Ankle and foot region: Physiotherapeutic management

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Objectives:

After the presentation:
- Clinical biomechanics and gait analysis of lower limb
- Pathomechanics of the ankle and foot complex
- Is excessive pronation a significant risk factor?
- To use foot orthoses or not?
- Clinical reasoning issues in the examination and treatment of leg, ankle and foot
Objectives:

- **Practical session:**
  - Physical examination of the leg, ankle and foot
  - Biomechanical assessment of LLs
  - Some common use taping techniques for ankle and foot
  - Some common use foam footpad for anti-pronation
  - Exercise prescription: design the exercise program and management program
Objective 1a:

Clinical biomechanics and gait analysis of lower limb (issue relating to ankle and foot)
Tibia Varum

• The normal lower limb is represented by a tibial varum angle of between 3-4 degrees
Talocrural joint

- DF: 10-20°
- PF: 45°

Close pack:
- dorsiflexion

Talar AP glide _ DF
Talar PA glide _ PF

Fig. 5.20 Ankle equinus
(a) Normal ankle dorsiflexion (top)
(b) Abnormal ankle dorsiflexion (bottom)
Subtalar joint

- Pronation: eversion, dorsiflexion, abduction
- Supination: inversion, plantarflexion, adduction

Clinically presented as calcaneal inv and eve: 20°;10° Root et al

In CKC, ST is a torque converter of lower leg
Mid-tarsal joint

- Calcanecuboid and talonavicular joints
- A rotation at CC during push off, calcaneus and cuboid allows cuboid to fix: acts as fulcrum
Metatarsal Phalangeal joints

- DF: to 50°-75°
- Windlass: plantar fascia; rigid lever for push off

Figure 4.17 Metatarsophalangeal joint motion during stance. Shaded toe indicates area of motion.
Ankle joint motion

Figure 4.1 Ankle motion: Normal range during a stride. Black line = the mean, dotted line = 1 standard deviation.
Subtalar joint motion

Figure 4.16 Normal subtalar joint motion during free walking. (Adapted from Wright DG, Desai SM, Henderson WH. Action of the subtalar and ankle-joint complex during the stance phase of walking. J Bone Joint Surg. 46A:361-382, 1964.)
Sequence of foot support areas

Figure 4.27  Sequence of foot support areas during stance. Heel only in loading response (LR). Foot flat in mid stance (MSt). Forefoot and toes in terminal stance (TSt). Medial forefoot in pre-swing (PSw). (Adapted from Barnett CH. The phases of human gait. Lancet 82(9/22):617-621, 1956.)
Typical pattern of rearfoot motion walking
(from Cornwall & McPoil, JAMPA 89:56 1999)

Major points:

– Rearfoot inverted prior to heel contact
– Rearfoot supination begins at 50-60% of stance phase
– Rearfoot operates about Resting standing posture (RSP) and not subtalar joint neutral position
– Typical total rearfoot ROM during stance phase ~6°-8°
**Typical pattern of rearfoot motion**

- **During running**
  - 3D motion analysis required to get accurate motion assessment
    12.7° (+/- 3.5 °) average total rearfoot eversion
  - More recent studies have reported
    avg total rearfoot eversion ~16 °
Muscle sequence controlling the foot joints during stance phase

**Figure 9.11 Muscle Sequence Controlling the Foot Joints During Stance**
Objective 1b:

Clinical biomechanics and gait analysis of lower limb (issue relating to pelvic and hip)
Pelvic motion and control

Pelvic drop in NWB leg
~7°
Anterior tilt ~ 4°
Rotation ~ 10°
Knee motion

Figure 5.1 Three-dimensional knee motion and arcs used in free walking: Sagittal plane flexion (60°); Transverse plane rotation (8°); Coronal plane abduction (8°).
Knee motion

Figure 5.13 Biceps restraint of passive internal rotation.

Figure 5.14 Iliotibial band as a lateral restraint of the adduction torque.
Knee motion

Figure 5.2 Knee motion. Normal range during a gait cycle for free walking.
Objective 2

Pathomechanics of the ankle and foot complex
Gait abnormalities simplified

- 3 common types of pronation dysfunction
  - Excessive: >40% of the stance phase
  - Prolonged: seems never supinated
  - Inadequate: small temporal & spatial amplitude pronation, late in mid stance

Why??
What compensation(s) if lack of T/C DF?

