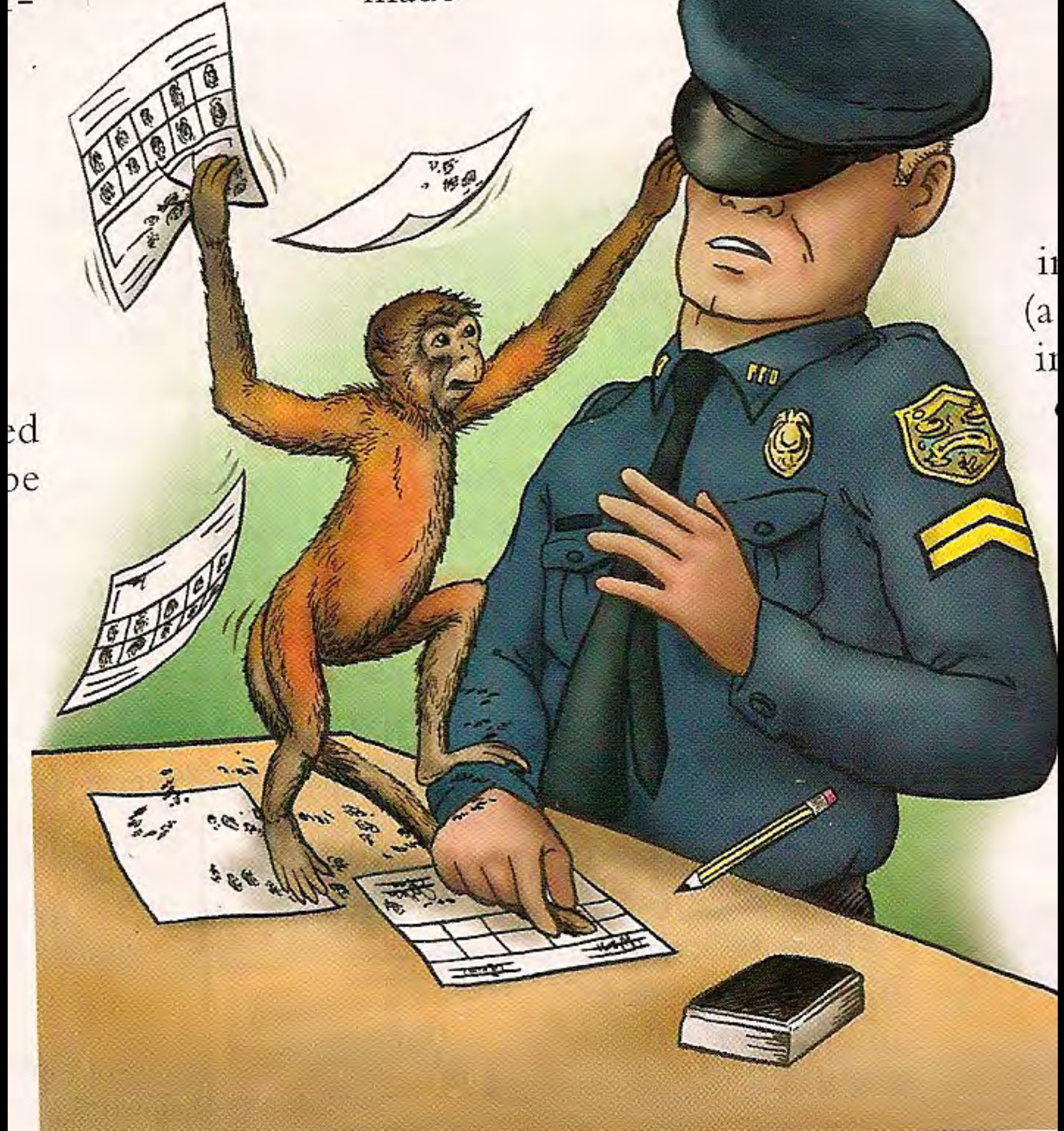
Forensic Podiatry & The Foot in Medicolegal Investigation

David Agoada, D.P.M., M.S.

Left: Print of left index toe of a young orangutan; right: print of right third finger of an adult koala

with cri du chat, perhaps



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Objectives

- ☑ Define Forensic Podiatry
- ☑ Review foot anatomy and biomechanics
- ☑ Discuss Foot Prints
- ☑ Demonstrate Shoe Structure
- ☑ Examine Foot Pathology
- ☑ Present Case History

Doctor of Podiatric Medicine

- Graduate of 4 year medical school specializing in podiatric medicine
- Two to five years of residency training
- Licensed in all 50 states to treat foot related problems medical and surgically

Podiatry Practice is based on a core of knowledge includes (modified from Vernon):

- Lower limb anatomy and physiology
- Structural pathologies of the foot
- Recognition and care of the “at risk” foot (eg. diabetes mellitus)
- Lower extremity biomechanics
- Relationship between foot wear and the functioning foot.
- Medical and surgical treatment of foot related problems.

"I'm sorry—I'm a left-foot podiatrist."

When to use a podiatrist's medical records to help determine an individual's identity

1. General patient information
2. Foot/ lower extremity description
3. General and foot specific medical history
4. Pedal surgical history
5. Relevant foot x-rays
6. Preserved lab specimens

FORENSIC PODIATRY

Forensic Podiatry is the:

“Application of sound and researched podiatric knowledge in the context of forensic and mass disaster investigations. This may be for the purposes of person identification, to show the association of an individual with the scene of a crime, or to answer any other legal question concerning the foot or footwear that requires knowledge of the functioning foot”.

A **footwear examiner** identifies and compares characteristics to match impressions left at the crime with that of the suspect.

A **forensic podiatrist** evaluates evidence relating to the human foot for the purpose of connecting an individual to footwear or a footprint

Forensic podiatrists analysis pedal evidence; they are not experts in technique or devise use.

