence
  - Extreme lateral bending or torsion
- Noncontact sports may be protective against disc herniation
  - Improved muscular conditioning protects disc from stress
- Treatment generally conservative (rest, NSAIDs, PT, activity modification)
- RTP after pain-free ROM and at least 80% strength
- Surgery if severe pain, neurological symptoms

Cervical Spine Injuries in the Athlete Bulletin of NYU Volume 64, Numbers 3 & 4, 2006
Cervical Surgery RTP

- Discectomy/Decompression
- Fusion
- Some research suggests faster RTP if decompression without fusion
- 1 level fusion (C3 or below)
  - Often can return to contact sport
- 2-3 level fusion
  - May return, surgeons usually advise against
  - Risk of Adjacent Segment Disease (ASD)
- >3 level fusion, fusion above C3
  - Contraindication to contact sport

Cervical Spine Injuries in the Athlete Bulletin of NYU Volume 64, Numbers 3 & 4, 2006

Strain & Sprain

- Strain: muscles, musculotendinous junction
- Sprain: ligaments
- Often coexisting as overlapping components of stretch & contusion during trauma
- Strain:
  - Resisted eccentric contraction resulting microscopic or macroscopic tensile failure
  - Muscles with high ratios of fast twitch fibers (type II) higher risk
- Severe sprain:
  - >3.5 mm AP displacement flexion-extension views
  - >11° of vertebral body rotation
  - Contraindication to contact/collision sport

Cervical Spine Injuries in the Athlete Bulletin of NYU Volume 64, Numbers 3 & 4, 2006
Strain & Sprain

- Treatment usually conservative
  - Rest, ice, NSAIDs, neck support if needed, gentle ROM
  - Sprains usually take longer to heal

- Bracing:
  - Used empirically for years in football
  - Can limit hyperextension while allow enough extension to prevent excess axial loading
  - Do not limit lateral bending
  - With flexion-extension trauma, no difference with immobilization vs. PT & return to activity as tolerated

- Bracing:
  - Used empirically for years in football
  - Can limit hyperextension while allow enough extension to prevent excess axial loading
  - Do not limit lateral bending
  - With flexion-extension trauma, no difference with immobilization vs. PT & return to activity as tolerated

Cervical Spinal Stenosis

- Traditional:
  - AP diameter <13mm on x-rays
  - Magnification error

- Torg ratio more accurate
  - 1.0 normal
  - <0.8 stenosis
  - Can predict higher risk for recurrent injuries (stingers & TQ)
  - No cord measurement or soft-tissue assessment

- MRI best
  - CSF effacement
  - Cord contour deformation
  - Cord signal changes
  - Cantu: presence of above + TQ absolute contraindication to contact sports
Unique Populations

• Down syndrome
  • High incidence of atlanto-axial AA instability (up to 30%)
  • Special Olympics impose restriction until lateral x-ray shows no instability
  • MRI if any neurological symptoms
  • AA instability restrictions:
    • Special Olympics’ gymnastics, diving, pentathlon, butterfly swim, high jump, soccer
    • Contact sports e.g. football, wrestling, rugby

• Rheumatoid arthritis
  • Similarly, AA instability up to 15% of RA

• Odontoid anomalies
  • Odontoid agenesis, odontoid hypoplasia, os odontoideum all contraindications to contact sport

• Atlanto-occipital fusion
  • Also contraindication to contact sport

• Klippel-Feil syndrome
  • Congenital fusion of at least 2 vertebrae
  • Usually contraindication if unless Type II (fusion C3 and below)
Vascular Injury

- Carotid and vertebral artery
- Blunt trauma → dissection, thrombus, or emboli
- Can result in stroke
- Prompt recognition and emergency treatment and transport

Thank you
Challenges in the Adolescent athlete

Suraj Achar MD
Clinical Professor UCSD SOM
Associate Director Primary Care Sports Medicine Fellowship
Team Physician UCSD Athletics, SD Sockers, USOC

Epidemiology of the problem

- 27/51 million play team sports
  - The hidden demographics of youth sports, ESPN July 2013
  - Aspen Institute
- > 1/3 injury → doctor or nurse/year
  - 20% of ER visits for age group
- Boys>Girls, Peak 10-12, > obesity
Introduction

• Why know about running injuries?
• Running facts
  – 9.3 million Americans run > 100 days/year
  – 45 - 70% runners injured each year
• Kids?
  – National Federation of High Schools
    • 429,000 young athletes in cross country 2008-9
  – Pediatric ER 1994-2007 (225, 344 running injuries)
    • 1994: 11,706 visits
    • 2007: 15,663 (∆34%)

Which is not a risk factor for running injuries

1. Overtraining
2. Not enough stretching
3. Female gender
4. Practice
5. Prior Injury
6. < 6 hours of sleep the night before
Stretching

- No pediatric data
- Adult data
  - No evidence for stretching (Cochrane 2015)
  - Decrease performance in short races

ARS Question
What is c/w growing pains

1. Focal PE findings
2. Fever
3. Able to play sports
4. Night pain
Active 10 yo F ongoing left knee pain for the last 3-4 months. Pain started while play soccer and being active, but has increased to pain with just walking around.

Swelling L knee ~ 2 weeks ago which has since resolved after ice & motrin. Mom has tried to back child off from activities, but pushing through & has continued most activities, but with less force.
No prior injury. No numbness, weakness or tingling. ROS: neg

1908 Scandinavian Olympics
Sinding-Larsen and Johanson syndrome
What is common with Pediatric Stress Fractures

1. Anterior tibial fractures are common
2. Younger children > higher risk
3. Radiographs are more useful in children than adults
4. Children always have pain

Presidential Fitness Test
A Pill for all ills?

