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Session 107: Avoid Overuse Foot & Ankle Injuries: Uncovering the Etiology & How to Treat It
Robert Donatelli, PhD, PT

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Robert Donatelli PT PhD
Las Vegas Physical Therapy & Sports
Facebook: Donatelli Physical Therapy & Sports

OVERUSE INJURIES
Symptoms, Causes & Treatment Of Common Overuse Injuries
Overuse Injuries Tendinopathy

- Tendinopathy – Muscle Weakness

- Etiology of Overuse Injuries LE - Tendinopathy
- Treatment: Eccentric Loading and tendon/muscle rehabilitation
- Neuromuscular Rehabilitation - Ballistic and Plyometrics
- Balance Training

Common Overuse Injuries

- Anterior Knee Pain
- Groin Strains
- Hamstring Tears
- Hip trochanteric bursitis
- Achilles Tendinopathy
- Plantar Fascitis
- Tibial Stress Syndrome
- Stress Fractures
- Ilio-tibial band FS

The Epidemic Of Overuse Injuries

- Multifactorial with abnormal gait biomechanics being recognized as a critical factor.
- Repetitive microtrauma that leads to local tissue damage in the form of cellular and extracellular degeneration
- Mismatch between overload and recovery
- Repetitive trauma
Intrinsic and Extrinsic Factors - Overuse

- **Intrinsic factors**: Misalignments, Muscle Imbalances, Inflexibility, Weakness, and Instability
  - Hyper pronation, limited STJ mobility, limited Dorsiflexion of the ankle, leg length discrepancy, increase rearfoot inversion predispose to a increased risk of Musculoskeletal overuse injury

- **Extrinsic factors**: Avoidable factors – poor technique, improper equipment, improper changes in duration or frequency

Factors Leading to Overuse

- **Predisposing** *
  Excessive pronation, rotto deformities of LE, Muscle weakness

- **Precipitating** *
  Excessive mileage, excessive shoe-wear, training errors

- **Perpetuating** *
  Continuing the activity, high intensity workouts do not allow tissue to recover

Association between Foot Type and LE Injuries: Systematic Literature Review with Meta-analysis

- Lack of consensus in the literature of potential relationship between foot type and lower limb injuries.
- Problem: Variations in operational definition of foot type
Weight Bearing X-Rays

Lateral angle of Calcaneal pitch (Inclination Angle of the Calcaneus and Declination angle of the Talus)

- Arch Type Radiographic Measurements

Conclusions:
- Visual/physical examination and foot posture index showed strong relationships
- Both High Arch and Flat Feet are significantly associated with lower limb injuries

Overuse Injuries

Excessive Forces – Repetitive Exceeds Individual Limits
- Runner weighs 150 lbs. / 75 kg with a stride length of 2.5 feet absorbs 220 tons of compressive forces in one mile
- An individual who runs 50 miles a week = 3 million strides each year.
Distribution of the most common sites of injury in 180 distance runners (James and Jones)

- Clement 1019 runner
- Knee 41.7%
- Lower Leg 27.9%
- Foot 10%
- Hip 5%
- L/S 3.7%
- Upper leg 3.6%

Foot Mechanics and Overuse

- Rearfoot valgus – prolonged eversion
- Forefoot
  - Supinatus excessive inversion limited eversion

Tendinopathy Facts

- Tendon injuries account for 30-50% of injuries in sports
- Overuse of tendons result in 30% of all running injuries and 40% of elbow injuries in tennis
- Patellar tendinopathy occurs 32-45% of basketball and volleyball players
Tendon Loading Increases Collagen Synthesis & Degradation
Tendinopathy in athletes, Reinking PT in Sports 2012

Degradation of collagen increased after exercise, greater than increase in synthesis.
Collagen Synthesis peaks around 24 hr after exercise and remains elevated up to 72 hours (Magnusson, Langberg, & Kjaer, 2010).
The first 36 h after exercise, the collagen metabolic system is in a negative balance with degradation greater than synthesis.
This may explain that repeated exercise without sufficient rest repeated collagen breakdown, overuse injury.