• Ideally TC DF=10°
• If TC DF<10°

??Related to:
1. Calf tightness
2. Bony limitation
3. Joint limitation
Subtalar joint neutral (Root et al 1971, 1977)

Fig. 2. Measurement of subtalar joint (STJ) neutral position indicating a slight varus angle in the normal foot. (Reprinted by permission of On-Site Biomechanical Education and Training, 1988.)
Subtalar joint neutral (Root et al 1971, 1977)

- Calcaneal varus: compensated excessive pronation
Subtalar joint neutral (Root et al 1971, 1977)

- Calcaneal valgus: very rare
Subtalar joint neutral (Root et al 1971,1977)

- Forefoot varus: very common; compensated prolonged pronation
Subtalar joint neutral (Root et al 1971, 1977)

- Forefoot valgus: compensated with supination
Objective 3

Is excessive pronation a significant risk factor?
Is mal-alignment a significant risk factor?
Why the need for motion control?

• What created the belief that "excessive pronation" was a significant risk factor in the development of running-related injuries?

• Anecdotal literature published by recognized clinicians
  – Shuster: Ann NY Acad Sci, 1977
Why the need for motion control?

  – Reviewed 180 runners with 232 conditions
    • 65% distance runners
    • 24% joggers
    • 11% track and field
  – Etiology of injuries fell into 3 categories
    • Training errors (60%)
      – Excessive mileage (29%)
    • Anatomic factors
    • Shoe & surfaces
Why the need for motion control?

  - Anatomic factors
    - 72 of 180 patients (58%) had pronated feet
    - 16 patients (25 feet) had excessive pronation
      - All feet exhibited forefoot supination
      - 58% had a subtalar varus
      - All feet had normal ROM
    - Functional orthotics used for 11 patients with excessive pronation
      - 8 patients reported orthotics were helpful
Alignment vs injury relationship

  - Noted that following alignment variations were repeatedly seen in runners with knee pain
    - Femoral neck anteversion
    - Tibial varum
    - Pronated feet
    - Excessive Q angle
    - Functional equinus
Alignment vs injury relationship

• Often difficult to associate alignment to injury because each individual appears to have a personal level of tolerance for tissue stress that may not be related to body structure or alignment
Alignment vs injury relationship

- Does the current research indicate a direct link between foot or LE alignment and the development of overuse injuries?
Alignment vs injury relationship

  - Cohort of 1288 runners was monitored for 12-month period for occurrence of ms injuries (985 males & 303 females)
  - Survey and physical assessment on each runner
    - Hip rom, pelvic obliquity, knee and patellar alignment, rearfoot position, somatotype
  - Results
    - None of the PE variables were significantly related to risk of injury in either sex
    - Two most important predictors for overall risk of injury
      - Training miles per week & previous injury
Alignment Vs injury relationship

  - Studied effect of LE alignment on risk of overuse injury in 304 experienced runners
    - Arch index (NTH/BL ratio), subtalar neutral, heel valgus, Q angle, LLD
  - Found few consistent relationships btw alignment measures & risk of overuse injury
  - Noted minor structural malalignment are probably not risk factors for running injuries in the cohort studied
  - Concluded that etiology of running injuries is multifactorial involving extrinsic factors (eg training parameters) activity on pre-disposed intrinsic make up (eg altered alignment)
Alignment vs injury relationship

  - Prospectively studied effect of measurable LE alignment is a risk factor for overuse injury in 255 runners in marathon training program
    - Arch index, heel valgus, Q-angle, knee varus or valgus, LLD
    - Past training and injury history using questionnaire
    - Overuse injuries recorded during 32-week training period
Alignment vs injury relationship

  - Of the 255 runners, 90 experienced overuse injuries
  - Found few consistent associations btw the alignment measures and overuse injuries
    - A higher AI was protective against overall injuries
    - A higher HV was protective against knee and foot injuries
    - A higher KV was associated with shin injuries
    - A low LLD was associated with more overuse injuries
  - Concluded that minor variations in LE alignment did not appear to be major risk factors for overuse injuries in runners
Foot alignment vs injury relationship