Pediatric stress fractures

- Plain radiographs: diagnostic utility in children
  - rapid healing phase that promotes active new bone formation, periosteal thickening, and early callus
- Refer pts who do not respond by 6-8 weeks MRI is useful if diagnosis is unsure
National Athletic Trainers' Association Position Statement: Prevention of Pediatric Overuse Injuries


• Stress fractures
  – age of onset was 12.9 ± 4.3 years (range, 3–17 years) and the tibia was most often affected (48%), followed by the metatarsals (18.5%)
  – Navicular drop (6.6mm)
  – >16 hours a week

Etiology

• Extrinsic Factors
  – training errors (overtraining)
    • too much, too fast, too soon!
  – old/inappropriate shoes
    • basketball shoes, etc
  – irregular surfaces
    • slanted roads
  – Overscheduled?
Etiology

- **Intrinsic Factors**
  - malalignment/biomechanical abnormalities
    - over-pronation, leg length, foot hyperpronation
    - poor flexibility?
      - hamstrings, heel cords
  - Female gender!
    - 16.7 vs 10.4
    - (p < 0.0001)

Sports-Related Injuries in Youth Athletes: Is Overscheduling a Risk Factor?

- Number of practices in 48 hours
  - (1.7 vs 1.3)
- Fatigue-related injuries were related to sleeping
  - ≤6 hours the night before the injury ($P = 0.028$).
- Which is more common overuse or injury?
- Answer: Overuse
  - Overuse (44.7%), compared with Al (41.9%)

12 y/o female runner with heel pain

- Diffuse heel pain
- 2 months
- ↑ training

PE:
- + squeeze test
- Tight heel cord

Sever’s Disease - Traction Apophysitis
Analogous to Osgood-Schlatter’s Disease
Case 3
10y6m African-American F

• “pop in my hip”
  – ~ two months ago while swimming
  – “Hurts while walking”
  – Ibuprofen +/-

• Exam:
  – Obese
  – Antalgic gait
  – ROM-<IR and pain

Case 3 - AP Pelvis and “Frog Leg” lateral

• “Klein line”

• lateral displacement of femoral neck
Slipped Capital Femoral Epiphysis

- Most common cause of adolescent limp
- Incidence
  - 2/100,000
  - M/F = 2.5:1
  - L > R?
- Peak incidence
  - early adolescent growth spurt.

Etiology of SCFE

- Multifactorial
  - Obesity -> Excessive mechanical shear
    - Metabolic syndrome
  - Biologic susceptibility of adolescent physis
  - Genetic predisposition
    - 4 cases in 1 family!!
Dx of SCFE

• History
  – Dull hip pain \( \rightarrow \) radiate to knee?
  – Pain during activity
  – Acute/chronic

• PE
  \( \oplus \) Antalgic gait
  – \(<\text{ROM on IR} \& \text{ER}

Slipped Capital Femoral Epiphysis

• Treatment:
  – No weight bearing!
  – Surgical Fixation-ASAP
    • Reduce???
  – RTP?

• Bilateral SCFE \( \sim 35\% \).
  – 1/3 at presentation
  – 2/3 \( \sim 18\text{m} \)
One month delay?

Stork test
20 y/o University student

- Chief complaint
  - Cough

- Led to Scoliometer and X-ray

Scheuermann kyphosis

- Abnormal Forward-Bending test
- Kyphosis Ø Scoliosis
  - 1# cause of thoracic kyphosis in children or adolescents
- Cannot correct posture!
  - Pain
  - Cosmetic deformity
Thank you!

sachar@ucsd.edu
Injectables: The Evidence & New Horizons

Kenneth S. Taylor MD
Professor School of Medicine
Director Primary Care Sports Medicine
Head Team Physician UCSD/SD Sockers

Introduction

Corticosteroids
Hyaluronic Acid/Viscosupplementation
Platelet-Rich Plasma (PRP)
Stern Cells
Emerging Technology
Supplies

- Consent-signed/in note
- Sterile techniques
  - Isopropyl wipes
  - Betadine- stain
  - Chlorhexidine swabs
- Local Anesthetics
  - Ropivicaine/Lidocaine 1% vs 2%>Bupivicaine
- Corticosteroids
  - Betamethasone
  - Triamcinolone
  - Methylprednisolone
  - Dexamethasone
- Needles
  - Spinal 22g; 25g 2”, 1 ½”, TB syringe

Common Corticosteroid Injectables

<table>
<thead>
<tr>
<th>Solubility/ Common Injectable Corticosteroids</th>
<th>Trade Name</th>
<th>Equivalent Dose (mg)</th>
<th>Large Joint (mg)</th>
<th>Small Joint (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most Soluble</td>
<td>Celestone</td>
<td>0.6</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Soluble</td>
<td>Decadron</td>
<td>0.75</td>
<td>2-4</td>
<td>0.5-1</td>
</tr>
<tr>
<td>Prednisolone sodium phosphate</td>
<td>Prednisol</td>
<td>5</td>
<td>10-20</td>
<td>4-5</td>
</tr>
<tr>
<td>Slightly Soluble</td>
<td>Triamcinol</td>
<td>4</td>
<td>10-40</td>
<td>5-10</td>
</tr>
<tr>
<td>Prednisolone acetate</td>
<td>Dipro-Med</td>
<td>4</td>
<td>20-80</td>
<td>3-20</td>
</tr>
<tr>
<td>Prednisolone succinate</td>
<td>Hydrocort</td>
<td>5</td>
<td>10-40</td>
<td>4-10</td>
</tr>
<tr>
<td>Relatively Insoluble</td>
<td>Hydrocortone</td>
<td>20</td>
<td>25</td>
<td>10-25</td>
</tr>
<tr>
<td>Decadron-LA</td>
<td>Decadron-LA</td>
<td>0.75</td>
<td>5-15</td>
<td>4-5</td>
</tr>
<tr>
<td>Prednisolone acetate</td>
<td>Prednisol</td>
<td>5</td>
<td>10-25</td>
<td>5-10</td>
</tr>
<tr>
<td>Triamcinolone hydrocortiside</td>
<td>Kenalog</td>
<td>4</td>
<td>2-40</td>
<td>2.5-5</td>
</tr>
<tr>
<td>Triamcinolone hexacarbonide</td>
<td>Aristocort</td>
<td>4</td>
<td>10-20</td>
<td>2.6</td>
</tr>
<tr>
<td>Combination</td>
<td>Celestone Soluspan</td>
<td>0.6</td>
<td>6-12</td>
<td>1.5-3</td>
</tr>
</tbody>
</table>