Tendinopathic Iceberg
Three stages: Reactive tendinopathy, Tendon disrepair, Degenerative tendinopathy

Fredberg & Pedersen (2008) tendinitis myth tendinopathic iceberg
long period of time of asymptomatic changes in tendon with tip of the iceberg being a painful tendon.

Pathological Breakdown of the Tendon Tendinopathy
- Chronic overtraining may contribute to an extended state of catabolism (autoimmune reaction) Ohberg et al 2001
- Tendinosis - non-inflammatory condition of collagen breakdown and disorganization, abnormal growth of capillaries into the tendon, calcification.
- Micro trauma occurs before tendon is healed, excessive strain may cause tendon cells to die - poor healing.
Each of these musculotendinous units absorbs power by stretching (eccentric action) just before it generates power by shortening.

Muscles function as “tensioner” of the tendon (or spring).

Tendon lengthening?

- **Tensile strength**
  - Resists elongation
  - Collagen
- **GAG – Hyaluronic acid**
  - Gliding of fibers as they straighten out = elongation

Lengthening is pseudoplasticity.

The elastic force = stiffness x amount of stretch

- For high force eccentric contractions of the calf muscles (triceps surae) during running, the Achilles tendon may be stretched as much as 10% of its resting length.
- The stiffer the muscle-spring, the greater the energy stored. This translates into better speed and economy of effort.
Achilles Tendon Spring

- Achilles Tendon:
  - Stores energy as stretched and returns 90% of this energy at push-off. Peak forces in the Achilles tendon 6 to 8 x body weight.

Pathophysiology of tendon function

- Tendons are stronger than muscles and withstand larger forces
- Tendons that go around corners are subjected to greater strain and interference with blood supply
- Max load capacity and resistance to tears peak in the third decade and decrease with age

Tendinopathy Symptoms

- Symptoms develop gradually with increasing training volume or intensity
- Pain & stiffness worse first step out of bed
- Pain at the beginning of activity and reduced during performance,
Pathological Breakdown of the Tendon Tendinopathy

- Immediately after training catabolism (protein breakdown) followed by protein synthesis
- Chronic overtraining may contribute to an extended state of catabolism (autoimmune reaction) Ohberg et al 2001
- Tendinosis – non-inflammatory condition of collagen breakdown and disorganization, abnormal growth of capillaries into the tendon, calcification.

Facilitate or Promote Normality of Tissue Repair

- **Bleeding** 3-6 hours
- **Inflammatory** – essential in tissue repair rapid onset
- **Proliferative Scar** Rapid onset 24-48hrs Peak 2-3 weeks Lasting 2-3 months
- **Remodeling** 2-3 weeks post injury
  - As early as the 1st week
  - Repairing with scar tissue provides a functional scar
  - long term mend 4-6 months

The body has an intricately complex & balanced mechanism thru which these wound healing events are controlled

- Therapeutic intervention can be of value after:
- Immobilization prolonged causing:
  - Inhibited response
  - Delayed reactions
- Repeated trauma

**Scarf tissue within a muscle restricts the fibers nerves & vessels** = pain and stiffness
Tissue Healing

- Regeneration & Repair
  - Replace destroyed tissue by living tissue
- Fibrosis
  - Repair by dense connective tissue
  - Granulation - Scar Tissue
- Adhesions?

Preform a Miraculous Rx
Stop causing no effect or more trauma

- Eccentric loading
- Manual Therapy
- Pressure Wave
- Foot Orthotics

Dry Needle
LASER
HIRT & HIIT

Progression of Muscle Injury

Eccentric Loading – Superior Exercise

- Greatest EMG activity
- Strength Tendons
- Hypertrophy of Muscle
- Reduced BP
- Reduced utilization of ATP and CP
- Protective Bout Effect
- Reduced DOM
Eccentric Loading – Miraculous Changes

- Stanish et al suggested that eccentric exercises prepare patients for return to functional, sports-related activities better than those that emphasize concentric muscle strengthening.

