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Managing Foot & Ankle Pathology in the Distance Runner

David Nolan, PT, DPT, MS, OCS, SCS, CSCS

Learning Objectives

- Describe at least two common running related injuries in the foot and ankle complex and lower leg.
- Describe at least three sound clinical reasoning skills and at least three evidence-based clinical tests and measures to the evaluation of the foot and ankle complex.
- Implement an evidence-based treatment plan that includes at least three interventions to address selected running related pathology.
- Outline a return to run program for a distance runner.

Running Statistics

- 10 – 30 Million Runners in United States
- Over 40 Million pairs of shoes sold in US
  - > $2 Billion/year industry
- Boston Marathon
  - Over 27K runners
  - Johnny Kelley (1907 – 2004)
    - Ran Boston 61 times
    - Won twice
    - 18 top10 finishes

Benefits of Running

- Cardiovascular Health
- Muscular Fitness
- Diabetes Control
- Osteoporosis
- Prevention of colon cancer
- Depression

Running Injuries

- **Extrinsic Factors /** Environmental
  - Training errors
    - "Terrible Too's"
      - *Too* much, *Too* soon, *Too* fast. With *Too* little rest.
  - Old shoes
  - Running surface
- **Intrinsic Factors / Person-Related**
  - Poor flexibility
  - Biomechanical faults
  - Previous injury
  - Running experience

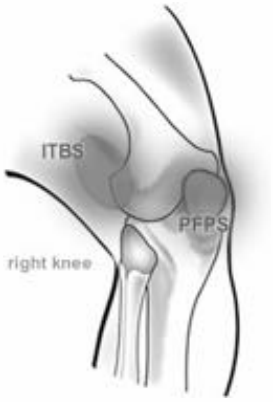
Epidemiology of Running Injuries

- **Taunton JE et. al. *BJSM* 2002**
  - Most Common Injuries
    - Patellofemoral Pain Syndrome (16.5%)
    - Iliotibial Band Friction Syndrome (8.4%)
    - Plantar fasciitis (7.9%)
    - Gastroc-Soleus complex (6%)
    - Meniscal Injuries of knee (5%)
    - Tibial Stress Syndrome (4.9%)

- Van Gent RN et al. *BJSM*, 2007
  - Systematic review of injury in distance runners
  - Knee was most common site of musculoskeletal injury

Epidemiology of Running Injuries

- **Taunton JE et. al. *BJSM* 2002**
  - Risk Factors
    - Age < 34 years
      - PFPS for both sexes
      - ITBS, patellar tendinopathy, tibial stress syndrome for men
    - Active < 8.5 years
      - Tibial stress syndrome for both sexes
    - Women with BMI < 21
      - Tibial stress fractures & spinal injuries



Epidemiology of Running Injuries

- **Taunton JE et. al. *BJSM* 2003**

Location	Men	Women
Knee	36%	32%
Shin	17%	15%
Foot	14%	13%
Achilles / Calf	8%	10%
Ankle	10%	10%
Hip / Pelvis	7%	10%
Low Back	7%	5%
Hamstring	0%	3%
Thigh	0%	1%

Epidemiology of Running Injuries

- **Taunton JE et. al. *BJSM* 2003**
  - Risk Factors
    - Age > 50 years
    - Running one day/week for women
    - Running shoe age
    - History of previous injury (50% of injured subjects)
    - Incomplete rehabilitation of previous injury prior to starting 13 week training program (42% of injured subjects)
  - Protective Factors
    - Age < 31 years
    - BMI > 26 in men

Epidemiology of Running Injuries

- **Buist, I et al *AJSM* 2010**
  - 532 novice runners (226 male, 306 female)
  - **13 week training for 4 mile event**
  - 21% had at least one running-related injury
  - Male
    - Higher BMI
      - Added physical stress on tissues
    - Previous injury in last year
    - Previous participation in sports without axial load
      - 2.1x higher risk
      - Ex. Cycling, swimming
  - Female
    - Navicular drop
      - Associated with greater foot pronation

Epidemiology of Running Injuries

- Nielsen RO et al. *Orthop J Sports Med*. 2013
  - 930 novice runners
  - 27% sustained RRI
    - Type B behavior (p=0.04)
    - Age 45-65 yo (p = 0.08)
    - Previous injury unrelated to running (p = 0.05)
    - Sex (p = 0.42)
    - Previous running related injury (p = 0.30)

Epidemiology of Running Injuries

- Tenforde AS et al. *PMR*, 2011
  - Adolescent Runners (13-18 yo)
  - Lifetime prevalence of previous running injury
    - Boys: 59%
    - Girls: 68%
  - Associated with
    - ↑ mileage
    - Faster performance

Epidemiology of Running Injuries

- Running Volume
  - Rasmussen CH et al *IJSPT* 2013
    - Retrospective study with marathon finishers
    - Self-Report RRI (↓ distance, speed, duration or frequency ≥ 14 days)
    - 10% reported RRI
    - 2x greater risk weekly volume <30K (18 miles)

Epidemiology of Running Injuries

IJSPT

ORIGINAL RESEARCH

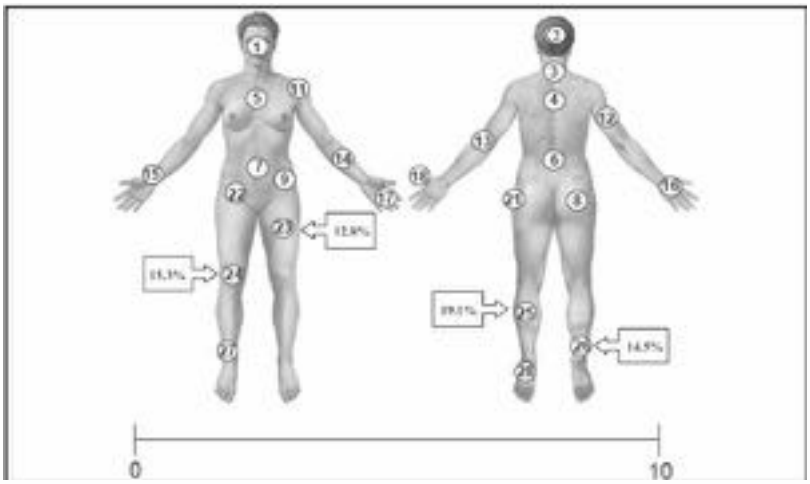
PREVALENCE OF MUSCULOSKELETAL PAIN IN MARATHON RUNNERS WHO COMPETE AT THE ELITE LEVEL

Renata Nakata Teixeira, MsC, PhD[1]
Adriana Lunardi, PT, MsC, PhD[1,2]
Ronaldo Aparecido da Silva, MsC, PhD[1]
Alexandre Dias Lopes, PT, MsC, PhD[2,3]
Celso R. F. Carvalho, PT, MsC, PhD[1]

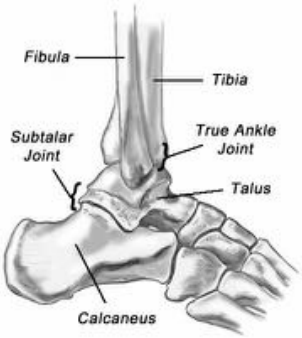
- Teixeira RN et al. *IJSPT*. 2016
  - 199 elite marathoners interviewed
  - 75% reported MSK pain
  - Independent of age, experience, running volume

Epidemiology of Running Injuries

- Teixeira RN et al. *IJSPT*. 2016

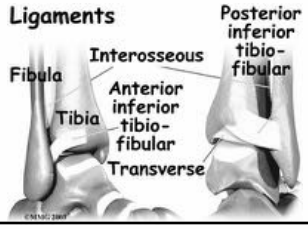


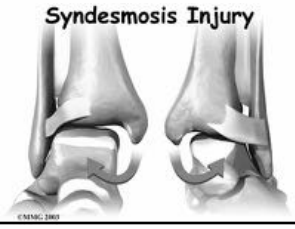
Ankle Joint Problems



Ankle Joint

- **Syndesmotic Ankle Sprain (High Ankle Sprain)**
  - Distal tibiofibular joint
  - Common in contact sports: (Williams GN et al. *AJSM* 2007)
  - Mechanism:
    - ER of talus that gaps distal tibiofibula joint
    - DF of ankle and IR of tibia on planted ER foot