*For example, 0.6 Celestone=0.75 Decadron=1 Prednisol
1/2p isn’t shoulder or ankle
Corticosteroid Benefits

- Adhesive capsulitis: short/long term; reduced surgery
- CTS: short term; reduced surgery
- DeQuervain’s tenosynovitis: short/long term
- “GT Bursitis”: short term
- Lateral epicondylitis: short term; high risk symptom rebound, PT/eccentric better long term outcomes
- Trigger finger: cure rates 54-86%

<table>
<thead>
<tr>
<th>Shoulder condition/studies</th>
<th>Duration of beneficial effect</th>
<th>Type</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subacromial impingement: Blar 1999</td>
<td>Up to 23 weeks</td>
<td>Kenalog</td>
<td>40 mg</td>
</tr>
<tr>
<td>Acromioclavicular arthritis: Jacob 1997</td>
<td>20 days</td>
<td>Celestone/Solu-Drol</td>
<td>6 mg</td>
</tr>
<tr>
<td>Glenohumeral arthritis</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Biceps tendinitis</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Adhesive capsulitis: Rajani 2005</td>
<td>6 weeks</td>
<td>Kenalog</td>
<td>20 mg</td>
</tr>
<tr>
<td>Buckbrider 2004</td>
<td>12 weeks</td>
<td>Depo-Medrol</td>
<td>40 mg</td>
</tr>
<tr>
<td>Cawth 2000</td>
<td>Up to 3 months</td>
<td>Kenalog</td>
<td>40 mg</td>
</tr>
<tr>
<td>Lanzhe 1998</td>
<td>24/26 (62%) at 2.5 years</td>
<td>Haldalone*</td>
<td>40 mg</td>
</tr>
<tr>
<td>Myofascial pain (trigger points)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Scapulohumeral bursitis</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Rotator cuff tendinitis: Adeeb 1999</td>
<td>4 weeks</td>
<td>Kenalog</td>
<td>80 mg</td>
</tr>
<tr>
<td>Putti 1983</td>
<td>4 weeks</td>
<td>Kenalog</td>
<td>40 mg</td>
</tr>
</tbody>
</table>

*Paramethasone acetate.
Corticosteroid Side effects

Side effects - Local

- Post-injection flare: Marked pain at the site of injection/joint – needle puncture/chemical synovitis due to crystals – treated with analgesics, ice packs
- Facial flushing – common in women – onset within a few hrs of injection
- Skin/fat atrophy – common with less soluble agents
- Joint sepsis - rare

Landmark/Palpation vs Ultrasound Guided Injx

<table>
<thead>
<tr>
<th></th>
<th>Standard Technique</th>
<th>Ultrasound Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shoulder:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC Joint</td>
<td>45%</td>
<td>100%</td>
</tr>
<tr>
<td>Glenohumeral Joint</td>
<td>79%</td>
<td>95%</td>
</tr>
<tr>
<td>Subacromial Joint</td>
<td>63%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Knee:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superolateral Approach</td>
<td>79%</td>
<td>99%</td>
</tr>
</tbody>
</table>
Hyaluronic Acid/Viscosupplementation

- Viscosupplementation: High Viscosity Hyaluronan
  - Mechanism of action
    - Shock absorption
    - Lubrication
    - Anti-inflammatory
    - Pain reduction

Hyaluronic Acid/Viscosupplementation
- Osteoarthritis
- Knee most studied, hip, PFS
  - Safe
    - Supartz: multiple courses safer?
  - Pseudosepsis
  - Efficacy similar to NSAIDS
  - Duration benefit 3-6 months per injx series
  - Delayed time to joint arthroplasty
  - Age
    - Young (post-trauma OA)>Older
  - Severity
    - Mild/Mod>Severe
  - Older/Severe OA pts.
  - Better with 2nd series

Table 1
Current FDA-Approved Hyaluronan Preparations

<table>
<thead>
<tr>
<th>NAME</th>
<th>ACTIVE INGREDIENT</th>
<th>MDW SUPPLIED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synvisc</td>
<td>Synthetic hyaluronan derived from bovine nacratrices</td>
<td>2 mL prefilled syringe containing 1 mg sodium hyaluronate</td>
</tr>
<tr>
<td>Synvisc One</td>
<td>Synvisc One: hyaluronan derived from bovine nacratrices</td>
<td>2 mL prefilled syringe containing 1 mg sodium hyaluronate</td>
</tr>
<tr>
<td>Gel-Gro</td>
<td>Hyaluronan sodium hyaluronate derived from chicken comb</td>
<td>2 mL prefilled syringe containing 1 mg sodium hyaluronate</td>
</tr>
<tr>
<td>Hyalogen</td>
<td>Hyalogen: sodium hyaluronate derived from chicken comb</td>
<td>2 mL prefilled syringe containing 1 mg sodium hyaluronate</td>
</tr>
<tr>
<td>Supartz</td>
<td>Supartz: sodium hyaluronate derived from chicken comb</td>
<td>2 mL prefilled syringe containing 1 mg sodium hyaluronate</td>
</tr>
<tr>
<td>Orthovisc</td>
<td>Orthovisc: sodium hyaluronate derived from bacterial cells</td>
<td>2 mL prefilled syringe containing 1 mg sodium hyaluronate</td>
</tr>
<tr>
<td>Effluxa</td>
<td>Effluxa: sodium hyaluronate derived from bacterial cells</td>
<td>2 mL prefilled syringe containing 1 mg sodium hyaluronate</td>
</tr>
</tbody>
</table>

MDW = high molecular weight.
Hyaluronic Acid/Viscosupplementation

- 2015 systematic review of meta-analyses
  - Highest level of evidence as viable option for knee OA
  - 26 weeks benefit
    - Improved pain
    - Improved function
  - Safe
    - Better side effect profile than oral NSAIDs
  - CSI better short term 1-5 weeks
  - HA better than CSI 5-13 weeks
  - PRP best at 8 – 26+ weeks