Positive changes tendon structure and mechanical properties with Eccentric Loading

- Langberg found that Type I collagen synthesis increased after eccentric training in a group of twelve soccer players with unilateral Achilles Tendinosis indicating of tendon healing. (Initial collagen Type III)

- Type I collagen

Achilles Tendinopathy

- Shalabi et al AJSM 2004
  - post eccentric training decreased tendon volume & reduced pain improved performance.
  - Increased Type I collagen after eccentric training
- Öhberg et al (2004):
  - 12 week eccentric training
Eccentric Loading Protocol
Achilles Tendon
Alfredson et al AJSM 1998

- 3 sets 15 reps bent knee & straight knee calf raises
- 2 times per day, 7 days per week
- 12 weeks
- Athletes were told to work thru pain unless disabling
- Load increased 5kg increments once training with body weight was pain free.

Eccentric decline squat superior 12 months compared traditional eccentric protocol patellar tendinopathy

- Decline squat protocols were effective in the treatment of tendon pain and sporting function in athletes with patellar tendinopathy
- Over 12 month period the decline squat protocol gave more significant relief than Step squat.

Benefits of Eccentric Exercise to Muscle

- 2-3x greater EMG
- Delayed Fatigue
- 75% less Oxygen
- Lower ATP/CP less perceived effort
  - Less muscle activity to maintain the same amount of force
- Greater heat production
- Reduced BP
**Delayed Onset of Muscle Damage**

**Beneficial effects to Muscle/Tendon**

- Best way to Hypertrophy muscle
- Force production in skeletal muscle is highest during negative work, maximizing increases in Fiber CSA
- Protective Bout Effect
- Strengthens tendons
- Stimulates Fibroblast to produce type I collagen fibers (not scar type III)

**Muscle Damage – DOMS**

**High Speed  Eccentric Loading**

- Stretching of active muscle at high speeds and at lengths beyond optimum does not involve uniform lengthening of sarcomeres, but more closely resembles “popping” of sarcomeres, one at a time, in order from weakest to strongest. This leads to damage.

**Muscle Damage with Eccentric Loading**

- Reduced strength (50-65% lasting 1-2 wks) most valid and reliable measures of Muscle Damage
- The repeated bout effect results in protective adaptation to the muscle
Muscle Protective Adaptation of Muscle Eccentric Exercises

- This causes a greater optimum length.
- More sarcomeres for the same muscle length leads to shorter sarcomeres, avoids extension beyond optimum length, avoids non-uniformities and so damage.

Sarcomeres in Series

Hamstring Strain

- The most common injury sustained by athletes, currently the most common in professional soccer
- 29% of the injuries in track and field

Eccentric Loading to Hamstring Strains

- Eccentric loading of the hamstrings is performed in the OKC Non wt bearing low velocity eccentric loading exercises
  - Stiff leg dead lifts
  - Nordic hamstring exercise
  - Eccentric backward steps
  - Eccentric forward pulls
  - Eccentric Lunge drops - forward flexion with wt ball
  - Eccentric loading more effective greater changes in neural activation and hypertrophy
The Role & Implication of Eccentric training in athletic rehab tendinopathy hamstring strains & ACL reconstruction
Lorenz D & Reiman M
Internat J Sports PT March 2011

- Eccentric forward pulls
- Forward flexion with wt ball
- Nordic hamstring exercise
- Eccentric backward steps
- Stiff leg dead lift

Eccentric Loading to Hamstrings

Case study JOSPT May 2006 Gerber et al.
- Semi-tendinosus-gracilis autograft initially and then Patella-tendon after 2nd tear.
- 3 weeks post-op patient started an eccentric exercise program for 31 wks
- Quad strength increased 28% while protecting the repair no anterior shear force
- 12 weeks after the repair
Micah Marino Holds World Record in Wt. Class – 800 lb. (362.87 Kg) dead lift

- Weight lifting record dead lift in wt. class 800lbs
- Post meniscus clean out and Micro-fracture surgery atrophy of left quads
- Started at 4 weeks post-op using the Eccentron to strengthen the left lower limb.
- Post-op 5 mounts 660 lbs