Ankle Joint

- **Syndesmotic Ankle Sprain (High Ankle Sprain)**
  - Special Testing
    - Squeeze Test
      - Pressure applied along tibia and fibula
    - Dorsiflexion External Rotation Test
      - Reliability (Kappa = 0.75, 0.50)
      - Creates gapping of syndesmosis

Ankle Joint

- **Syndesmotic Ankle Sprain (High Ankle Sprain)**
  - Treatment (Williams GN et al. *AJSM* 2007)
    - Phase I: Protection
      - Immobilization
        - » Cast or walking boot in severe cases with significant pain
        - » Stirrup brace or tape in cases with low pain
      - Weight Bearing
        - » Partial with crutches until normal gait pattern
      - Inflammation
        - » Compression / Elevation / Cryotherapy
      - Progression criteria:
        - » Pain and swelling controlled with minimal gait abnormality

Ankle Joint

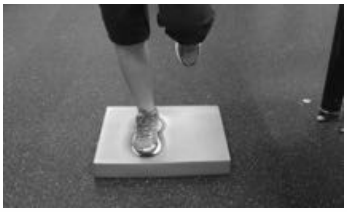
- **Syndesmotic Ankle Sprain (High Ankle Sprain)**
  - Treatment (Williams GN et al. *AJSM* 2007)
    - Phase 2: Subacute
      - Strength
        - » Progress from band to CKC exercises
      - Neuromuscular Control
        - » Balance on unstable surfaces
        - » Introduce pivoting activity, obstacles, light hopping (double limb)
      - Range of Motion
        - » Joint mobilization & stretching introduced
        - » Avoid dorsiflexion: gap distal tibiofibular joint
      - Progression Criteria
        - » Able to hop and jog without pain/swelling

Ankle Joint

- **Syndesmotic Ankle Sprain (High Ankle Sprain)**
  - Treatment (Williams GN et al. *AJSM* 2007)
    - Phase 3: Sport Specific Training
      - Strengthening
        - » Increase load with ankle strength
        - » Proximal strengthening
      - Neuromuscular Training
        - » Plyometrics, shuttle runs, carioca drills
      - Sport Specific Agility Drills
        - » Dribbling soccer ball, running pass routes
      - Return to Play Criteria
        - » Hopping drills, acceleration/deceleration, pivoting

Ankle Joint

- **Lateral Ankle Sprain**
  - Risk Factors (Willems TM et al. *Am J Sports Med*. 2005)
    - Slower running (fatigue)
    - Less cardiorespiratory fitness (fatigue)
    - Less balance & movement coordination
    - Decreased ankle dorsiflexion ROM and muscle strength
    - Decreased reaction time of tibialis anterior & gastrocnemius

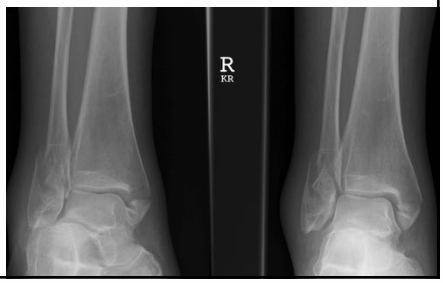


Ankle Joint

- **Lateral Ankle Sprain**
  - Risk Factors (Beynnon BD et al. *J Orthop Res*. 2001)
    - Women
      - Increased calcaneal eversion ROM
      - Increased tibial varum
      - Participation in high risk sport (i.e. soccer)
    - Men
      - Increased talar tilt
    - Variables with *No Association* with ankle sprain
      - Ankle strength
      - Foot posture
      - Generalized joint laxity

Ankle Joint

- **Lateral Ankle Sprain**
  - Diagnosis
    - Ottawa Ankle Rules: Radiographs indicated with
      - Bone tenderness at medial/lateral malleoli or talus
      - Bone tenderness at
        - » Posterior tip of medial/lateral malleolus
        - » Base of 5th metatarsal
        - » Navicular
      - Inability to weight bear



Ankle Joint

- **Lateral Ankle Sprain**
  - Hubbard TJ & Hertel J. *Man Ther*. 2008
    - Isolated ATFL 66%
    - CFL involved 20%
    - PTFL is rarely involved

Ankle Joint

- **Lateral Ankle Sprain**
  - Beynnon BD et al. *J Orthop Res*. 2001
    - Grade I
      - No loss of function
      - No ligamentous instability
      - Little or no ecchymosis / point tenderness
    - Grade II
      - Some loss of function
      - Decreased motion
      - (+) Anterior drawer, (-) Talar tilt
      - (+) Ecchymosis, swelling and point tenderness
    - Grade III
      - Significant loss of function: inability to weight bear
      - (+) Anterior drawer, (+) Talar tilt
      - Diffuse swelling, ecchymosis, extreme point tenderness

Treatment Based on Grading

- Petersen, W et al. *Arch of Orthopedic Trauma Surg*. 2013
- Systematic review of Treatment of Acute Ligament Injuries
  - Grade I and II – Early mobilization
  - Grade III – Immobilize for a maximum of 10 days
  - All Grades transition to Semi-Rigid ankle brace
- Neuromuscular and Balance training decreased recurrence

Ankle Joint

- **Lateral Ankle Sprain**
  - Treatment
    - Aiken AB et al. *J Orthop Sports Phys Ther.* 2008
      - <5% of acute ankle sprains referred to PT
      - ER Rx of PRICE: Perceived recovery as "incomplete" after 30 days & had muscle weakness & reduced ankle mobility
    - Hubbard TJ & Cordova M. *Arch Phys Med Rehabil*. 2009
      - Used arthrometer to measure anterior laxity
      - 3 Days Post injury:
        - » Involved = 15.3 mm; uninvolved = 9.8 mm
      - 8 Weeks Post injury:
        - » Involved = 14.2 mm; uninvolved = 9.7 mm
      - Treatment: Advice on ice & compression only

Ankle Joint

- **Lateral Ankle Sprain**
  - Treatment
    - Hupperets MD et al. *BMJ*. 2009
      - Unsupervised HEP
        - » One-legged knee flexion
        - » Toe stand
        - » One legged stand
        - » Runners pose
        - » Crossed leg sway
        - » Toe walk
      - Effective at decreasing risk of re-injury

Ankle Joint

- **Lateral Ankle Sprain**
  - Treatment: Manual Therapy
    - Green T et al. *Phys Ther*. 2001
      - Manual therapy & RICE compared to RICE alone
      - A & P mobilization at talocrural joint
      - ↑DF ROM & stride speed with manual therapy group
    - Whitman JM et al. *J Orthop Sports Phys Ther*. 2009
      - Predicting (+) response to manual therapy techniques
        - » Worse with standing
        - » Worse in evening
        - » Navicular drop >5mm
        - » Distal tibiofibular hypomobility
      - 95% Success with 3 of 4 present

Ankle Joint

- **Lateral Ankle Sprain**
  - Treatment: Manual Therapy
    - Truyols-Dominguez S et al *JOSPT.* 2013
      - Compared thrust & nonthrust manipulation and exercise with/without myofascial therapy
      - Greater improvement in pain and function with myofascial therapy group

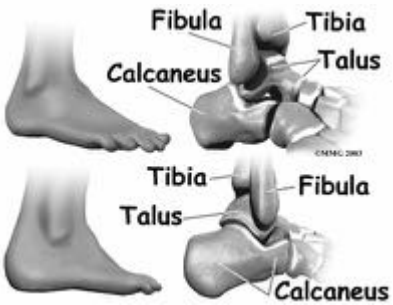
Ankle Joint

- **Lateral Ankle Sprain**
  - Treatment: Manual Therapy
    - Cleland JA et al. *JOSPT*. 2013
      - Manual Therapy & Exercise VS. Supervised Home Exercise
      - Randomized into 2 groups
        - » MTEX (n = 37) or HEP (n = 37)
      - FAAM (ADL & Sports subscales), LEFS, NPRS
        - » Baseline, 4 weeks & 6 months
      - Improvements in all functional outcome measures and pain significantly greater at 4 week & 6 month F/U in MTEX group
      - Manual therapy approach is superior to HEP in treatment of inversion ankle sprains