Platelet-Rich Plasma (PRP)

- Indications
  - Tendinopathy/Tears
    - Elbow Common Extensor
    - Patellar Tendon
    - Achilles Tendon
      - High Platelet & WBC concentration
  - Debatable success
    - PRP vs ABI vs Dry needling
Platelet-Rich Plasma (PRP)

- Indications
  - Osteoarthritis
    - knee
    - hip
  - single injx
  - high plot, low WBC
  - Increase pain few days
  - long term superiority over CSI/HA and some benefit 1-2 years
  - MRI: no deterioration at one year (4-6% cartilage loss per year no injx group)

Emerging Therapies

- Stem cells
  - Adipose
  - Bone Marrow
  - Amniotic
- Allogeneic Cell Therapy-phase 3
  - IA chondrocytes
- Sustained Release Corticosteroid: FX006-phase 3
  - >12 week efficacy
  - Phase 3 trials
- Ozone
  - Prolozone
Important Considerations

- Sports US Guided Injections
  - HA/ABI/PRP/Needle Fenestration
    - Placement of solution with pinpoint accuracy
    - Gold standard for Hip and certain injectables
- Placebo
  - Psychobiological effects are profound
  - ‘The Sell’
  - Medical Hypnosis

References

- Bannuru et al. Safety of repeated injections of sodium hyaluronate (Supartz) for knee OA: a systematic review and meta-analyses. *Cartilage* 2016
- Miller et al. US approved IA HA injections are safe and effective in patient with knee OA: systematic review and meta-analysis of randomized, saline controlled trials. *Clin Med Insights Arthritis* 2013
- Ong KL et al. Hyaluronic acid injections in Medicare knee OA patients are associated with longer time to knee arthroplasty. *J Arthroplasty* 2016
The Foot Core System: A New Paradigm

Jay Hertel, PhD, ATC, FACSM, FNATA
University of Virginia
Departments of Kinesiology & Orthopaedic Surgery
Exercise & Sport Injury Lab

The foot core system: a new paradigm for understanding intrinsic foot muscle function

Patrick O McKeon,¹ Jay Hertel,² Dennis Bramble,³ Irene Davis⁴

Panjabi’s Spinal Stability Model

- Lumbo-pelvic active stability primarily provided by local stabilizers: short, deep musculature
  - Transverse abdominis
  - Lumbar multifidus
  - Other short posterior muscles (intersegmental)
- Trunk movement caused by global movers
  - Rectus abdominis
  - Oblique abdominals
  - Erector Spinae

Local stabilizers and global movers must work in concert to provide efficient movement

CORE STABILITY

Bergmark
Core Stability Muscle Concepts

- **Motor Control:**
  - Coordination of local stabilizer and global mover muscles
  - Lumbopelvic core:
    - abdominal draw-in maneuver
  - Foot core:
    - Short foot maneuver?

- **Motor Capacity:**
  - Strength
  - Muscle endurance

---

The Foot Core

**Neural Subsystem**
Musculotendinous Receptors – Local and Global Ligamentous Receptors (including plantar fascia)
Plantar Cutaneous Receptors

**Passive Subsystem**
Bones of the arches (Foot Half Dome)
Plantar Fascia
Ligaments

**Active Subsystem**
Intrinsic Foot Muscles (Local stabilizers)
Extrinsic Foot Muscles (Global Movers)
Foot Core: Passive Subsystem

• Arches!
  – “Foot Dome” –
  (McKenzie 1955)

• Bony architecture

• Plantar fascia

• Ligaments on plantar aspect of foot

Foot Core: Active Subsystem

• Intrinsic muscles

• Extrinsic muscles

• Coordination between muscle groups
Intrinsic Foot Muscles
First Layer (most superficial)

1. Abductor Hallucis
2. Flexor Digitorum Brevis
3. Abductor Digiti Minimi

Intrinsic Foot Muscles
Second Layer

4. Quadratus Plantae
5. Lumbricals
Linked to FDL tendon
Intrinsic Foot Muscles
Third Layer

6. Flexor Digiti Minimi
7a. Adductor Hallucis Oblique
7b. Adductor Hallucis Transverse
8. Flexor Hallucis Brevis

Intrinsic Foot Muscles
Fourth Layer (Deepest/most dorsal)

9. Plantar Interossei
10. Dorsal Interossei
11. Extensor Digitorum Brevis
Intrinsic Foot Muscles
Functional Role poorly understood

Foot Core: Neural Subsystem

- Ligamentous receptors
  - Joint capsule
  - Plantar fascia

- Musculotendinous receptors
  - Muscle spindles
  - Golgi tendon organs

- Plantar cutaneous receptors
Foot Core Hypothesis

- Optimal function of the extrinsic foot muscles is reliant on function of the passive, active, and neural subsystems of the foot core.

- The intrinsic foot muscles play a critical role in foot function.
  - Their role includes coordination, capacity, and sensory.

Critical Questions

- What do we know about intrinsic foot muscle (IFM) function?
- How can IFM function be best assessed?
- What evidence is there that IFMs are impaired in patients with LE pathology?
- What exercises target specific IFMs?
- Does exercise improve IFM function?
- How does barefoot running influence IFM function?
What do we know about the intrinsic foot muscles?

- Intrinsic foot muscle activate more with increasing demands:
  - Sitting to standing
  - Bipedal to unipedal stance
  - Slower gait to faster gait
  - Barefoot running to shod running


How can (IFM) function be best assessed objectively?

- Dynamometry
- Electromyography
- Imaging

\(\text{Kurihara et al, 2014} \)
\(\text{Minetto et al, 2009} \)
\(\text{Cameron et al, 2009} \)
How can (IFM) function be best assessed subjectively?