Eccentric Muscle Damage

Eccentron
Eccentric Exercises in Rehab

<table>
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<th></th>
<th>L</th>
<th>Change</th>
<th>R</th>
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<tr>
<td>Avg Force</td>
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<td>193.5 / 203.3 Pounds</td>
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<td>227.3 / 369.7 Pounds</td>
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<td>13.5 %</td>
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<tr>
<td>Session Duration</td>
<td>300.0 / 544.0 Seconds</td>
<td></td>
<td>98.0 %</td>
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Eccentric Loading

While the mechanism of action of eccentric exercise is poorly understood, it is theorized that eccentric exercise loads the tendon to a greater magnitude compared with concentric contraction, thereby stimulating a more effective repair response.

Ballistic Training - Explosive Weight Training - Eccentric Loading

- Method to develop explosiveness. The athlete accelerates and releases the weight into "free space." Common ballistic training exercises are: bench throws, jump squats, cleans, snatches, and push presses. 40-80% sub max
- Ballistic training recruits and trigger fast twitch muscle fibers. Slow return – Eccentric Loading
- Ballistic training requires the central nervous system to coordinate and produce the greatest amount of force in the shortest time possible.
- Eccentric Loading to control the fall - weight – excessive force to the muscle and tendon
3 experimental groups performed explosive resistance training at three intensities = 20%, 50%, or 80% of their 1RM.

- Trained 2 days/wk - 8 or 12 weeks using analogue Keiser pneumatic resistance-training machines

High-intensity explosive resistance training presents the best strategy for simultaneous improvements in whole-body peak power, strength, and local muscular endurance in healthy older adults

Plyometrics

Stretch Reflex or Myotactic–Intrafusal fibers / muscle spindle responds to the rate at which the muscle is stretched

Stronger muscle contraction to reduce the stretch

Plyometrics Prerequisites

Can Your Patient Jump???

- Strength base – Power Squat 60 % body wt.
- One leg half squat – balance & quad strength
- Stork balance test Eyes open / closed
- Good Quad strength MMT
- No patella femoral pain / poor alignment
- Good landing surface/shoes
- No acute injuries to the foot or ankle
Plyometric Training in Female Athletes

- Decreased impact forces and increased hamstring torque AJSM 1996
- Hewett, Stroupe, Nance, Noyes
- Results
  - After training peak landing forces dec. 22% and knee add & abd moments dec. 50%
  - Hamstring power inc. 44%

Plyometrics

Balance Training
Post-op Surgery Achilles repair
Case Prof Basketball Player

Post-op
Three months post-op

Achilles repair 3 months post-op

Eccentric Loading - Eccentron
**Increases in Microcirculation and Tissue Oxygenation**

- The increase of blood flow after laser therapy is an important factor in pain relief
  - Increases lymphatic drainage, the activity of neutrophils, macrophages, fibroblasts, and the metabolism of damaged or defective cells
  - Radiant Medical – research


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**Radial Pressure Wave**

- Treatment - damaged osteotendineous tissue, enhancing fibroblast proliferation
- Increase in Nitric Oxide release and re-vascularization.

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**Extracorporeal Shock Wave Therapy: Physiological Effects**

- Up-Regulation of Angiogenesis Related Markers* Which Demonstrate Local Neovascularization And An Increase In Local Blood Flow
- Tendon Tissue Converts SW Stimulation Into Biochemical Signals Which Release Growth Factors+ That Up-Regulate Biosynthesis By Tenocytes, Fibroblasts
- Increased GAG & Extra Cellular Protein Synthesis, Indications of Early Metabolic Stimulation, Which Accelerate Healing/Regeneration
- Increased Fibroblastic Proliferation And Activity In Production of Type-I And Type-III Collagen

*VEGF, eNOS and PCNA
+TGF-β1, IGF-1, PDGF

SW = Shock Wave
GAG = Glycosaminoglycans
Neovascularization

Achilles repair 4 months post-op

Miraculous Changes in the Body
Without Trauma – Physiology –
Histology – Anatomy – Mechanics