Ankle Joint

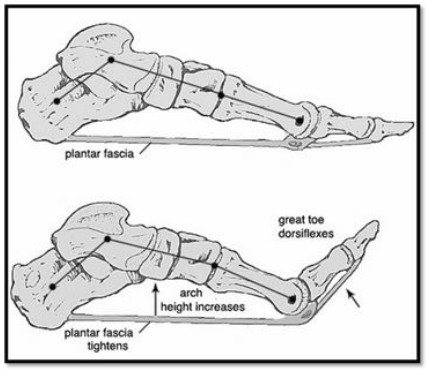
- **Lateral Ankle Sprain**
  - Treatment: Manual Therapy
    - Cleland JA et al. *JOSPT*. 2013
      - Rearfoot distraction manipulation
      - TCJ posterior mobilization
      - WB TCJ posterior mobilization
      - Calcaneal lateral glides & eversion
      - Proximal tibiofibular manipulation
      - Distal tibiofibular mobilization

Rearfoot Problems



Plantar Fasciopathy

- **Fasciitis or Fasciosis?**
  - Degenerative process *without* inflammation (Lemont H et al. JAPMA 2003)
- **Epidemiology**
  - Peak incidence 45-64 y.o. (Riddle DL & Schappert SM. *Foot Ankle Int*. 2004)
  - Gender studies are conflicting
- **Anatomic Risk Factors**
  - Excessive femoral anteversion
  - External malleolar torsion
  - Pes planus or cavus foot
  - Excessive pronation
- **Biomechanical Risk Factors**
  - Limited flexibility (gastroc-soleus)
  - BMI > 30
  - Poor footwear



Plantar Fasciopathy

- **Risk Factors**
  - Running
    - Lopes AD et al. *Sports Med* 2012
    - Sobhani S et al. *Scand J Med Sci Sports* 2013
    - Tenforde AS. Et al. *PMR* 2011
  - High Arch
    - DiCaprio F et al. *J Sports Sci Med*. 2010
  - High BMI
    - Klein SE et al. *Foot Ankle Int.* 2012
    - Riddle DL et al. *J Bone Joint Surg*. 2003
  - Decreased ankle DF
    - Patel A & DiGiovanni B. *Foot Ankle Int*. 2011
    - Riddle DL et al. *J Bone Joint Surg*. 2003

Plantar Fasciopathy

- **Patient Presentation** (Martin RL et al. *JOSPT*. 2014)
  - Pain on palpation medial calcaneal tubercle
  - 1st step pain in AM & after sitting
  - ↓ pain with movement
  - Limited ankle dorsiflexion
  - (+) Windlass test & (-) Tarsal Tunnel test
  - ↑ BMI in nonathletic individuals

Podiatric Medicine and Surgery © 2001 Primal Pictures Ltd

Plantar Fasciopathy

- Differential Diagnosis (McPoil TG et al. *JOSPT*. 2008 / Martin RL et al. *JOSPT*. 2014)
  - Calcaneal stress fracture
    - Squeeze test: medial/lateral pressure
  - Bone bruise
  - Fat pad atrophy (Yi TL et al. *Ann Rehabil Med*. 2011)
    - (-) 1st step pain
  - Tarsal tunnel syndrome
    - Burning/tingling in foot
    - No pain with dorsiflexion of toes
  - Sever disease
  - S1 radiculopathy

Plantar Fasciopathy

- **McPoil TG et al. *JOSPT* 2008 / Martin RL et al. *JOSPT* 2014**
  - Modalities (Moderate evidence)
    - Iontophoresis (dexamethasone 0.4%) or (acetic acid 5%) provides short term relief (2-4 weeks)
  - Modalities (Conflicting evidence)
    - May or may not use iontophoresis with dexamethasone or acetic acid to provide short-term (2-4 weeks) pain relief and improved function
  - Stretching (Moderate evidence)
    - Calf and/or plantar fascia provides short term relief (2-4 months)
    - No difference between dosage of 20 sec or 3 minutes
  - Stretching (Strong evidence)
    - Plantar-Fascia specific and gastroc-soleus stretching to provide short-term (1 week to 4 months) pain relief

Plantar Fasciopathy

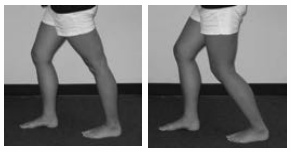
- **McPoil TG et al. *JOSPT* 2008 / Martin RL et al. *JOSPT* 2014**
  - Taping (Weak evidence)
    - Calcaneal or low-Dye provides short term relief (7-10 days)
  - Taping (Strong evidence)
    - Antipronation taping for immediate (up to 3 weeks) pain reduction and increased function
    - Elastic therapeutic tape applied to gastrocnemius and plantar fascia for short-term (1 week) pain reduction
  - Orthotic Devices (Strong evidence)
    - No difference in pain reduction or improved function between pre-fabricated or custom devices
  - Orthotic Devices (Strong evidence)
    - Pre-fabricated or custom devices to support the medial longitudinal arch and cushion the heel to reduce pain and improve function for short (2weeks) to long term (1 year) especially in those who respond to antipronation taping techniques

Plantar Fasciopathy

- **McPoil TG et al. *JOSPT* 2008 / Martin RL et al. *JOSPT* 2014**
  - Night Splints (Moderate evidence)
    - Patients with symptoms > 6 months most appropriate
  - Night Splints (Strong evidence)
    - Prescribe a 1-3 month program of night splints for individuals who consistently have pain with first step in morning
  - Manual Therapy (Theoretical evidence)
    - Joint mobilization & nerve gliding
  - Manual Therapy (Strong evidence)
    - Joint and soft tissue mobilization procedures to treat relevant lower extremity joint mobility and calf flexibility deficits

Plantar Fasciopathy

- Cleland JA et al. *JOSPT*, 2009
  - Electrophysical Agents & Exercise (EPAX)
    - Ultrasound
      - 3 MHz, 1.5 w/cm2, 20%, 5 minutes
    - Iontophoreses
      - Dexamethasone 40 mA-Min
    - Stretching
      - Gastroc, Soleus, Plantar Fascia
    - Ice x 15 min
  - Manual Physical Therapy & Exercise (MTEX)
    - STM of triceps surae & plantar fascia insertion
    - Rearfoot Eversion Mobilization
    - Manual therapy (hip, knee, ankle & foot)
    - Self-mobilization (ankle eversion)
    - Self massage
    - Stretching to gastroc, soleus & plantar fascia



Plantar Fasciopathy

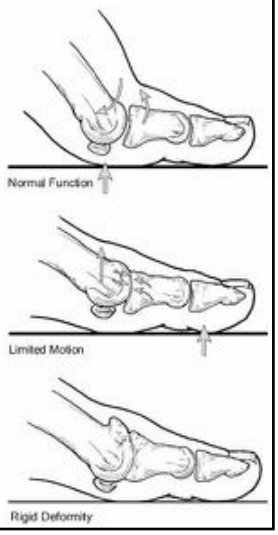
- Cleland JA et al. *JOSPT*, 2009
  - MTEX compared to EPAX
  - LEFS
    - +13.5 @ 4 weeks; +9.9 @ 6 months
  - FAAM
    - + 13.3 % @ 4 weeks; +13.6 @ 6 months
  - NPRS
    - -1.5 @ 4 weeks; No difference @ 6 months

"The combined treatment approach, consisting of manual physical therapy and exercise, provides greater clinical benefits in terms of function than an approach using electrophysical agents and common exercise in managing patients with plantar heel pain"

Forefoot Problems

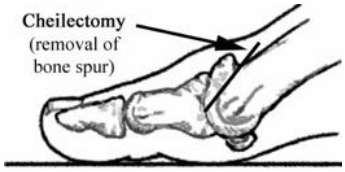
Hallux Limitus / Rigidus

- Degenerative arthritis of 1st MTP
- More common in females
  - Coughlin MJ & Shurnas PS. *Foot Ankle Int*. 2003
- Impingement from dorsal surface osteophytes



Hallux Limitus / Rigidus

- Treatment
  - Early: Distraction & extension mobilization
  - Limit 1st MTP motion for protection
    - Stiff shoe with deep toe box, rocker bottom
    - Carbon graphite footplate (Morton's Extension)
  - Smith RW et al. *Foot Ankle Int*. 2000
    - 22 Patients treated conservatively
    - 75% chose nonoperative treatment at 14 year F/U
  - Surgery: Cheilectomy
    - Removal of bone spurs
    - Goal = 70° MTP dorsiflexion