What a forensic podiatrist may do:

- Examination of foot prints; bare or sock clad
- Examination of foot impressions
- Examination of footwear - particularly where there is a question of the predominant wearer or ownership of the footwear in questions
- Footprint profiling
- Mass disaster applications

When to seek the help of a forensic podiatrist

1. Foot wear examiner makes a positive ID between the foot impression and the suspect's shoes, but..
   -the suspect denies ownership
   -it is an inclusive footwear exam

2. Gait analysis is needed

3. Foot profiling is required: Need approximations to help determine an individual's height or shoe size from print or impression

4. Determine pathological or biomechanical problems.

Success of the Forensic podiatrist's evaluation depends on:

1. The abilities of the footwear examiner

2. The quality of the evidence

3. Examination quality photographs in natural size

4. The availability of quality exemplars used for comparison purposes

Methods of collecting exemplars that the forensic podiatrist will be able to use for a thorough analysis

1. Photographs

2. Foot prints and Footwear prints

3. Casts of impressions

Fabrication of known standards from the suspect

(Forensic podiatrist should be involved in this process)

- Photographs of pedal evidence in different positions
- Inked bare footprints or one step taken with the soft tissue outlined perpendicular to the weight bearing surface
- Casting using foam weightbearing and filled with dental stone

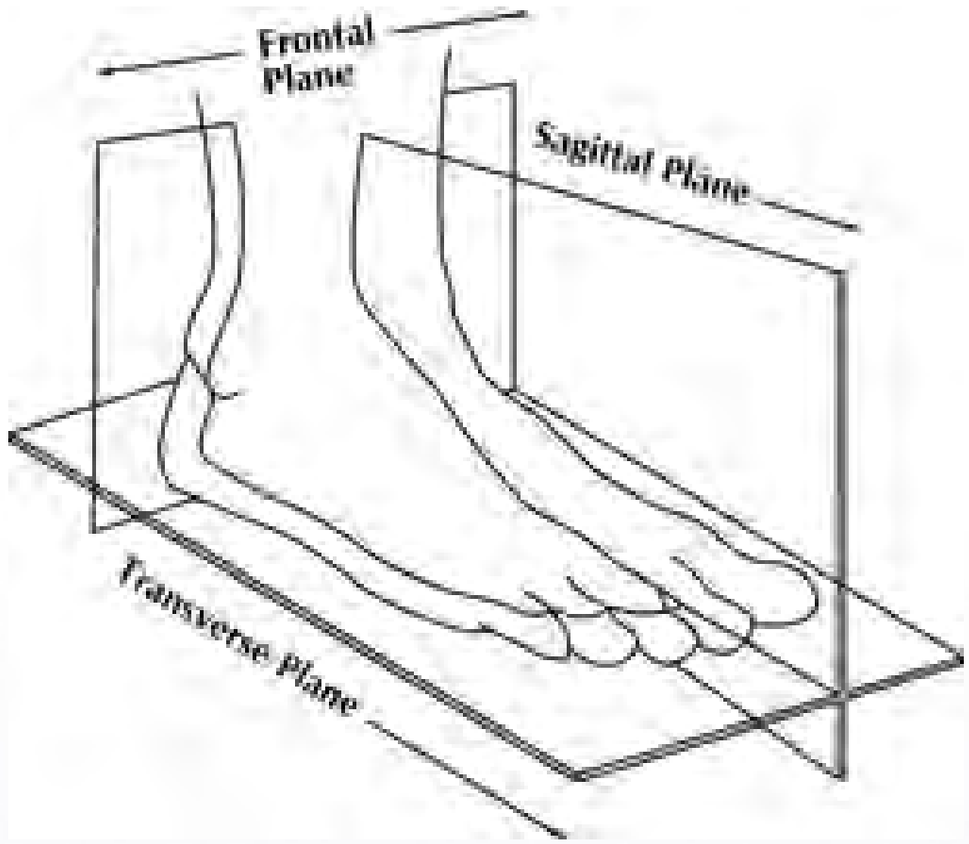
<u>Fabrication of known standards from the suspect</u> (cont'd)

•Inked gait pattern:

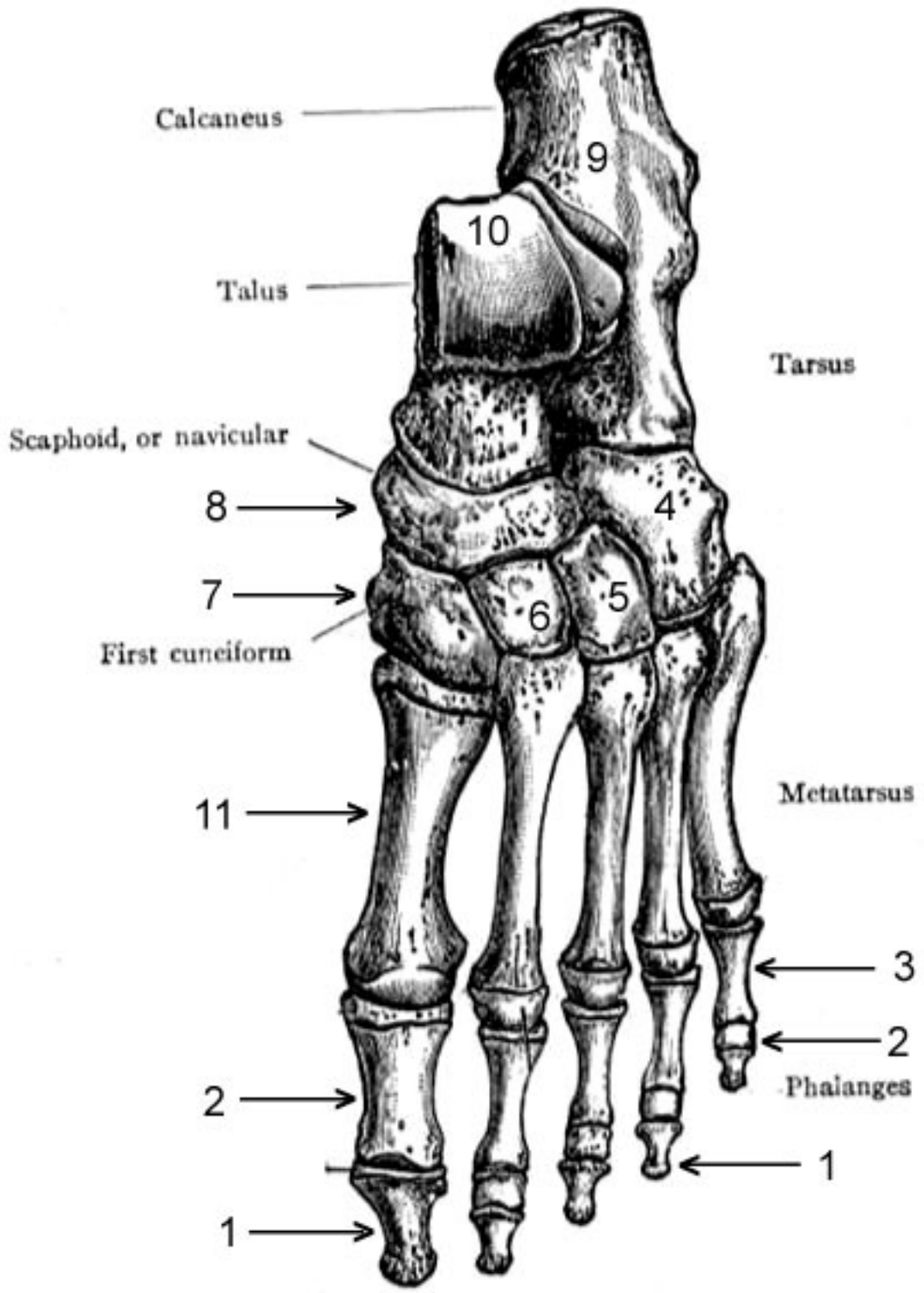
Repeat 3 times using ink on the bottom of the foot
Use butcher style paper 20 feet by 3 feet
Videotape entire process