1. Change Muscle Fiber
2. Stimulate the Fibroblast to produce Type I collagen fibers
3. Inc. Mitochondria
4. Inc. synchronization of motor unit firing
5. Stimulate production of growth hormones
6. Increase collateral circulation to the heart

1. Prevent Diabetes
2. Increase bone growth
3. Lower blood pressure – pulse
4. Reverse effects of sarcopenia
5. Hypertrophy muscle at any age
6. Break up adhesions
Summary

Eccentric Exercises and Neuromuscular Training in Rehabilitation of the Athlete

Keys Points
- Strengthening Tendons
- Protective Effect on Muscle
  - Treatment for Tendinopathy
  - Muscle Strengthening
  - Ballistic Exercise
  - Plyometrics Neuromuscular Training and Eccentric Loading

Foot Mechanics

Robert Donatelli PT PhD
- Las Vegas Physical Therapy & Sports
- 7229 West Sahara Ave. Suite 105
- Las Vegas, NV 89117
- 702 586 2177
- Facebook
- Donatelli Physical Therapy & Sports
Foot Mechanics and Lower Limb Function
Robert Donatelli PhD PT

- Interrelationship of Foot and Lower Limb
- Normal mechanics of the foot & LE
- Abnormal Foot Mechanics
- Evaluation of the rearfoot/forefoot/midfoot
- 7 tests
- Foot orthotics Evidenced based

I never have just feet walk into my office??

Foot and Ankle Kinematics
Reciprocal Gait

Inman: Human Gait Rotation Begins
- T4-5
- Lumbar spine
- Pelvis
- Femur
- Tibia
- Subtalar - torque converter

Hip - Foot Connection
Torque conversion — Shock absorption
- Internal rotation of Hip - Femur
- Internal rotation Tibia
- HS – Foot Flat
  - Torque conversion
  - Pronation of STJ
  - Shock Absorption
  Medial arch lowers Eccentric muscle activation

Figure: Illustration shows a scene with a shoe on the foot. The text explains the mechanics of the foot and how it converts torque. The images depict the movement of the foot and leg during walking.
Hip and Foot Interrelationship

- Pelvis rotation
- Femur rotation
- Tibial Rotation
- Foot supination
- Foot pronation

Normal Forces
patient stays within normal limits of running – walking-foot function & soft tissue stress

Hyperpronation on Pelvis Align.

Khamis S., Yizhar Z. Gait and Posture 2007 “Effect of hyperpronation on pelvic alignment in a standing position”

- Foot hyperpronation alters pelvic and lower limb alignment standing
- N= 35, progressive lateral wedging into pronation (10E, 15E, 20E)

Result: Significant increase in tibial and hip rotn and pelvic tilt with greater pronation
Neuromuscular mechanisms

- Ground reaction
  - Impact force increases with speed of gait
  - 150 lb male stride length of 2.5 feet
  - Absorbs 220 tons of compressive force one mile
- Impact forces CNS response muscle activation reduce soft tissue trauma
- Four types of mechanoreceptors
  - Touch-pressure
  - vibration-tension

Normal mechanics of the Foot & Ankle

- Triplane movements
  - The axis of movement in 3 planes
  - Ankle joint
  - Subtalar joint
  - Midtarsal joint
  - MTP sagittal plane movement

Ankle Joint

- Ankle Joint Mechanics
  - Axis through the tips of the malleolus
  - Function during gait dorsi - plantarflexion
Ankle CKC Dorsiflexion

- Stretch Soleus – toe in
  - prevents midtarsal joint collapse

Ankle Instability Testing

- Anterior Drawer
  - Positive Instability
- Talar tilt Excessive

Subtalar Joint Mechanics

- Motion is around an oblique axis pure triplanar joint movement
- Calcaneocuboid / Talonavicular
- NO muscle attachments
Subtalar Joint

Torque Conversion
- Most Important Function during gait
  Provides a mechanism to permit the rotations of the lower limb to occur without movement of the foot
Load Response
- Torque Conversion-Shock absorption

Torque, moment is the tendency of a force to rotate an object about an axis, fulcrum, or pivot. A torque can be thought of as a twist to an object.