- Williams et al; Clin Biomech, 2001
  - 20 high & 20 low arch runners (at least 6 miles per week)
    - High arch –
      - Lateral ankle sprains, ITBFS, plantar fasciitis
    - Low arch –
      - General knee pain, patellar tendonosis, plantar fasciitis
Studies reporting “excessive pronation” factor in overuse injuries

- **Retrospective studies**

- **Prospective studies**
  - Willems et al: Gait & Posture, 2005
Physical fitness vs injury relationship

  • Studied effect of LE alignment on risk of overuse injury in 294 male army recruits
  • Overall risk of overuse injury was 30% (84 recruits)
  • Concluded that the degree of anatomic deformity associated with increased injury risk depends on the amount & intensity of training as well as the fitness characteristics of population
Physical fitness vs injury relationship

  - Studied injury patterns of 1143 recruits during 12-week basic training
    - Monitored hours of vigorous training
  - Top 3 injuries – ankle sprains (71/6.2%), ITBFS (61/5.3%), stress fractures (52/4.0%)
  - Findings suggest type of training, particularly running and abrupt increase in training volume increase injury risk
• **Most current evidence**
  
  – *Is unclear* whether individuals who exhibit *increased pronation* have a higher level of risk for developing LE/foot injuries
  
  – *Current research* *indecisive* regarding a direct correlation among hip, knee, patellar & foot alignment and the development of overuse injuries

  (Murphy et al, BJSM, 2003)
Running overuse injuries

- Previous injury
- Sudden increase in training
- Total training load
- LE & Foot altered alignment
- Weekly mileage
- Footwear usage

Training habits
Objective 4

To use foot orthoses or not?

→ management of overuse injuries
Primary factors that can cause or enhance tissue stress

- Repetitive application of forces to involved tissues or excessive mechanical loading
  - Insufficient recovery time allowed
- Fatigue
  - Both physical or mental
- Training intensity & previous injury
  - Inadequate rehabilitation
- Physiological factors
  - Metabolic
  - Circulatory
  - Nutritional
Management protocol using tissue stress model (McPoil & Hunt, 21:6, JOSPT, 1995)

- Reduce tissue stress to a tolerate level
  - REST, footwear, orthoses
- Aid the natural healing process of the involved tissues and pain management
  - Medications, modalities, manipulate/mobilize
- Restore, maintain or improve joint and muscle flexibility of involved tissues
- Restore, maintain or improve muscle strength, speed, and endurance
- Plan a functional progression to permit the return to desired level of activity
  - Including cardiovascular endurance
Management protocol using tissue stress model

- Footwear
- Adhesive strapping
  - Low dye
  - Reverse 6
  - Calcaneal sling
- Foot orthoses

Are foot orthoses required?

↓

What is the likelihood of success?

- 32 year old male
- Competitive soccer player
- Achilles tendinopathy II+
- 2 year history of the condition
- Agg by soccer, jogging & netball
- TOP over Achilles tendon
- Prolonged & excessive pronation determined by clinical observation
- Run to pain threshold = 103m
TDT step 1:

- Client specific outcome measure

Either one or both:

- Jogging to pain first start onset
  - mark down the distance and time
- Single leg hop test
  - Note down the number of repetitive hop; note down the height
Step 1: Hypothesis building

- Clinician needs to determine that there is some movement abnormality that may relate to symptoms and condition
- An hypothetical pathomechanics model for the patient (pronation-Achilles tendinopathy)
  Clement et al, AJSM, 1984
TDT step 2: physical manipulation

- Reverse 6

Figure 1. The chosen anti-pronation taping was in the form of three reverse sixes (Vicenzino et al 1997; Vicenzino et al 2000). Tape application started at the medial malleolus, moving laterally across the foot, under the plantar surface and back up the medial side to anchor on the distal one-third of the leg. Circumferential tape was then applied to lock in the reverse sixes.
TDT Step 3: Re-evaluate

Either one or both:

- Jogging to pain first start onset
  - mark down the distance and time
- Single leg hop test
  - Note down the number of repetitive hop; note down the height
Results