- **Intrinsic Foot Muscle Test**
  - Maintain arch steadiness during single limb stance without over activity of the extrinsic muscles
  - Grading scheme
    - Satisfactory
    - Fair
    - Poor

- **Validity of IFM assessments needs to be established**
  (Soysa et al, 2012)

---

**Intrarater and Interrater Agreement of the Intrinsic Foot Muscle Test**

Facchini et al. IJATT. 2015

**Table 1**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>Unable to maintain navicular height and/or displayed compensatory extrinsic muscle movements throughout the majority of the trial</td>
</tr>
<tr>
<td>Fair</td>
<td>Movement of the navicular height or compensatory extrinsic muscle movements occurred inconsistently throughout the trial</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>A neutral navicular height was maintained without compensatory extrinsic muscle motions throughout the trial</td>
</tr>
</tbody>
</table>

**Table 2**

<table>
<thead>
<tr>
<th>Limb</th>
<th>Rater-I</th>
<th>Rater-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>.41</td>
<td>-.06</td>
</tr>
<tr>
<td>Right</td>
<td>-.05</td>
<td>.12</td>
</tr>
</tbody>
</table>

**Table 3**

<table>
<thead>
<tr>
<th>Limb</th>
<th>Session I</th>
<th>Session II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>.25</td>
<td>.51</td>
</tr>
<tr>
<td>Right</td>
<td>.55</td>
<td>.60</td>
</tr>
</tbody>
</table>

---
What evidence is there that IFMs are impaired in patients with LE pathology?

• Intrinsic foot muscle volume is reduced by up to 50% in patients with diabetic neuropathy compared to healthy controls
  – Amount of atrophy is strongly correlated with severity of neuropathy
    (Andersen et al, 2004)

What evidence is there that IFMs are impaired in patients with LE pathology?

• **Plantar fasciitis** patients have 5% reduction in forefoot intrinsic muscle volume compared to healthy controls
  – No differences in rearfoot muscle volume
  – No difference in tibialis posterior muscle volume
    (Chang et al, 2012)

• Experienced runners with **plantar fasciitis** compared to healthy runners:
  • 11.8% less total IFM volume
  • 20.5% less rearfoot IFM volume
  • 4.4% less forefoot IFM volume
    (Cheung et al, 2016)
**Chronic Ankle Instability:**

- 2D outline = muscle area for given slice
- Muscle Volume Formula
  - 2D area × 5mm = 3D (Slice volume)
- 3D reconstruction and muscle volumes are created and computed in Matlab (MSEG)
  - Volume is normalized to height × mass

---

**CAI: Intrinsic Foot Muscle Volumes**

- CAI Mean
- Healthy Mean

- Quotients Plantar
  - ES = -0.88 (-1.97, 0.21)

- Intorsesus
  - ES = -0.45 (-1.50, 0.60)

- Flexor Digitorum Brevis
  - ES = -0.37 (-1.42, 0.68)

- Abductor Hallucis Obliquus
  - ES = -0.06 (-1.17, 0.91)

- Flexor Digitorum Brevis
  - ES = -3.42 (-5.06, -1.79)

- Abductor Hallucis
  - ES = -0.70 (-1.77, 0.91)

- Flexor Digitorum Brevis
  - ES = -0.60 (-1.64, 0.47)

- Abductor Hallucis Transversus
  - ES = 0.19 (-0.85, 1.23)

- Adductor Hallucis Obliquus
  - ES = -0.37 (-1.42, 0.68)

- Flexor Hallucis Brevis
  - ES = -3.42 (-5.06, -1.79)

- Abductor Hallucis
  - ES = -0.06 (-1.17, 0.91)

- Flexor Digitorum Brevis
  - ES = -0.60 (-1.64, 0.47)

- Adductor Hallucis Obliquus
  - ES = -0.37 (-1.42, 0.68)

Muscle Volume (cm³)/(m² • kg)
What exercises target specific IFMs?

Intrinsic Foot Muscle Training: Short Foot Exercise

- Slide the 1st MT head towards the heel
- Keep the toes straight – no flexion
  - no hyperextension
- Emphasis on plantar intrinsic muscle activity
- No extrinsic muscle activity allowed
**Toe Spread Out Exercise**

Cues:
- Raise all 5 toes (extension)
- Spread all 5 toes outwards
- Bring 1st (big) and 5th (pinky) toes back to ground

**Isolated Great Toe Extension**

Cues:
- Foot flat on ground
- Knee and ankle at 90 degrees
- Raise 1st toe off ground
- Keep 2-5th toes relaxed
**Isolated Lesser Toe Extension**

**Cues:**
- Foot flat on ground
- Knee and ankle at 90 degrees
- Raise 2-5th toes off ground
- Keep 1st toe relaxed

---

**Which muscles are targeted with specific exercises?**

- Short foot vs. Toe Spread Out

- Abductor Hallucis is 2x more activated with TSO than short foot

- Minimal difference in Adductor Hallucis activation between the two exercises

*(Kim et al, 2013)*
Intrinsic Foot Muscle Activation During Specific Exercises: A T2 MRI Study

Thomas M. Gooding, MEd, ATC, CSCS
Mark A. Feger, PhD, ATC
Joe M. Hart, PhD, ATC
Jay Hertel, PhD, ATC

Journal of Athletic Training (in press)

Methods: Subjects

• 5 male, 3 female collegiate D1 Cross Country & Track Runners
  – No limitations in sport participation due to injury upon time of testing
  – No conditions known to adversely affect muscle size or function measurements
  – Prior experience with IFM exercises

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 +/- .93</td>
<td>180.98 +/- 10.84</td>
<td>70.91 +/- 7.82</td>
</tr>
</tbody>
</table>
**Methods: Processing**

Regions of Interest

<table>
<thead>
<tr>
<th>Pre-Exercise</th>
<th>Post-Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre (41.42%)</td>
<td>Post (59.95%)</td>
</tr>
<tr>
<td></td>
<td>~18.53% change in activation</td>
</tr>
</tbody>
</table>

**Short Foot Exercise**

Gooding et al, *JAT* (in press)
**Toe Spread Out Exercise**

Gooding et al, *JAT* (in press)

**1st Toe Extension**

Gooding et al, *JAT* (in press)
Muscle Activation Results

- All muscles were activated in all four exercises at varying levels
  - SFE (16.6-35%) - TSO (17.3-35.2%)
  - 1st TE (13.1-18.1%) - 2-5th TE (8.9-22.5%)

- Wide between subject variation in muscle activation patterns for all exercises

- Activation vs. purposeful inhibition

Gooding et al, JAT (in press)
What about traditional toe curl exercises?