Torque is a measure of how much a force acting on an object causes that object to rotate. The object rotates about an axis, which we will call the pivot point.

Torque Conversion
- Subtalar joint torque conversion of:
  - Transverse Plane
    Rotations T3-6 – L/S, pelvis, hip, femur and tibia are transferred INTO sagittal and transverse plane motions of the talus and frontal plane motion of the calcaneal
**Torque Conversion**

- Pronation = Int. Rotn. tibia – talus plantar flexes and add- unlocking MTJ – calcaneus everts
- FF supination-dorsi flexion 1st metatarsal

**Subtalar Joint ROM**

- Calcaneal Inv/Ever
- Increased calcaneal valgus

**Calcaneus Inclination angle Objective measure of Pronation/Supination**
Talar Declination Angle Increased with Pronation plantar flexion/adduction

Unlocking Locking of MTJ

Pronation STJ
- Eversion of calcaneus moves navicular in a medial direction
- Tibia rolls forward on talus (closed kinetic chain dorsifexion)

- Pronation reduces the height of rearfoot
- Supination-Increased vertical height of the rearfoot

Forefoot Mechanics

- Supination twist *
  Dorsiflexion of 1st ray and plantarfexion of the 5th ray

- Pronation twist *
  Plantarfexion of the 1st ray and dorsiflexion of the 5th ray

Inversion and Eversion of the forefoot while stabilizing the rearfoot (calcaneus)
Forefoot Abduction - Adduction

MTP Joint Dorsiflexion Windlass Effect

- Increased tension on the aponeurosis
- Increased medial arch height

Locking up of the midtarsal and facilitates supination of the subtalar joint

Summary of Normal Mechanics

- Transverse Rotations - Internal Rotation
- Stance phase 25% pronation
- Talus planta-reflects and adducts
- Tibia internally rotates
- Calcaneus everts

- Midtarsal Unlocks (Pronation) Clockwise-counterclockwise rotation: Talus/navicular calcaneus/cuboid
- External rotation after midstance –supination and push-off –reversal of pronation movement
Foot Types That May Lead to Dysfunction

- Pes planus and Pes Cavus
- Low Arch and High arch
- Forefoot varus and valgus
- Calcaneal valgus and varus
- Excessive pronation and supination

Pes Planus – collapse mid-tarsal

- Characteristics of pes planus that contribute to overuse injuries:
  - 1. Excessive inversion of the forefoot on the rearfoot.
  - Calcaneus is stabilized
  - 2. Forefoot Varus
    - STJ neutral/non-wt
  - 3. Calcaneus Valgus (eversion) in stance
  - 4. Limited dorsiflexion of the ankle
  - 5. Prolonged pronation in stance
Prolonged Pronation

Excessive Inversion of FF

Seven Foot Tests
Test One
- Excessive forefoot inversion - Limited eversion of the forefoot
- Treatment lateral forefoot post to promote eversion
- Mobility of the first ray
  - Increased dorsiflexion first ray insufficient
  - Poor mobility into plantar flexion
Cut-out under first Metatarsal

Integrity of Plantar Fascia

- Test 2 Jack's Test
- Treatment dual density with medial or varus posting rearfoot
Jack’s Test

- Windlass
- Hick 1954 Raises arch

Plantar fasciae Functions

- Supports Arches M & L
- Limits STJ pronation
- Assists re-supination STJ
- Reduces collapse of arch assisting intrinsic muscles
- Reduces tensile force on plantar ligaments
- Promotes plantar flexion of the 1st Ray & provides a lever for propulsion and forward progression

Sagittal plane Facilitation of Motion

Alterations of motion in sagittal plane gait
Increase forces at the MTP joint compensation

Hallux - Rigidus

Hallux - Limitus
Forefoot add and abduction
Test 3
Abnormal – Metatarsus adducto-varus bony deformity – (toe-in gait)
Treatment Varus post under forefoot