Metatarsalgia

- Forefoot pain associated with stress at metatarsal head region (typically 1-3)
  - Predisposing factors
    - Impact activity
    - Toe deformities
    - Prominent metatarsal heads
    - Limited gastroc-soleus flexibility
    - Pes planus or cavus foot type
  - Treatment
    - Reduce loading at forefoot
      - ↑ Ankle dorsiflexion
    - Orthoses with metatarsal pad

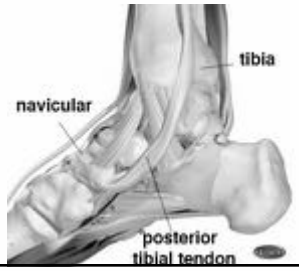
Morton Neuroma

- Perineural fibrosis & nerve degeneration of common digital nerve between 3rd & 4th metatarsals
- Predominantly in women between 45-50
- Aggravated by narrow toe box & high heels
- Pain & paresthesias with plantar pressure between metatarsal heads
- Treatment
  - Steroid injection (Saygi B et al. Foot Ankle Int. 2005)
    - 82% complete or partial relief
  - Correct biomechanical faults
  - Cushion shoes with wide toe box

Sesamoiditis

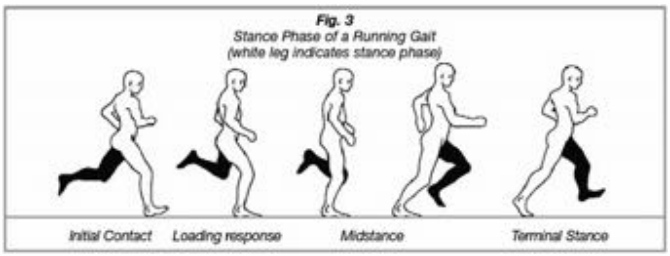
- Avascular changes or inflammation without radiographic evidence of fracture
- Sesamoids embedded in Flexor Hallucis Brevis
  - Function
    - Absorb weight nearing forces
    - Decrease friction
    - ↑ moment arm of FHB to PF toe
  - ↑ stress on sesamoids
    - Pes cavus / rigid midfoot/forefoot
    - Plantarflexed first ray
    - Ankle equinus / ↑ pronation
  - Treatment
    - Alter weight bearing, reduce load at forefoot
    - Limit PF of 1st Ray 2° DF of 1st MTP
      - Metatarsal pad proximal to 1st met head
    - Surgery: sesamoidectomy: DF of 1st MTP may result

Foot & Ankle Tendon Disorders



Achilles Tendinopathy

- Soleus
  - Midstance



- Gastrocnemius
  - Push-Off

Achilles Tendinopathy

- Clinical Presentation
  - Palpation
    - Pain along distal 1/3 of tendon
    - Possible ↑ density
  - Mobility
    - Pain with passive dorsiflexion
  - Muscle Performance
    - Pain with resisted plantarflexion
  - Activity
    - Pain with running uphill
    - Pain with longer runs

Achilles Tendinopathy

"Itis"

- Inflammatory process
- Rare given chronic nature of most presentations
- Recover within 2 weeks

"Osis"

- Degeneration within the tendon
- Repetitive microtrauma
- Increase in vascularity
- Recovery may take several months
- Clinical pearl
  - Tendon enlargement will move with tendon; swelling will not

Achilles Tendinopathy

- Epidemiology (Carcia CR et a. *JOSPT*. 2010)
  - 7% - 9% of distance runners
  - Men > Women
  - More common in older athlete
    - 30 – 50 year old

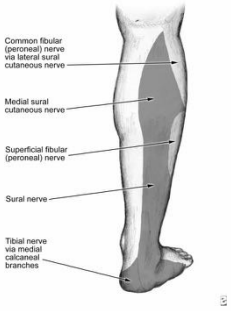
Achilles Tendinopathy

- Etiology
  - Training errors (Schepsis AA. et al. *AJSM* 2002)
    - ↑ intensity, change in surface or schedule and inappropriate shoewear
  - Lower Extremity Intrinsic Factors (Carcia CR et a. *JOSPT*. 2010)
    - Abnormal subtalar joint ROM
    - Limited ankle dorsiflexion
    - ↓ plantarflexion strength
    - Foot pronation
    - Co-Morbidities: Obesity, HTN, DM, ↑ cholesterol
  - Increased pronation (Ryan M et al. *Foot Ankle Int*, 2009)
    - 27 runners with mid portion achilles tendinopathy
    - ↑ STJ eversion during mid-stance
      - 13° ± 3° vs. 11° ± 3° ($p = 0.04$)

Achilles Tendinopathy

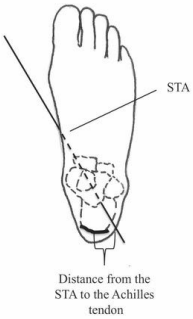
- Differential Diagnosis
  - Os Trigonum
  - Posterior ankle impingement
  - Medial tendon tendinopathy
  - Bursitis
  - Sural neuropathy
  - S1 radiculopathy

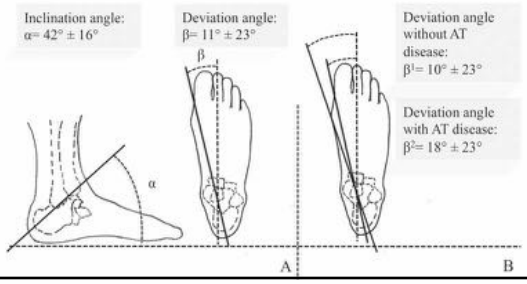
Sports Injuries - Foot and Ankle © 2001 Primal Pictures Ltd



Achilles Tendinopathy

- Biomechanical Variables
  - Reule, CA et al. *BJSM* 2011
    - More oblique STJ axis
      - 18° ± 23° vs. 10° ± 23°(p=0.002)
      - STJ axis passes more laterally through Achilles tendon
      - Longer moment lever arm for medial Achilles tendon fibers
      - ↑ load in tendon may lead to degeneration





Achilles Tendinopathy

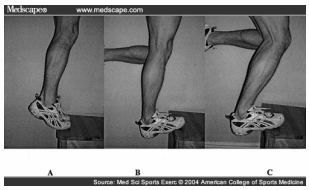
- Management
  - Acute
    - ↓ pain & effusion
    - Relative rest
      - Control load on healing tissue
    - Control dorsiflexion
      - Guided by pain
    - Possible heel lift (walking)
  - Sub-acute
    - Progress to full ROM
    - Initiate strengthening / remodel tissue

Achilles Tendinopathy

- Eccentric Calf Strengthening
  - Alfredson H et al. *AJSM* 1998
  - 15 recreational athletes Dx with achilles tendinosis
    - 12 men & 3 women (age 44.3 +/- 7 years)
  - Training Program
    - 2x/day for 12 weeks
    - 3 sets of 15 reps
      - Knee straight (gastroc) & Knee bent (soleus)
      - Body weight initially progressed to external load
  - Results
    - VAS decreased from 81.2 (+/- 18) to 4.8 (+/- 6.5)
    - All 15 subjects returned to pre-injury running level
    - 15 athletes received conservative treatment
      - All underwent surgical intervention

Achilles Tendinopathy

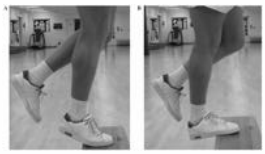
- Non-Operative Treatment
  - Eccentric Training
    - Knobloch K et al. *JOSPT* 2007
      - 12 week eccentric program performed daily
      - ↓ paratendinous capillary blood flow by 45%
      - ↓ pain level by 48%
    - Shalabi A et al. *AJSM* 2004
      - 3 months of eccentric calf strengthening
      - MRI evaluation revealed:
        - » 14% decrease in tendon volume
        - » 23% decrease in intratendinous signal
      - Results correlated with improved clinical outcome