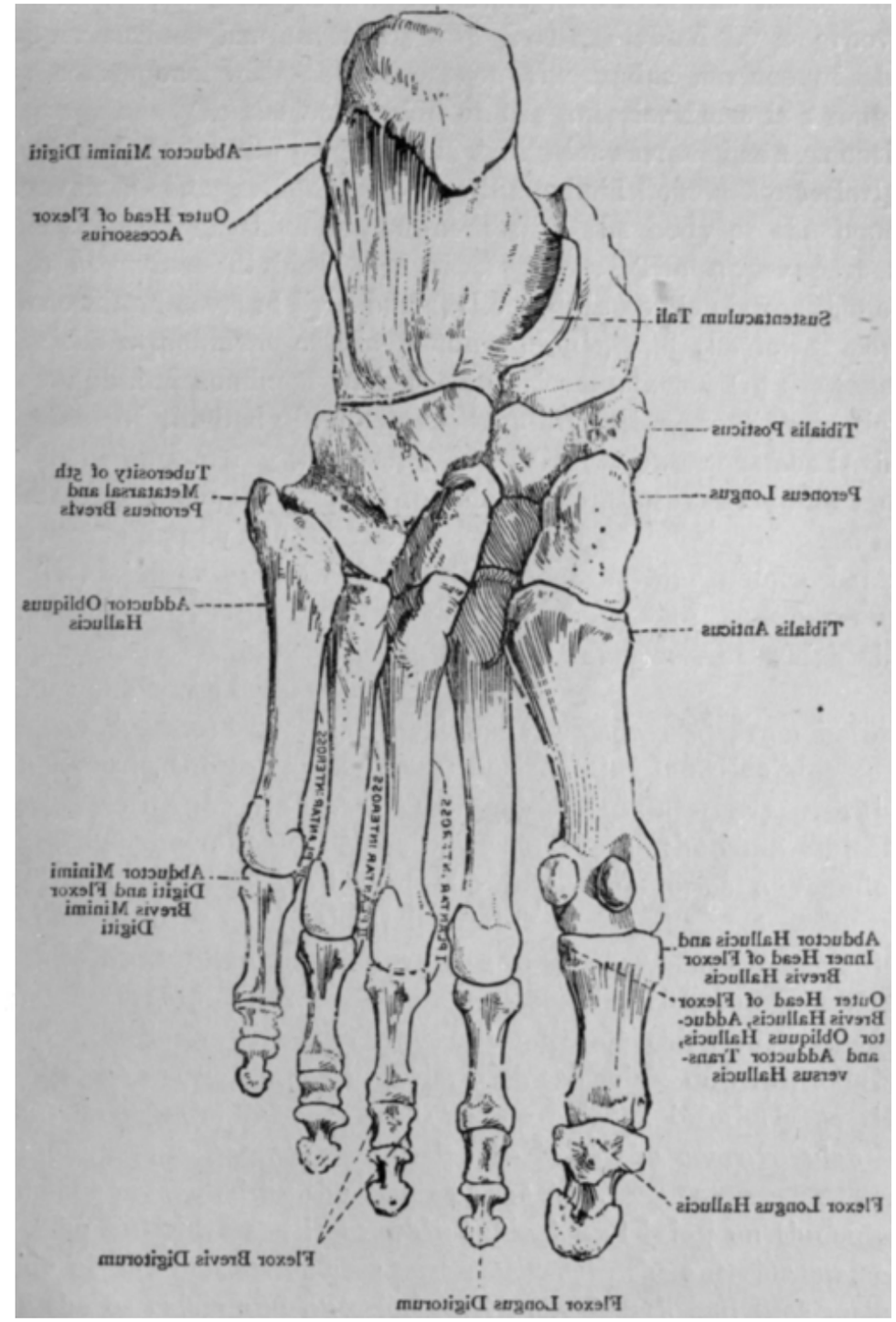
Foot morphology

“The foot’s anatomical, morphological and biomechical configuration is genetically programmed and modified by use and events throughout one’s life. It is different in everyone, even ridge patterns in identical twins. The challenge is to identify those unique features and compare them with the evidence available.”