• Cross sectional area of the medial (r=.52) and lateral (r=.32) plantar IFM were predictive of max toe flexion strength, while extrinsic toe flexor muscles were not significant predictors in the model (Kurihara et al, 2014)

• Flexor hallucis brevis & flexor digitorum brevis intramuscular EMG amplitude were increased ~45% when performing toe flexion in plantar flexed vs. neutral ankle position (Hashimoto & Sakuraba, 2014)

Does short foot exercise improve IFM function?

• Mulligan & Cook (2013)
  – 4 week home exercise program
    • 3 minutes per day
    • Sitting to bipedal to unipedal
  – Significant improvements in:
    • Navicular drop
    • Arch height index
    • Star Excursion Balance Test
    • Intrinsic Foot Muscle Test
  – Effects retained
  – No control group
Does short foot exercise improve IFM function?

- **Jung et al (2011)**

  - 8 week home exercise program comparing orthotic intervention to orthotic + short foot exercise in individuals with pes planus
  - 6 sets of 5 repetitions per day
    - Each rep held for 5 seconds
  - All exercises done in unipedal stance

- Compared to Orthotic Only group, the group also doing SFE had significant improvements in:
  - Cross sectional area of AbdHal muscle (11% gain)
  - Great toe flexor strength (28% gain)

---

**Short Foot Exercise vs. Towel Curl Exercises for Balance**

- **4 week home exercise program**
  - Short Foot Group: 100 reps/day
  - Towel Curl Group: 100 reps/day
  - Control Group: No exercises

  **N = 8 in each group**

  Pre-Post Effect Sizes: Negative values indicate improvement

<table>
<thead>
<tr>
<th></th>
<th>Dominant Stance Limb</th>
<th>Non-dominant Stance Limb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Static Balance</td>
<td>Dynamic Balance</td>
</tr>
<tr>
<td>Short Foot</td>
<td>.45</td>
<td>-.66</td>
</tr>
<tr>
<td>Towel Curl</td>
<td>.02</td>
<td>-1.57</td>
</tr>
<tr>
<td>Control</td>
<td>.12</td>
<td>-.92</td>
</tr>
</tbody>
</table>
Electrical Stimulation as an adjunct?

<table>
<thead>
<tr>
<th>Table 1</th>
<th>The parameters for neuromuscular electrostimulation of the intrinsic foot muscles during the active-assisted modeling phase of isolated training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters for Neuromuscular Electrostimulation for Active-Assisted Modeling</td>
<td>Waveform</td>
</tr>
<tr>
<td>Frequency</td>
<td>85 Hz</td>
</tr>
<tr>
<td>Pulse length</td>
<td>400 μs</td>
</tr>
<tr>
<td>Contraction time</td>
<td>4 s</td>
</tr>
<tr>
<td>Ramp up time</td>
<td>0.25 s</td>
</tr>
<tr>
<td>Ramp down time</td>
<td>0.75 s</td>
</tr>
<tr>
<td>Rest time</td>
<td>8 s</td>
</tr>
<tr>
<td>Treatment time</td>
<td>15 min</td>
</tr>
<tr>
<td>Contractions</td>
<td>75</td>
</tr>
</tbody>
</table>

McKeon & Fourchet, 2015
Fouchet et al, 2011

Foot Core Rehab Paradigm

McKeon & Fourchet, 2015
What are the optimal parameters for training the IFMs?

- Sets, reps, frequency, progressions?

What fiber types are predominant in the different intrinsic foot muscles?

- Tremendous variability in fiber type of Quadratus Plantae seen across individuals
  - In 11 cadavers, type I fiber percentage ranged from:
    - 19.1 to 91.6% in lateral head
    - 20.4% to 97.0% in medial head
  (Schroeder et al, 2014)

How does barefoot running influence IFM function?

- Purported benefits of barefoot/minimalist running:
  - Forefoot strike pattern
    - Lower impact loading
    - Shorter stride length
    - Less injuries?
  - Improved running efficiency
  - Increased somatosensation
  Altman & Davis, 2012
How does barefoot/minimalist running influence IFM function?

- 5 months of running in minimalist shoes produced increased CSA of Abductor Hallucis & Quadratus Plantae by 5%
  
  Bruggermann et al, 2005 (abstract)

- 12 weeks of running in minimalist shoes produced increased volume of:
  - Flexor Digitorum Brevis: 27%
  - Abductor Digiti Minimi: 25%

  Miller et al, 2014

- 6 months of running in minimalist shoes produced increased volume of:
  - Leg muscles by 7.1%
  - IFM by 8.8%
    - Rearfoot: 6.6%
    - Forefoot: 11.9%

  Chen et al, 2016

How does barefoot running influence IFM function?

- 10 weeks of running in minimalist shoes increased Abductor Hallucis CSA by 10% compared to 1.8% change in controls
  - No significant changes in FDB, FHB, or EDB

- 8 out of 18 subjects transitioning to minimalist shoes developed bone marrow edema in at least one foot bone
  - 7 of 8 were females
  - Smaller IFM size in those developing bone marrow edema
  - Only 1 out of 19 subjects in control group developed bone marrow edema

  (Johnson et al, 2016)

There is a lack of studies linking changes in muscle morphology to running biomechanics and injury risk.
When lacking high level experimental evidence, resort to expert opinion

“You can’t let the arches of your feet collapse. The collapse of your arches is the collapse of your sex life.”