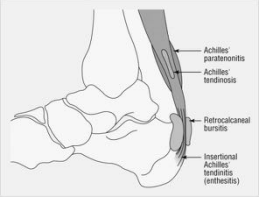
Achilles Tendinopathy

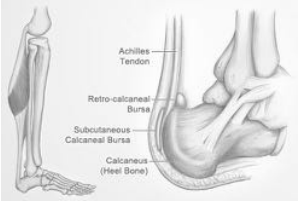
- Silbernagel KG. et al. *Am J Sports Med*. 2011
  - 34 patients with Achilles tendinopathy treated with exercise alone
  - 5-Year follow up
    - 80% fully recovered

Achilles Tendinopathy



- Fahlstrom M. et al. 2003
  - 32% patients with insertional Achilles tendinopathy successful with eccentric training into dorsiflexion
    - Compressive forces in dorsiflexion
    - Impingement between tendon, bursa and bone





Achilles Tendinopathy

- Jonsson P. et al. *Br J Sports Med*. 2008
  - 27 subjects (20 unilateral & 7 bilateral)
    - 12 men, 15 women, mean age = 53.4 yrs (25-77)
  - Mean duration of symptoms = 26.5 months (6-96)
  - Eccentric exercise performed without dorsiflexion
  - 3x15 reps, 2 x/day, 7 days/week for 12 weeks
  - Load increased to create pain during exercise
  - Results: 67% satisfied @ 4 month F/U
    - 18 "satisfied"
      - VAS ↓ 69.9 to 21.0 ($p<0.001$)
    - 9 "not satisfied"
      - VAS ↓ 77.5 to 58.1 ($p<0.006$)

Achilles Tendinopathy

- More Than Just Eccentrics….
  - Tibialis posterior strength
    - Control transverse plane Williams DS et al *JOSPT* 2008
  - Unstable surfaces
    - Multi plane muscle balance

  - Single leg hopping
    - Control of ground reaction forces

Achilles Tendinopathy

- Shock-Wave Treatment
  - Rompe JD et al. *AJSM*, 2009
    - 68 patients with recalcitrant noninsertional Achilles tendinopathy (4 month F/U)
    - Group 1: Eccentric loading
      - VISA-A ↑: 50 to 73
      - Pain ↓: 7 to 4
      - "Completely Recovered" or "Much Improved": 56%
    - Group 2: Eccentric loading + low-energy shock-wave therapy
      - VISA-A ↑: 51 to 87
      - Pain ↓: 7 to 2
      - Completely Recovered" or "Much Improved": 82%
    - 1 year follow-up: No difference

Posterior Tibial Tendon Dysfunction

- **General Population**
  - Associated with flat foot; 80% of patients are female and overweight
    - O'Connor K et al. *Foot Ankle Int*. 2010
- **Running Population**
  - Eccentric control of pronation
    - 1st half of stance phase

Posterior Tibial Tendon Dysfunction

- Clinical Presentation
  - Palpation
    - Pain posterior to medial malleolus, navicular & posteromedial 1/3 of distal tibia
  - Differential Diagnosis
    - MTSS / Stress fracture: tibial pain
    - Tarsal tunnel: paresthesia
  - Mobility
    - Pain with passive dorsiflexion & eversion
  - Muscle Performance
    - Pain with resisted plantarflexion & inversion
  - Activity
    - Running increases excursion of pronation and muscular load

Posterior Tibial Tendon Dysfunction

- Bluman EM et al. *Foot Ankle Clin*. 2007
  - Staging for Posterior Tibialis Dysfunction

Stage	Signs/Symptoms	Pathology
I	Tender to palpation, pain with heel rise Swelling distal to medial malleolus	Tendon pathology with/without synovitis
II	Flexible flat foot posture •Forefoot abduction •Lower medial longitudinal arch •Rearfoot eversion	Damage to Spring ligament Hypermobility of talonavicular joint
III	Non flexible flat foot posture that is more pronounced	Damage to Deltoid ligament Development of joint contractures
IV	Ankle osteoarthritis	Damage to Deltoid ligament Development of joint contractures

Posterior Tibial Tendon Dysfunction

- Management
  - Acute
    - ↓ pain & swelling
    - Relative rest
      - Control load on pronation forces
      - Symptom driven
    - Possible orthosis / taping
      - Control pronation
  - Sub-acute
    - Progress to full ROM
    - Initiate tibialis posterior eccentrics
    - Intrinsic strengthening

Posterior Tibial Tendon Dysfunction

- **Treatment**
  - Neville CG & Houck JR. *JOSPT*. 2009
    - Brace to control rearfoot eversion & support medial longitudinal arch
      - Solid ankle AFO
        - » May limit plantarflexion function
        - » Preferred for stage III-IV
      - Hinged ankle AFO
        - » Prevention of weakness by allowing for normal function
        - » Preferred for stage I-II

Posterior Tibial Tendon Dysfunction

- **Treatment**
  - General leg & foot strengthening
    - Alvarez RG et al. *Foot Ankle Int*. 2006
  - Eccentric exercise
    - Kulig K et al. *Phys Ther*. 2009 & Kulig K et al. *Foot Ankle Int*. 2009
  - Role of Exercise in PTTD
    - Tendon remodeling
    - Prevention of weakness
    - Hypertrophy or lower leg muscles
  - Wobble Boards (CW / CCW)
  - Plyometric Progression

Fibularis Tendons

- Associated with lateral ankle sprain & cavus foot
  - Philbin TM et al. *J AM Acad Orthop Surg*. 2009
  - Heckman DS et al. *J Bone Joint Surg Am*. 2008
  - Ogawa BK & Thordarson DB. *Foot Ankle Int*. 2007
  - Manoli A & Graham B. *Foot Ankle Int*. 2005
- 77% of fibularis tendon pathology as with lateral ankle sprain
  - Heckman DS et al. *J Bone Joint Surg Am*. 2008

Fibularis Tendons

- **Examination Findings**
  - Pain along posterolateral region of foot
  - Swelling, clicking, visible tendon subluxat
  - Subtalar eversion weakness
  - Pain with heel rise, resisted PF/Eversion
- **Fibularis Brevis**
  - Lateral & posterior on foot 2-3cm distal to lateral malleolus
- **Fibularis Longus**
  - Cuboid tunnel or insertion at base of 1st metatarsal

Fibularis Tendons

- **Treatment**
  - Restore subtalar eversion to ↓ load on tendon
    - Calcaneal mobilization
  - 1st Ray plantarflexion
  - Frontal plane stability
    - Wobble board / ball toss
    - Eccentric pronation/supination
    - SLS: M/L stabilizers
      - On toes: Peroneus longus
      - On heel: Peroneus brevis
  - Surgery indicated with subluxation

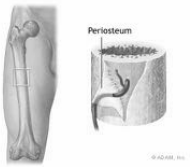
Medial Tibial Stress Syndrome

Medial Tibial Stress Syndrome

- Shin Splints
  - Stress Fractures
  - Myositis
  - Periostitis
  - Tendinitis
  - Compartment Syndrome
  - Fasciitis
  - Ischemic Disorders
- MTSS
  - Excludes stress fractures & posterior compartment syndrome

Medial Tibial Stress Syndrome

- Pathogenesis (Tweed JL. et. al. *J Am Podiatr Med Assoc*. 2008)
  - Periostitis
    - Traction on muscular origins
      - Tibialis Posterior / Soleus
    - Strain on medial tibial fascia
  - Periostalgia
    - Chronic presentation: periosteum detached from bone
    - Adipose formation between periosteum & underlying bone
- Presentation
  - Pain on palpation over distal 2/3 of posterior medial tibia



Medial Tibial Stress Syndrome

- Risk Factors (Yates B, White S. *AJSM* 2004)
  - Training on hard surface
  - Uneven terrain
  - Increased intensity
  - Changes in footwear
  - Muscle imbalances
  - Biomechanical abnormalities

Medial Tibial Stress Syndrome

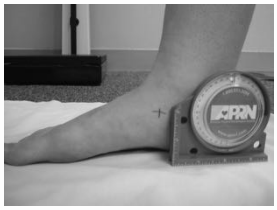
- Risk Factors (Sharma J et al. *Gait Posture*. 2011)
  - Military recruits
    - Most significant risk factor was "poor biomechanics" (9.2x)
      - ↑ weight bearing on medial side of foot
      - ↑ medial pressure in forefoot
      - ↑ pressure in calcaneus at heel strike
      - ↑ foot pronation