- Standing calcaneus everted position
- Excessive Eversion movement of the calcaneus in stance > greater than 8 degrees (pronation)
- Treatment medial – rearfoot varus post
- Mobilization inversion 20E
- Eversion 10E

Calcaneus Valgus

Supination Resistance Test

- Test 5 Reduced axis Increased resistance excessive pronation Treatment Dual Density
- Increased axis reduced axis
Limited Dorsiflexion of the Ankle

- **Test 6**
  - Closed chain dorsiflexion anterior movement of the tibia over the talus – single leg stance for balance
  - Compensation= prolonged pronation of the MTJ- Midtarsal collapse during the stance phase to allow the tibia to move anterior to the talus

Balance

- **Test 7**
  - Y-Test - BEST
  - Four system = balance
  - Somato sensory
  - Vestibular
  - Vision
  - Hip strength

Pronator – Gait Assessment
Pes Cavus

- Characteristics of pes cavus that contribute to overuse injuries:
  1. Forefoot valgus (STJ neutral)
  2. Rigid plantar flexed first metatarsal
  3. Increased inversion of the STJ
  4. Excessive supination of the STJ

- Calcaneal Rock during stance (varus movement of the calcaneus)

Forefoot Valgus

- Eversion of the forefoot on the rearfoot with the STJ in neutral

- Rigid Plantarflexed first Ray

- Compensation in stance - increased supination (varus calcaneus)

FF Valgus; PlantarFlx 1st Ray

- Rearfoot held in neutral position forefoot valgus or plantar flexed 1st metatarsal – 1st Ray

- Calcaneus moves into inversion to get the 5th metatarsal on the floor calcaneal ROCK
Huang found plantar fascia and plantar ligaments support the medial arch.

Kayano during stance there is a dynamic change in the medial arch through body weight, bone structure, ligament—muscle force.

Thordarson reported a combined effect of four muscles for arch supporting function:
- Posterior Tibialis
- Flex Dig Longus
- Flex Hallucis Longus
- Peroneus Longus
Foot Structure Prolonged Pronation
- Forefoot varus non-weight bearing
- Rearfoot valgus in standing
- Excessive FF Supination Twist
- Limited ankle dorsiflexion
- In stance – Lack of windlass effect
- Overpronation - excessive/prolonged – gait
- Excessive resistance to supination test

Collapse of midtarsal

Foot Structure and Injury Summary
- Excessive Supination of STJ - inversion of calcaneus in stance (Calcaneal rock)
- Excessive Eversion of the forefoot on the RF in non-weight bearing
- Rigid Plantar flexed 1st Ray
- Characteristics of Pes Cavus that can
Compensated FF Varus & Valgus

Foot Orthotics Increase comfort
Improve neuromuscular mechanisms

- Foot Orthotic Research
- Thermolabile - Customized
- Treatment of Overuse Injuries
- Improving Balance
- Aerobic Cost of during Running
- Neuromuscular Activation of Muscles within the lower limb and pelvis

Can custom-made biomechanical shoe orthoses prevent problems in the back and lower extremities?

A randomized, controlled intervention trial of 146 military conscripts.
- Boots and Formthotics
- Reduced Back and LE injuries.
- Reduced time off
- Significantly reduced Shin Splints.
- Significantly reduce Achilles pain.
- 1/3 less ankle Sprains.

© Foot Science International Ltd 2006

Comparative trial of the foot pressure patterns between corrective orthotics, Formthotics, bone spur pads and flat insoles in patients with chronic plantar fasciitis.

- Formthotics and Custom FOs.
  - Significantly decreased peak rearfoot pressure.
  - Increased midfoot pressure.
  - “Distributed pressure more evenly over the rearfoot region.”

Distinct Hip and Rearfoot Kinematics in Female Runners With a History of Tibial Stress Fracture

JOSPT 2010, Milnar

- Runners previous tibial stress fx greater peak hip adduction and rearfoot eversion angles during the stance phase of running compared to healthy controls.
- A consequence of these mechanics altered distribution of load within the lower extremity, predisposing individuals to stress fracture.