Colleen Saidman Yee
The First Lady of Yoga
*New York Times, April 5, 2013*

Conclusions

- Think about the “foot core” hypothesis
- Consider intrinsic muscle (dys)function in patients with LE injuries
- Incorporate intrinsic foot muscle exercises into prevention and rehabilitation programs as appropriate
Thank You…

Jhertel@virginia.edu

twitter
@Jay_Hertel
Clinical Pearls in Hip Rehabilitation: Femoroacetabular Impingement

Kristi Tomovich, PT, DPT, SCS
UC San Diego Health: Sports Medicine for Primary Care
October 2016

Road Map

1. The Hip: Anatomy Review & Causes of Pain
2. FAI Deep Dive
3. FAI Treatment: Conservative & Surgical
4. Rehabilitation: Post-Operative Protocol
Anatomy Review: The Hip Joint

• Labrum: triangular fibrocartilaginous structure
  • Deepens acetabulum → increased hip stability
  • Proprioceptive and nociceptive feedback
  • Aids in lubrication of the joint
  • Poorly vascularized → low healing potential

• Absence of labrum:
  • Decreased joint stability, increased contact pressure of femoral head against acetabulum, loss of fluid between cartilage layers

Hip Pain in the Athlete

• Soft tissue injuries:
  • Bursitis, tendinitis, snapping hip, piriformis syndrome, hamstring syndrome, contusion, avulsion injury

• Skeletal causes:
  • Bony avulsion injury, fracture (stress or pathologic), hip dislocation

• Pediatric athlete:
  • Non-traumatic causes (SCFE, LCP Disease, developmental dysplasia)

🌟 Articular causes:
  • FAI, Labral tear, cartilage injury, OA
Femoroacetabular Impingement (FAI)

- **Bony abnormalities** of proximal femur and/or acetabulum → abnormal impingement of acetabular rim and femoral head/neck junction
  - Occurs mostly with hip FLEXION and IR

- Leads to pain, articular cartilage disease, labral abnormalities, and progressive secondary OA of the hip

- Early diagnosis is important → surgery can lead to favorable outcomes prior to OA changes
Femoroacetabular Impingement: Types

1. **Cam Impingement**: non-spherical femoral head and/or widening of femoral neck
   - With hip flexion, non-spherical head rotates into acetabulum
     → compression and shear forces on anterosuperior labrum and articular cartilage
   - 3:1 men:women; usually presents in young adulthood

2. **Pincer Impingement**: excessive prominence of acetabular rim
   - With hip flexion, prominent rim crushes labrum against femoral neck
     → breakdown of acetabular labrum
   - Equal men:women, onset of symptoms in middle age

3. **Mixed**: often leads to degeneration of labrum
   - Most common

Patient Evaluation

- **History**
  - Insidious symptom onset
    - Groin pain, mechanical symptoms, instability
  - Pain location: “C Sign”
    - Anterior groin, medial thigh, lateral hip, low back, buttock
  - Worse with walking, running, pivoting, prolonged sitting/standing, max hip flexion

- **Exam**
  - ROM
    - Limited flexion and IR (pain at end-ranges)
  - Special Tests
    - Anterior Impingement (flex, ADD, IR)
    - FABER
  - Strength
  - Gait & Posture
Patient Evaluation

• Differential Diagnosis
  • Neuro screen to rule out lumbar spine pathology
  • Palpation: rule out snapping hip, bursitis, athletic pubalgia

• Imaging
  • X-ray: initial evaluation to identify bony abnormalities
  • MR arthrogram: gold standard for labral tears and cartilage damage

• Sports
  • Sports involving hyperflexion, hyperextension, rotational movements
    • Abnormal forces on acetabular rim → microtrauma and injury
  • Soccer, hockey, dance, baseball

Treatment of FAI and Labral Tears
Conservative Treatment

- Trial of conservative treatment x 4 weeks, especially if symptoms are mild and stable
- NSAIDs, rest, activity modification, PT
- PT:
  - Education and activity modification
  - Joint mobility and soft tissue flexibility
  - Core strength
  - Functional movement patterns
  - Avoid aggressive PROM
- Often not enough to fully resolve symptoms

Surgery

- Objectives of surgery:
  - Correct bony deformities and treat intra-articular pathologies resultant from FAI
  - Reduce hip pain, improve function, return to sport, slow down degenerative changes

- Contraindications:
  - Advanced joint degeneration
  - Unwilling to comply with rehab protocols, WB status, precautions, etc.
  - Cellulitis, femoral neck stress fracture, arthrofibrosis, hip fusion

- Complications:
  - Low complication rate for hip arthroscopy (<1.5%)
  - Neuapraxias (usually transient), heterotopic ossification, infection, femoral neck fracture, avascular necrosis of femoral head
Surgery for Bone & Cartilage

- **Bony Deformities**
  - Cam impingement: osteoplasty to reshape the femoral head-neck junction
  - Pincer impingement: rim trimming to correct acetabular overcoverage
  - Full bony remodeling takes 3 months
    - Avoid high-impact, torsional forces during this period

- **Cartilage Damage**
  - Chondroplasty
  - Microfracture: facilitate growth of hyaline-like fibrocartilage
    - Medium-sized, full-thickness articular lesions
    - Precautions following surgery: PWB x 6-8 weeks to optimize healing response

Surgery for Labral Tears

- **Resection/Debridement**
  - Remove unhealthy tissue, attempting to spare as much stable tissue as possible
  - Small, stable tears (<3mm)

- **Repair**
  - Refixation to acetabular rim with suture anchors
  - Larger, unstable tears; partially-detached labrum

- **Reconstruction**
  - ITB, ligamentum teres, or gracilis tendon graft
  - Irreparable labrum (complex tears)
  - Indicated in young, active patients → must have at least 2mm joint space
Surgical Outcomes

• Outcomes following hip arthroscopy for FAI
  • Studies indicate **return to excellent function and high patient satisfaction**
  • Factors associated with GOOD outcomes:
    • Pre-op joint space >2mm, repair of labrum rather than debridement
    • **Greatest risk of failure: joint space <2mm**
    • Up to 30% of patients treated surgically for FAI eventually require THA

• Outcomes for labral reconstruction
  • Short-term improvement in patient-reported outcomes and functional scores
  • High level of return to sport in athletes
  • INFERIOR outcome if >30 y/o or joint space <2mm