Medial Tibial Stress Syndrome

- Prevention (Craig DI. *J Athl Train*. 2008)
  - ↑ strength & endurance of soleus
  - Control overpronation
    - Alleviate stress along medial fascial attachment of soleus
  - Promote adequate shock absorption
    - New shoes, insoles
  - 1 day/week of cross training
    - Non-impact activity

Medial Tibial Stress Syndrome

- Bennett JE. et al. *JOSPT* 2001
  - 125 HS X-Country runners
  - Variables Measured
    - Tibiofibular varum
    - Resting calcaneal position
    - Gastrocnemius length
    - Navicular drop (after injury)
  - Results
    - 12% reported MTSS symptoms
      - 13 female & 2 male
    - Navicular drop (p = 0.003)
      - Injured: 6.8 mm (+/- 3.7)
      - Non-Injured: 3.6 mm (+/- 3.3)
  - Conclusion
    - Combination of being female and large navicular drop provides an accurate indication of those predisposed to MTSS



Medial Tibial Stress Syndrome

- Plisky, MS et al. *JOSPT* 2007
  - 105 HS X-Country runners followed for one season
  - Variables Measured
    - Bilateral navicular drop
    - Foot length
  - Questionnaire
    - BMI, Injury history, Running experience, Orthotic & tape use
  - Results
    - 15.2% reported MTSS symptoms
    - Injury Rates: 2.8 / 1000 athletic exposures
      - Girls: 4.3 / 1000 AEs
      - Boys: 1.7 / 1000 AEs
    - Female gender and increased BMI were related to MTSS
      - Only BMI was significant when controlled for orthotic use
  - Conclusion: Navicular drop was not an effective preseason screening tool for MTSS

Medial Tibial Stress Syndrome

- Treatment
  - Rest
    - Complete or relative
  - Address training errors
    - Surface modification
  - Muscle Imbalance
    - Eccentric control of Tibialis Posterior
  - Gastroc-Soleus complex flexibility
    - Compensation for ankle equinus seen at midfoot which may increase load on Tibialis Posterior and Soleus
  - Strengthening of plantar intrinsics
    - Offer dynamic support to arches of foot and assist in pronation control

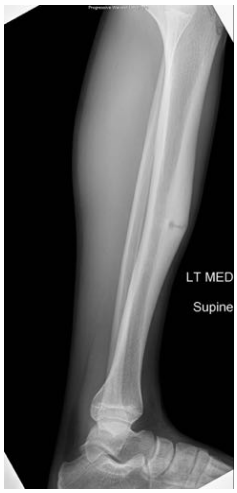
Medial Tibial Stress Syndrome

- Summary
  - Literature does not offer a clear picture
  - Greater incidence in MTSS injury in women reported
  - Question the impact of hip mechanics on MTSS development
  - Future Research
    - Include hip strength and motion as variables
    - Include all proposed theoretical contributing factors
      - Navicular drop
      - Calcaneal eversion
      - Tibiofibular varum
      - Others?
    - Increased number of variables present may be more related to developing MTSS rather than a single variable

Stress Fractures

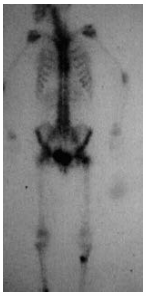
Stress Reaction / Stress Fracture

- Pathophysiology
  - Repetitive loading alters structure
  - Fatigue of bone if load continues without rest
- Etiology
  - Training errors
    - ↑ mileage or frequency
    - Old running shoes
  - Biomechanical faults
    - Lack of shock absorption in LE
      - (Milner et al. *Med Sci Sports Exerc*. 2006)
  - Systemic conditions
    - Osteopenia / Osteoporosis
    - Hormonal abnormalities
    - Inadequate nutrition
    - Female athlete triad
      - Low bone density
      - Disordered eating
      - Amenorrhea



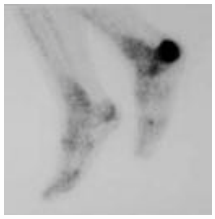
Stress Reaction / Stress Fracture

- Imaging
  - Radiographs
    - Early injury may not be detected
  - CT
    - 3D capability
  - MRI
    - Method of choice
  - Bone Scan
    - High sensitivity
    - Low specificity



Stress Reaction / Stress Fracture

- Common Sites
  - Cortical bone most common
    - Slower remodeling
  - Tibia
    - 20% - 45% of all stress fractures
      - (Brukner P. et al. *Clin J Sports Med*. 1996)
      - (Bennell KL. et al. *Am J Sports Med*. 1996)
    - Horizontal vs. Vertical tenderness
  - Calcaneus
    - Lateral vs. Medial
    - Posterior vs. Plantar
  - Metatarsals
    - 5th metatarsal = high incidence of non-union

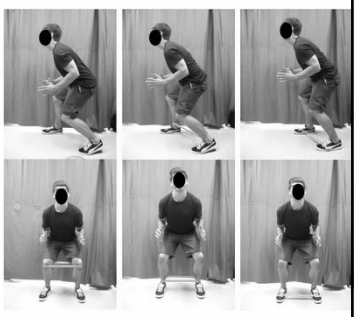


Stress Reaction / Stress Fracture

- Milner CE. et al. *JOSPT* 2010
  - Subjects
    - 29 females with history of tibial stress fracture
    - 29 females matched for age and weekly running distance
  - Peak rearfoot eversion greater in tibial stress fracture group
    - ↑ Torsional load on tibia
  - Peak hip adduction greater in tibial stress fracture group
  - Runners may be utilizing frontal plane rather than sagittal plane to absorb impact forces

Stress Reaction / Stress Fracture

- Treatment: Control impact forces
  - Proximal strength
    - Cambridge ED et al *Clin Biomech* 2012
      - Forefoot resistance:↑ gluteals vs. TFL
      - Likely due to ER of hips

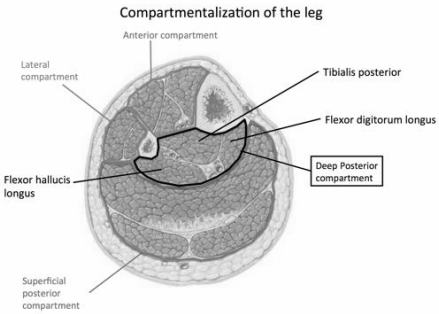


  - Joint mobility
    - Subtalar
    - Talocrural
    - Knee
    - Hip

Compartment Syndromes

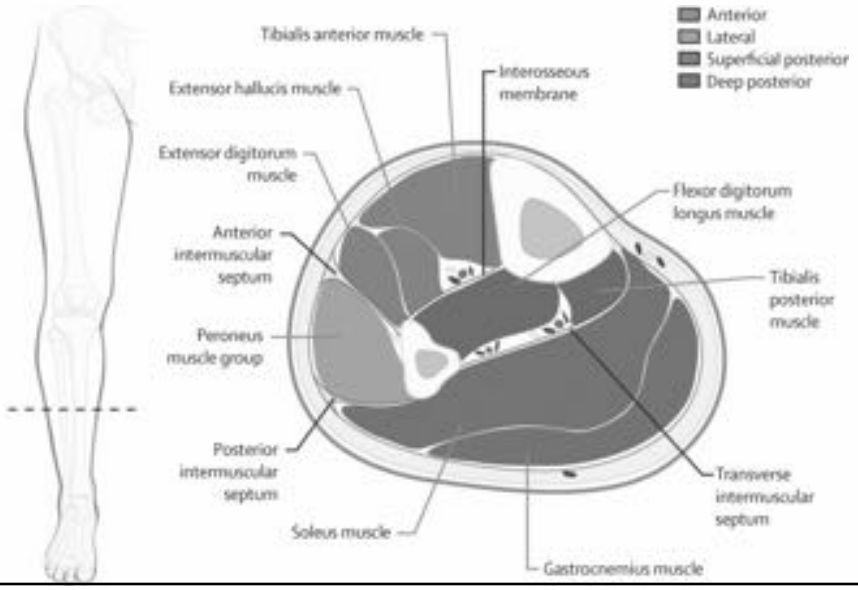
- Acute or chronic elevated tissue pressure within a closed fascial space, resulting in occlusion of vessels and compromised neuromuscular function
  - Frink M et al. *Clin Orthop Relat Res*. 2010
- **Acute**
  - Direct trauma, tibial fractures, muscle rupture, burns
  - Medical Emergency
- **Chronic**
  - Exertional Compartment Syndrome
  - Exercise Induced Compartment Syndrome
  - Exertion → ↑ muscle size → ↑ intra-compartmental pressure → ischemia & reduced neuromuscular function