Figure 2. Physical function measures of jogging (distance in metres = triangles, time in seconds = squares) in the ABA study design. Days of the study are indicated on the horizontal axis and running distance and time on the vertical axes. The jogging test was limited to 1150 m.
Objectives 5: Clinical reasoning issues in the examination and treatment of leg, ankle and foot

- Multifactorial risk factor & overuse injury

Complex and clinically challenging
Multifactorial mix of risk factors (proportional)

*training (1,3), equipment (1,3), environment (1,3), biomechanical (2,3)

1. Extrinsic factors largely checked in interview
2. Intrinic factors examined physically
3. Must be checked in clinical examination
Multifactorial Mix of risk factors (proportional): training error

- Training error:
  1. Too much load
  2. Too little rest
  3. Poor preparation of heavy work
  4. Plyometric
  5. Change in technique
Multifactorial Mix of risk factors (proportional): Equipment error

- Equipment error:
  1. Worn out shoes: too little or too much control
  2. Inappropriate shoes
  3. Cold turkey from old to new shoes
  4. Inappropriate innersoles or orthotics
Multifactorial Mix of risk factors (proportional): Environment error

Diagram showing Risk of Injury with factors like Biomechanical Error, Environmental Faults, Equipment Faults, Training Error, and Environmental Error (e.g., camber, slope, compliance, change).

- Environment error:
  1. Camber of the surface
  2. Slope/hill
  3. Firmness or compliance
  4. Change of surface
  5. Sand and grass
Multifactorial Mix of risk factors (proportional): Biomechanical error

- Biomechanical error:
  1. Acquired or congenital?
  2. Compensatory
  3. History of deformity/prior injury
  4. Foot wear abnormally worn
  5. Poorly control conventionally
  6. Sensori-motor system
  7. Muscle dysfunction
Evidence of biomechanical involvement??

- Clinicians frequently report positive changes with orthotic or other biomechanical interventions
- Overuse injuries linked to abnormal biomechanics (eg Lysens, Tomaro)
- But not all studies find such evidence!!!

Prospective longitudinal study of 185 (118 male, 67 female) aged 18.3±0.5yrs

Muscle weakness, ligamentous laxity & muscle tightness intensified by large body weight and height, high explosive strength and malalignment of the lower limbs (female > male)

20 subjects with unilateral overuse disorders had their tibiofibular varum measured while standing in relaxed and neutral calcaneal stance positions

Significantly greater varus on injured side when standing in relaxed calcaneal stance phase
Clinical example: Achilles Tendinopathy

Diagnostic features:
Achillies tendinopathy

- **Aetiological (in brief)**

  1. Degenerative changes not inflammatory in chronic tendinopathy (Khan and colleagues)
  
  
  

  2. **Further explanation in our chapter**

Achilles Tendinopathy

- Pathomechanics
  

Relating to excessive pronation, whipping action of the achilles tendon
Clinical challenge:

- Problem:
  No research evidence to be absolutely sure that the pronation abnormality is related to the Achilles tendonopathy!

How do we know that pronation problem is associated to the condition??

OR if the movement abnormality related to pain

TREATMENT DIRECTION TEST
Treatment Direction Tests applied:

• Several circumstances encountered:
  – In clinic
    Standing or sit to stand
    Walking or jogging (approx <5mins)
  – Runner or long time for onset
    Apply tape and send out to re-test
    Send out for run and examine at time of pain
  – Other
    Beware of client who is unsure of aggravating factor and dysfunction (ie don’t know when pain is a problem)
Clinical reasoning: possible multifactorial causes of Achilles tendon pain?

- **Training error**
  - Too much, too soon
  - Plyometrics with poor preparations

- **Equipmental faults**
  - Old shoes
  - Inadequate control

- **Environmental faults**
  - Too quick an intro into hills
  - Beach sand running

- **Biomechanical faults**
Clinical reasoning: possible causes of abnormal pronation?

- Lack of T/C doriflexion
  - Calf tightness
  - Joint limitation
  - Bony limitation
- Forefoot/rearfoot varus
- Hypermobile midstarsal joint
- Poor muscle control of foot (intrinsics, TP, PL)
- Don’t forget causes extrinsic to the foot
  - Poor pelvic control (excessive internal rotation)
  - Genu valgum or varum