Valgus heel – pronation excessive

Effects of In-Shoe Thermoformed Orthotic Devices on Static and Dynamic Balance

- Formthotics.
- Postural Stability.
- Static and Dynamic.
  - Immediate Improvement.
  - Improved at 6 weeks.
  - Improvement when not standing on the devices.
Methods

- Dynamic balance
  1. Star Excursion Balance Test
  2. Planter pressures during walking

Methods

- Measurement of static balance - Sway
  - Gravity Goniometer

Balance and Foot Orthotics

The results provide preliminary evidence that foot orthoses can effect improvement in balance measures for older adults.

Michael Gross, J Orthop Sports Phys Ther 2012;42(7):649-657,
Single leg stance
Tandem stance and Tandem Gait test
Neuromuscular & Aerobic Cost of a 1 hr. Run Formthotics – 12 men mean age 32

- Effect of Orthoses on Changes in Neuromuscular Control and Aerobic Cost of a one hour Run
- Heart Rate significantly lower while wearing foot orthoses (Formthotics)
- Normalized EMG activity and Peak Torque –
  - Modified recruitment strategies in VM, GM, help reduce demand for muscles to control kinetics of knee and RF
  - PL increase activity – counter act lateral instability and increased stability of the first metatarsal in push-off

Rigid Orthotics and Muscle Activity

- Hertel et al EMG activity in vastus medialis and gluteus medius significantly increased during single leg squat with FO when compared to non-FO and shoe only
- Mondermann et al, highest EMG intensity of the peroneus longus, biceps femoris at pre-heel strike

Muscle Activation

- Do foot orthoses change lower limb muscle activity in flat-arched feet towards a pattern observed in normal-arched feet?
  - Murley, Landorf, Hylton, Menz, Clin Biomechanics 2010
  - The foot orthoses significantly altered Tib Post & Peroneus Longus EMG amplitude.
  - Only the modified prefabricated orthosis changed peroneus longus electromyographic amplitude towards a pattern observed with normal-arched feet.
Kulig et al., demonstrated that a FO can enhance selective activation in Tib Post in adults with pes planus to level equivalent to those with a normal arch index.

Nawoczenski & Ludewig
- Decrease 11% in EMG of Biceps Femoris
- Increase 37.5% EMG of Tib Anterior

Case Study
- History of a horse falling on his right leg. No Fractures
- Tibial Varum
- Squinting patella
- Posterior Lateral Hip pain
- Shin Splints

Foot Orthotic Correction
Before

After
**Hip Rotation Plate**
Dr. Donatelli

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**Hip Exercise Phased Program**
R. Donatelli

<table>
<thead>
<tr>
<th>Phase One</th>
<th>Phase Two</th>
<th>Phase Three</th>
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</thead>
<tbody>
<tr>
<td>Double leg bridge</td>
<td>Quadruped all fours arm/leg lift (42% MVC)</td>
<td>Single Leg Bridge (47% MVC)</td>
</tr>
<tr>
<td>External rotn - Side Lying</td>
<td>Lateral Step Up (48% MVC)</td>
<td>Wall slides</td>
</tr>
<tr>
<td>Single Leg Stance</td>
<td>2 step Hip standing on step</td>
<td>Abduction/extension</td>
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<tr>
<td></td>
<td>abduction/ext rotn</td>
<td>Internal rotation</td>
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<tr>
<td></td>
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<td>Side Bridge (74% MVC)</td>
</tr>
</tbody>
</table>

Ekstrom, Donatelli 2007
Foot Orthotics to Control pronation and soft tissue strain

no orthotic

With foot orthotic

Summary- Rehabilitation Considerations in the LE

- Core hip and trunk strengthening to control femoral rotation and patella alignment
- Foot Orthotics controlling foot posture and affecting the lower limb
- Improved Neuromuscular Control and Aerobic Cost of a one hour Run
- Manual Therapy to increase mobility of the Foot and Ankle, Knee, and Hip

THANK YOU