Compartment Syndromes



- Anterior
  - Tibialis Anterior
  - Anterior tibial artery / vein
  - Toe extensors
- Lateral
  - Peroneus Longus & Brevis
  - Superficial Peroneal nerve
- Superficial Posterior
  - Gastroc-Soleus
  - Plantaris
- Deep Posterior
  - Tibilais Posterior
  - Peroneal artery & vein
  - Tibial nerve
  - Posterior Tibial Artery & Vein

Compartment Syndromes

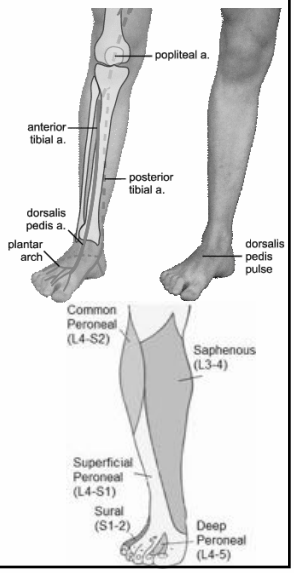


Compartment Syndromes

- Presentation
  - Acute
    - Pain, palpable swelling, ? paresthesia
  - Chronic
    - Dull ache following activity
    - ? paresthesias
    - Anterior & Deep posterior compartments most common

Acute Anterior Compartment Syndrome

- **History**
  - Ache or sharp pain
  - Pain out of proportion to injury
  - Persistent, progressive, unrelieved by immobilization
  - May be accentuated by passive stretch of muscles within compartment
- **Examination**
  - Diminished sensation along distribution of deep peroneal nerve
  - Diminished Dorsalis pedis pulse
  - Weakness and paralysis of muscles within compartment
- **Medical Rx is a fasciotomy**
  - Release the pressure before permanent changes occur



Compartment Syndromes

- Management
  - Acute
    - Medical Emergency
      - >12 hours of nerve & muscle ischemia will lead to irreversible damage (>30 mm Hg)
      - <4 hours ischemia high probability of no permanent damage
    - Fasciotomy
      - Relieve intra-compartmental pressure
      - Post-Op
        - » Ice & elevation, WBAT, AROM, Gentle PROM

Compartment Syndromes

- Management
  - Chronic
    - Differential diagnosis of acute anterior compartment syndrome
    - Chronic exertional comes and goes with activity
      - Usually related to a biomechanical dysfunction of the LE
    - Chronic mimics MTSS
      - Check pulses and sensation
    - If conservative measures fail…surgery may be indicated

Return to Running Considerations

David Nolan, PT, DPT, MS, OCS, SCS, CSCS

Risk Factors

- Prior activity level / mileage
  - Tenforde AS et al. *PMR*. 2011.
  - Messier SP et al. *Med Sci Sports Exerc*. 2008
  - Ryan M et al. *Int Sportsmed* J. 2006
- Injury history
  - Buist I et al. *Am J Sports Med*. 2010
  - Van Gent RN et al. *Br J Sports Med*. 2007
- >15-20 hours of activity each week

Risk Factors

- Intrinsic
  - Psychological variables
    - Runners want to run

Psychological Factors

Development and Preliminary Validation of the Injury-Psychological Readiness to Return to Sport (I-PRRS) Scale

Douglas D. Glazer, DPE, ATC

- *J Athl Train* 2009
- **Injury-Psychological Readiness to Return to Sport Scale (I-PRRS)**
  - Questionnaire
  - 0 (no confidence) to 100 (complete confidence)
- **Injury-Psychological Readiness to Return to Sport Scale (I-PRRS)**
  - My overall confidence to play is___
  - My confidence to play without pain is___
  - My confidence to give 100% is___
  - My confidence to not concentrate on the injury is___
  - My confidence in the injured body part to handle demands of the situation is___
  - My confidence in my skill level/ability is___
  - Score <50: Athlete may not be psychologically ready

Risk Factors

- Intrinsic
  - Hip Adduction
  - Genu valgus
- Extrinsic
  - Training errors
    - Excessive volume
    - Progressing distance/pace too quickly
  - Running surface
    - GRF
  - Running form
    - Cadence

Milestone Criteria

- Full ROM
- Minimal pain / swelling
- >90% strength compared to uninjured
  - Variable in literature (70%)

Not Just Strengthening

[RESEARCH REPORT]

RICHARD W. WILLY, PT, PhD, OCS • IRENE S. DAVIS, PT, PhD, FAPTA

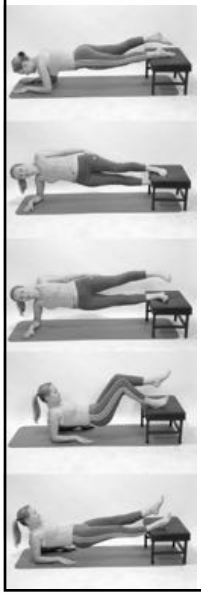
The Effect of a Hip-Strengthening Program on Mechanics During Running and During a Single-Leg Squat

- Strengthening alone did not improve running mechanics
- ***Must integrate running specific interventions***

Functional Tests

- Small Knee Bend (SKB) / Single-Leg Squat (SLS)
  - Whatman C. et al. *Phys Ther Sport*. 2011
    - Standing upright squat to max DF without heel rise
    - Similar hip & knee ROM seen with running
    - Trunk / Pelvis
    - Hip
    - Knee
    - Foot

Functional Tests



- Bunkie Test
  - deWitt B & Venter R. *J Bodyw Mov Ther*. 2009
    - Assess function of core musculature
    - Maintain test position for 40 sec
      - Anterior power line
      - Medial power line
      - Lateral power line
      - Posterior stabilizing line
      - Posterior power line

Video Analysis

- 2-D is a reliable option

IJSPT

ORIGINAL RESEARCH

CONCURRENT VALIDITY AND RELIABILITY OF 2D KINEMATIC ANALYSIS OF FRONTAL PLANE MOTION DURING RUNNING

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Mark V. Paterno, PT, PhD, MBA, SCS, ATC[3]
Christopher A. DiCesare, MS[3]
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[BRIEF REPORT]

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Reliability of a Qualitative Video Analysis for Running

IJSPT

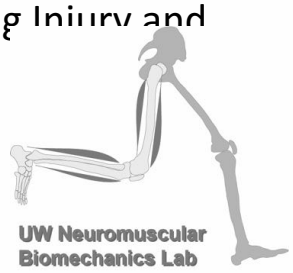
ORIGINAL RESEARCH

RELIABILITY OF VIDEO-BASED QUANTIFICATION OF THE KNEE- AND HIP ANGLE AT FOOT STRIKE DURING RUNNING

Camma Damsted[1]
Rasmus Oestergaard Nielsen[2]
Lars Henrik Larsen[3]

Outcome Measures

- Lower Extremity Functional Scale (LEFS)
  - Generic LE function
  - ? Ceiling effect
  - 20 questions; max score of 80
- University of Wisconsin Running Injury and Recovery Index (UWRI)
  - Limited data right now
  - 9 questions; max score of 36
  - Specific to running