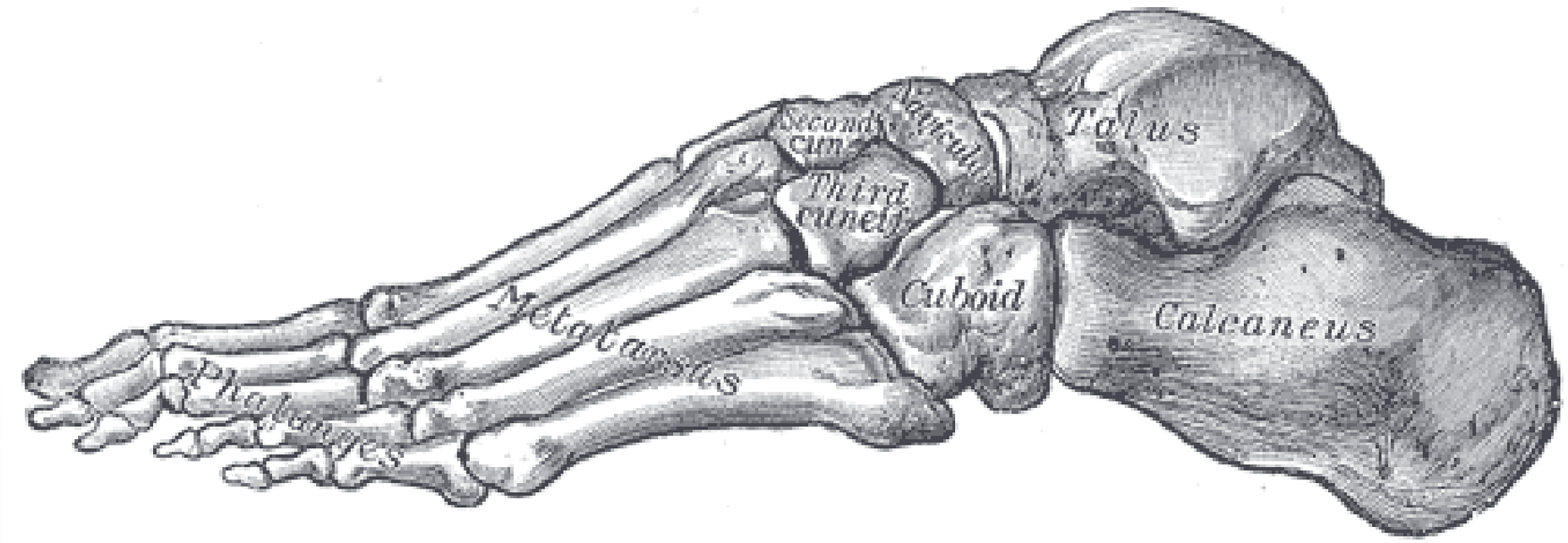
Planes of the foot





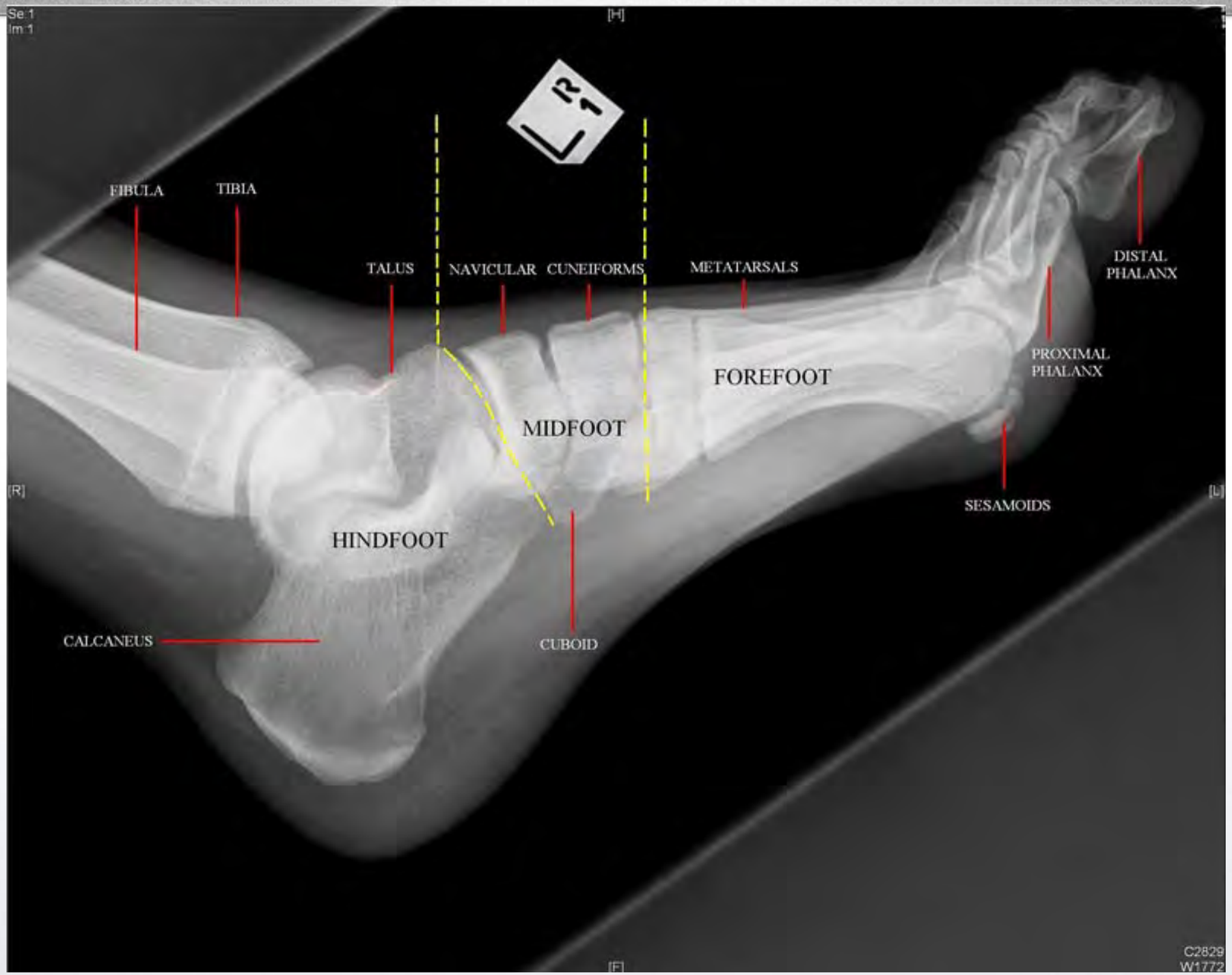
Anterior-posterior view (transverse view)

Anterior-Posterior (DP) view



Bones of the foot: Lateral view

Bones of the foot: Lateral x-ray view


Se:1
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[H]
FIBULA
TIBIA
TALUS
NAVICULAR
CUNEIFORMS
METATARSALS
DISTAL PHALANX
PROXIMAL PHALANX
FOREFOOT
MIDFOOT
HINDFOOT
SESAMOIDS
CALCANEUS
CUBOID
[R]
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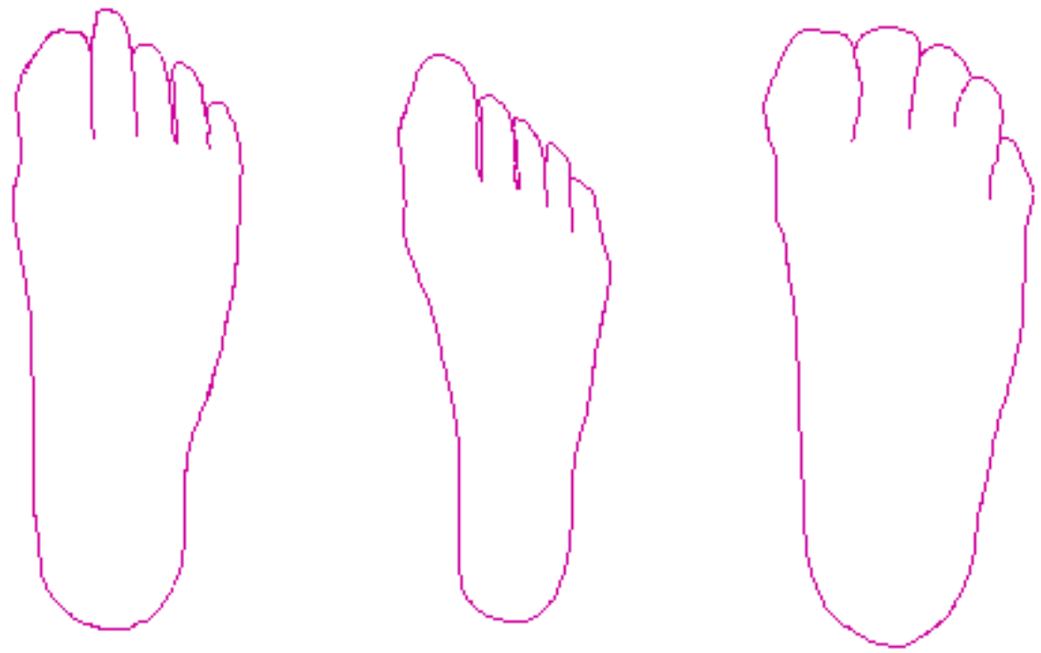
C2829
W1772