Rehabilitation
Pre- & Post-Operative Rehab

• Pre-Operative Rehab Goals:
  • Maximize ROM, strength, endurance
  • Identify patients who might not comply with post-op protocol
  • Explain post-op rehab process (WB restrictions, duration/frequency of PT)
    ✪ Set patient expectations

• Post-Operative Rehab:
  • Timelines vary based on procedure performed and activity goals
    ✪ Rehab must be individualized and evaluation-based
  • Consider specific procedure, patient's goals, age, sport-specific demands

Phase I: Motion (0-4 weeks)

• GOALS:
  • Control inflammation and pain
  • Begin ROM
  • Prevent muscle inhibition

• Precautions:
  • ROM and WB restrictions based on procedure
  • Brace, CPM, rotation precaution boots

• ROM: prevent adhesions
  • CPM, PROM including circumduction, stationary bike (no resistance)

• Soft tissue mobility:
  • Careful stretching and STM, prone lying, joint mobilizations (thoracic/lumbar spine)
    • Avoid joint mobs of hip x 6 weeks to avoid stress to joint capsule
Phase I: Motion (0-4 weeks)

- Gait & Balance Training
- Strength:
  - Prevent muscle inhibition (hip isometrics, TrA activation)
  - Avoid active hip flexion (no SLR) x 4 weeks
  - Emphasize gluteus medius recruitment and lumbopelvic stabilization
  - Risk for lower crossed syndrome
- Criteria to Progress
  - Minimal Pain
  - ROM at least 75% of uninvolved side
  - MD clearance for WB; non-Trendelenburg gait; good firing of gluteals
  - Appropriate muscle recruitment with exercises

Phase II: Muscle Endurance & Proprioception (4-8 weeks)

- GOALS:
  - Progress strength, vary proprioceptive environment, continue to work on restoration of ROM, flexibility, gait
- ROM:
  - PROM, stretching, STM, joint mobs for hip (pain-free)
- Strength:
  - Muscle endurance (high reps, low resistance)
  - Dissociation of pelvic movements, proper recruitment of gluteals
  - Progress from OKC → CKC, double leg → single leg
- Balance:
  - Progress from stable → unstable surface
Phase II: Muscle Endurance & Proprioception (4-8 weeks)

- Cardiovascular Training
  - Add resistance to bike
  - Begin elliptical by 6-8 weeks
  - Freestyle swimming and water jogging (6-8 weeks)
  - Avoid treadmill walking secondary to increased shear force at hip

- Criteria to Progress
  - Normal, pain-free gait
  - Full ROM
  - Strength 60-70% of uninvolved side

Phase III: Advanced Functional Strengthening (Week 8-12)

- GOALS:
  - Progress endurance, proprioception, hip/core strength
  - Emphasis on functional movements

- Precautions:
  - Avoid contact activities, aggressive hip flexor strengthening, forced/aggressive stretching that elicits pain

- Strength, Power, Speed:
  - Focus on strength and power, eccentric control
  - Change rate/timing of contractions to prepare for return to sport
  - SL exercises, vary proprioceptive environments, functional movements using multiple muscle groups
Phase III: Advanced Functional Strengthening (Week 8-12)

- Phase III typically end of rehab for general population
- Running (with MD clearance):
  - Walk/jog progression if able to demonstrate:
    • Good eccentric control with SL activities
    • Sufficient muscle endurance and power
    • Initiate light, single plane agility drills
- Criteria to Progress:
  • Hip strength 70-80% of uninvolved side
  • Symmetrical ROM and flexibility
  • CV status nearly equal to pre-injury level
  • Functional movement without Trendelenburg sign or improper muscle recruitment

Phase IV: Return to Sport (Week 12+)

- GOAL:
  • Safe and effective return to competition or previous activity
- Strength:
  • Advance functional strengthening and multi-planar exercises
  • Emphasize demands of athlete’s specific sport and position
- Agility and sport-specific drills
  • Straight ahead ➔ lateral ➔ multi-directional drills
  • Begin in controlled environment with stable footwear and no external influences from other athletes
    • Progress to appropriate surface (grass, turf, ice) and add additional players
Phase IV: Return to Sport (Week 12+)

- **Functional Sports Tests**
  - Sport Cord tests (Steadman Hawkins Clinic and Howard Head Sports Medicine)
    - SL squats with SC, forward/backward/lateral jogging with SC
  - Return to Play tests
    - Y-balance, hop tests, lateral cone shuffles
    - Video analysis of squats, SL squats, drop jumps with squat landing

- **Criteria to Return to Sport**
  - Full, pain-free ROM
  - Normal strength and flexibility in core and LE
  - CV endurance required for specific sport
  - Demonstrate sport and position-specific drills at competition speeds/settings
  - Successful completion of Sport Test

---

Gluteus Medius Exercise Progression

- Gluteus medius influences hip, knee and low back function
  - Weakness → excessive pelvic rotation and femoral IR → pain and injury
- Gluteus medius weakness often accompanied by iliopsoas tendinitis
  - Q: What exercises are safe?

- Study by Philippon et al.
  - 10 healthy individuals ages 26-30 (5 male, 5 female)
  - Intramuscular electrodes inserted under ultrasound guidance; EMG signals collected
  - Measured muscle activation of gluteus medius and iliopsoas during 13 exercises

Gluteus Medius Exercise Progression

**GLUTEUS MEDIUS ACTIVATION**

**LOWEST**

1. Resisted prone TKE
2. Supine hip flexion
3. Resisted prone knee flexion
4. Stool hip rotations
5. Hip clams in neutral
6. Double-leg bridge
7. Traditional clam
8. Resisted hip ext (bent knee)
9. Sidelying hip abd with ER
10. Sidelying hip abd, heel against wall
11. Prone heel squeeze
12. Sidelying hip abd with IR
13. Single-leg bridge

**HIGHEST**

Activation of gluteus medius muscle 10 times greater than activation of iliopsoas muscle

Moderate iliopsoas activation → Caution


Questions?
References


References