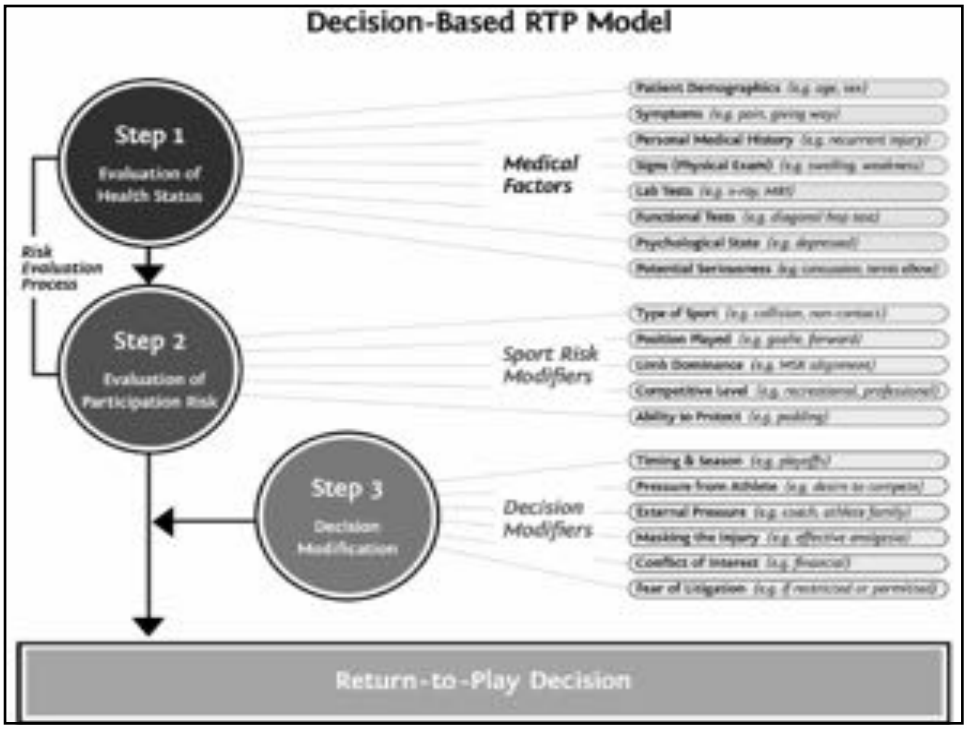
UW Neuromuscular Biomechanics Lab

Decision Making

Return-to-Play in Sport: A Decision-based Model

David W. Creighton, MS, Ian Shrier, MD, PhD,† Rebecca Shultz, PhD,*
Willem H. Meeuwisse, MD, PhD,‡ and Gordon O. Matheson, MD, PhD**

- Creighton DW et al. *Clin J Sport Med*. 2010
  - Evaluate health status
    - History, examination, testing, video gait analysis
  - Evaluate participation risk
    - Demands (mileage etc.), RRI risk factors (?modifiable)
  - Decision modification
    - Timing of injury / event



Milestone Criteria

- Fast-paced walk for 60 minutes
  - No pain/swelling during or after
- Plyometric progression
  - Double leg PBW
  - Double leg FBW
    - In place → Forward / Backward → Side to Side
  - Single leg PBW
  - Single leg FBW
    - In place → Forward / Backward → Side to Side
    - Resistance → Multi-planar

Milestone Criteria

- No symptoms & proper form
  - Triple flexion / extension
    - Hip flexion, Knee flexion, ankle DF
    - Hip Extension, Knee extension, Ankle PF
  - "Soft landing"
- 750 foot contacts per mile (each leg)

Walk – Jog Progression

- Each bout begins with 15' warm up and 10' cool down

Day	1	2	3	4	5	6	7
Week 1	W5/J1x5		W5/J1x5		W4/J2x5		W4/J2x5
Week 2		W3/J3x5		W3/J3x5		W2/J4x5	
Week 3	W2/J4x5		W1/J5x5		W1/J5x5		**Return to Run**

- Progress only if no pain/swelling during/after

Return to Run

- No running back to back days
  - Non-impact cross training
- One day off each week (complete rest)
- Progress only if no pain/swelling during/after
- Begin on treadmill if possible
  - Maintain flat terrain
  - Maintain selected pace
- Focus on increasing distance / time before pace
- Pitfall: Modifying multiple parameters simultaneously

Return to Run Progression

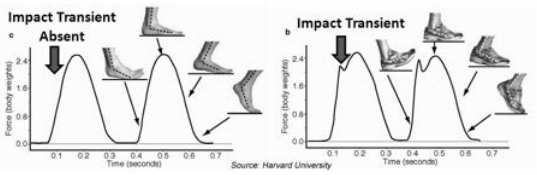
- Each bout begins with 15’ warm up and 10’ cool down

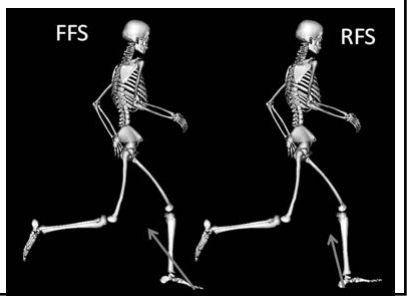
Week	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	20 min		20 min		20 min		25 min
2		25 min		25 min		30 min	
3	30 min		30 min		35 min		35 min
4		35 min		40 min		40 min	
5	40 min		45 min		45 min		45 min
6		50 min		50 min		50 min	
7	55 min		55 min		55 min		60 min
8		60 min		60 min			

- Initiate running on consecutive days
- Integrate modifications to pace

General Recommendations

- No more than 10% increase in weekly mileage
  - Hrejac A. *Phys Med Rehabil Clin N Am*. 2005
- Avoid running downhill initially: ↑ impact force
  - Gottschall J & Kram R *J Biomech*. 2005
- Consider strike pattern





General Recommendations

[RESEARCH REPORT]

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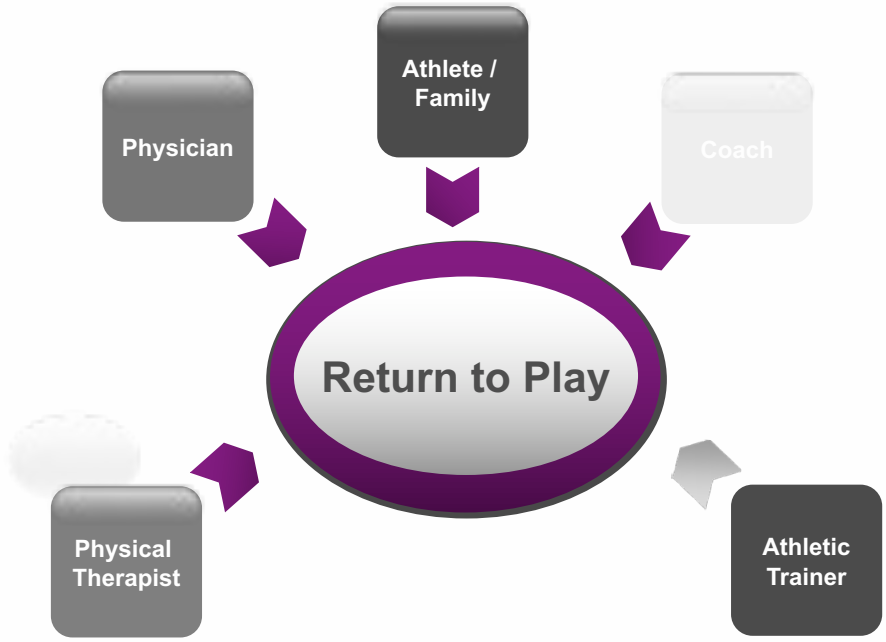
Excessive Progression in Weekly Running Distance and Risk of Running-Related Injuries: An Association Which Varies According to Type of Injury

- Nielsen RO et al. *JOSPT*. 2014
  - 3 progression groups: <10%, 10-30%, >30%
  - No statistically significant differences in RRI rates
  - ↑ rate of "distance-related injuries" in >30% group



PATIENT CASE

Case Study

- 24 yo woman
- Elite Runner (distance)
- C/O right medial ankle & plantar foot pain (0-8/10)
- Typical training = 40+ miles/week
- Currently pool running only

Case Study

- Key findings:
  - Gluteal and core weakness
  - Limited flexibility: hip flexors, ITB and GS
  - Limited joint mobility: STJ
  - Hypermobile midfoot
  - Poor control with step down and single leg squat

CASE VIDEOS

CASE VIDEOS:
BAREFOOT WALK

CASE VIDEOS: BAREFOOT FAST WALK

CASE VIDEOS:
BAREFOOT WALK-LATERAL

CASE VIDEOS:
RUN-POSTERIOR

CASE VIDEOS: RUN-LATERAL

Case Study

- Interventions:
  - Gluteal strength
    - SL Abduction in extension
    - Prone hip extension in abduction
  - LE flexibility
    - Hip flexors with stable pelvis
    - GS with supinatory bias
  - Joint mobility
    - Calcaneal lateral glides

THANK YOU

MASSACHUSETTS
GENERAL HOSPITAL