DISTAL PHALANX
PROXIMAL PHALANX
METAMORDIA
FIRST METATARSAL
DISTAL PHALANX
INTERMEDIATE PHALANX
PROXIMAL PHALANX
FOREFOOT
METATARSAL 5
CUNEIFORMS
MIDFOOT
NAVICULAR
CUBOID
TALUS
HINDFOOT
TIBIA
CALCANEUS

Foot morphology classification may be based on:

1. Relative digit length
2. Arch configuration
3. Biomechanics (the “dynamic foot”)
4. Pathology and pathologic features

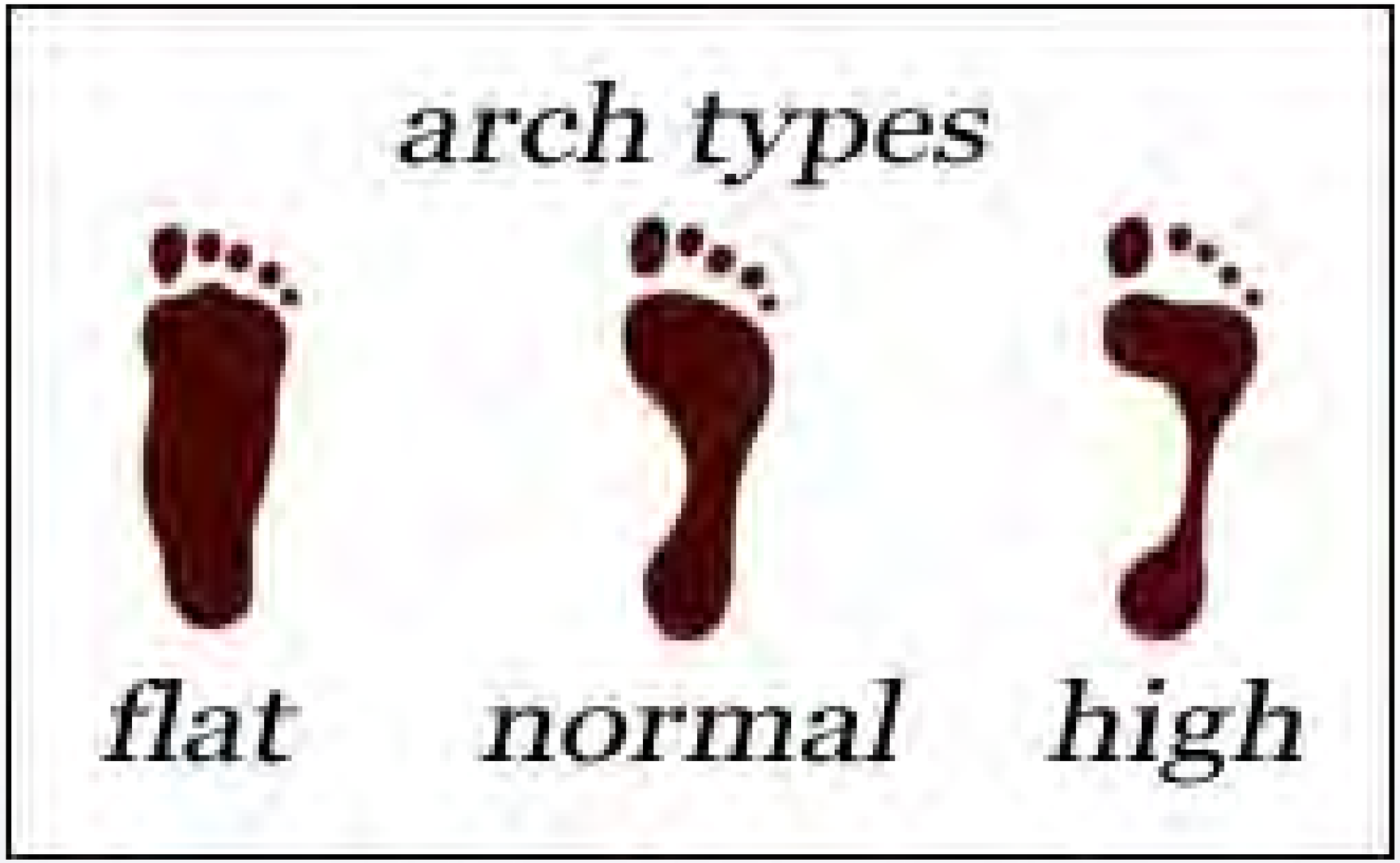
Illustration of digital length pattern



Greek/Morton's Foot

Egyptian Foot

Giselle/Peasant Foot


arch types
flat
normal
high

Biomechanics:

The application of mechanical laws to living structures, specifically the locomotor system of the human body.

Lower extremity biomechanics: Basic terminology

1. Body planes
   a. sagittal
   b. frontal
   c. transverse

2. Joint motion
   a. sagittal: dorsiflexion-plantarflexion
   b. frontal: inversion (supination)
   -eversion (pronation)
   c. transerse: abduction-adduction

Joint motion during the gait cycle

(In each plane)

1. Knee

2. Ankle joint

3. Subtalar joint

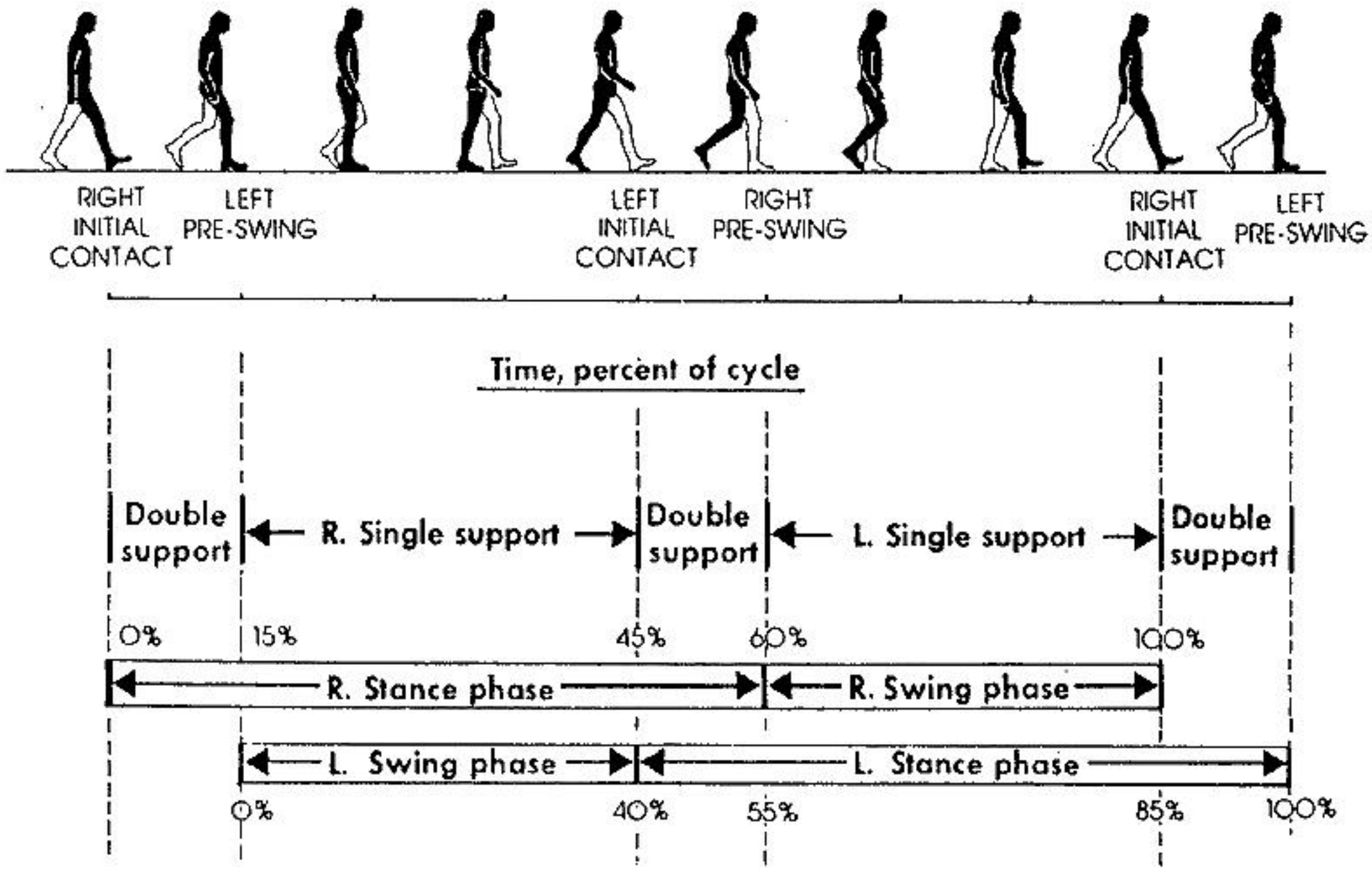
4. Midtarsal joint

5. 1st metatarsal phalangeal joint

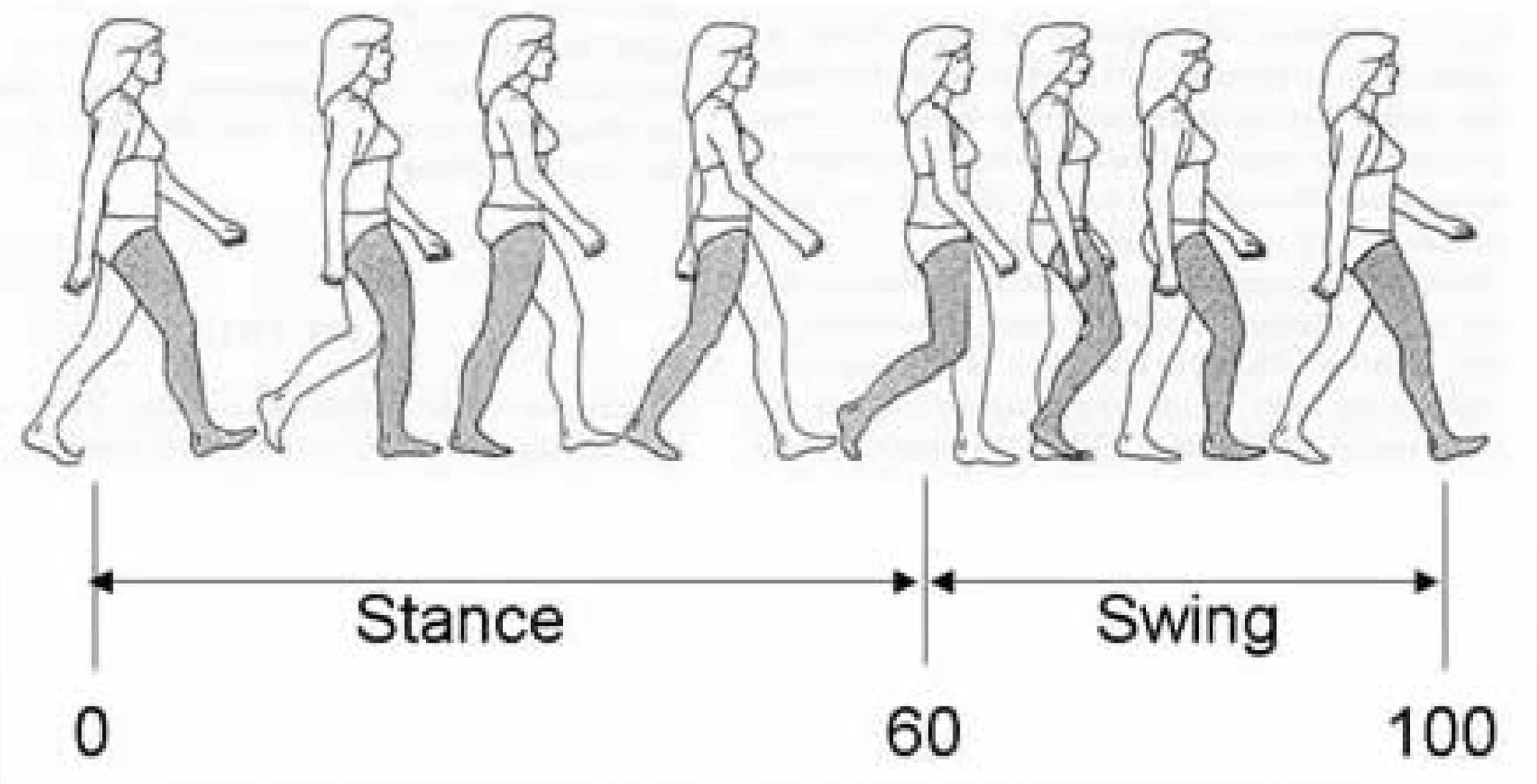
The Gait Cycle

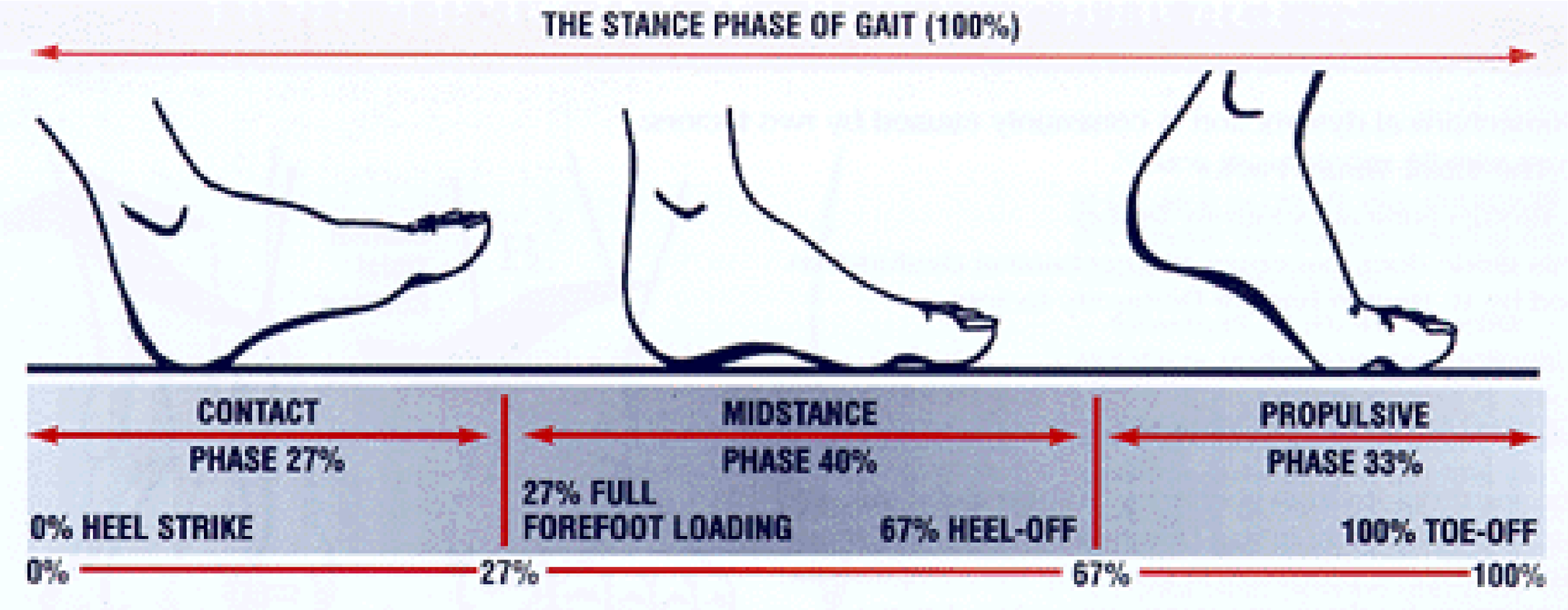
Weight bearing (Stance phase)
1. Heel contact
2. Midstance
3. Propulsion

Non weightbearing (Swing phase)

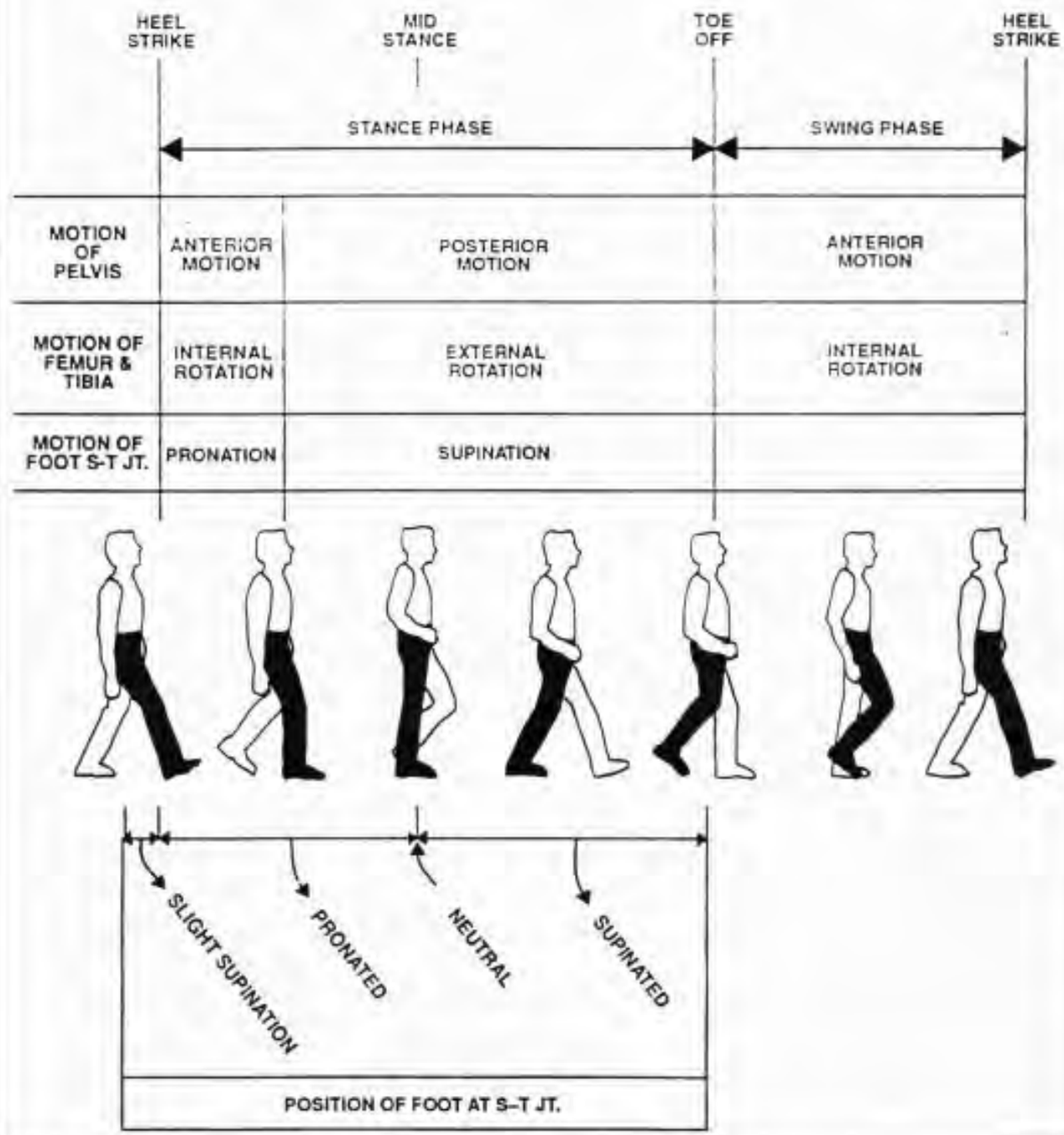

RIGHT INITIAL CONTACT
LEFT PRE-SWING
LEFT INITIAL CONTACT
RIGHT PRE-SWING
RIGHT INITIAL CONTACT
LEFT PRE-SWING
Time, percent of cycle
Double support
R. Single support
Double support
L. Single support
Double support
0%
15%
45%
60%
100%
R. Stance phase
R. Swing phase
L. Swing phase
L. Stance phase
0%
40%
55%
85%
100%

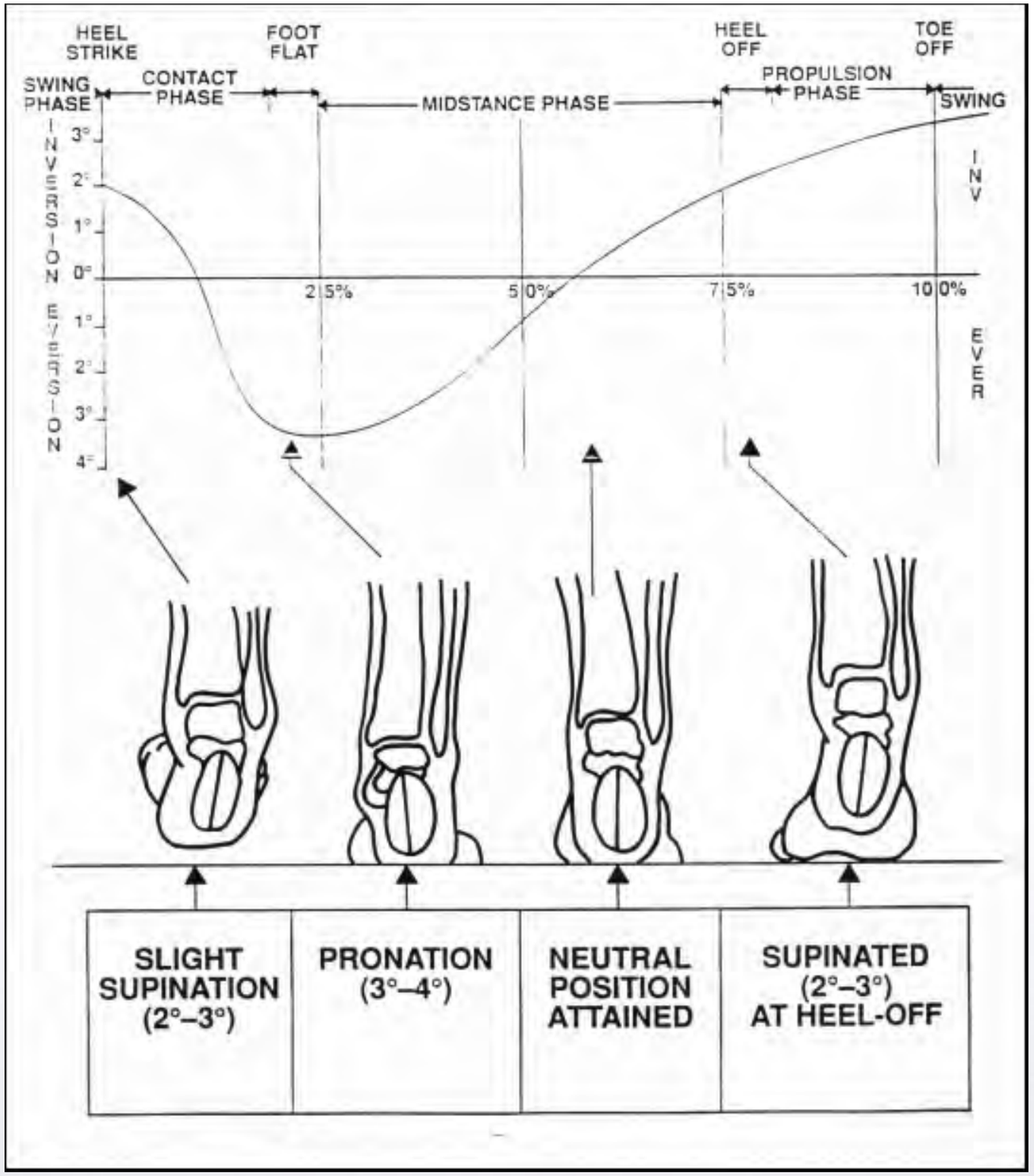
Gait Cycle




THE STANCE PHASE OF GAIT (100%)
CONTACT
PHASE 27%
0% HEEL STRIKE
MIDSTANCE
PHASE 40%
27% FULL
FOREFOOT LOADING
67% HEEL-OFF
PROPULSIVE
PHASE 33%
100% TOE-OFF
0%
27%
67%
100%

LOWER EXTREMITY MOTION




HEEL STRIKE
FOOT FLAT
HEEL OFF
TOE OFF
SWING PHASE
CONTACT PHASE
MIDSTANCE PHASE
PROPULSION PHASE
SWING
INVERSION
EVERSION
3°
2°
1°
0°
1°
2°
3°
4°
25%
50%
75%
100%
INV
EVER
SLIGHT SUPINATION (2°–3°)
PRONATION (3°–4°)
NEUTRAL POSITION ATTAINED
SUPINATED (2°–3°) AT HEEL-OFF

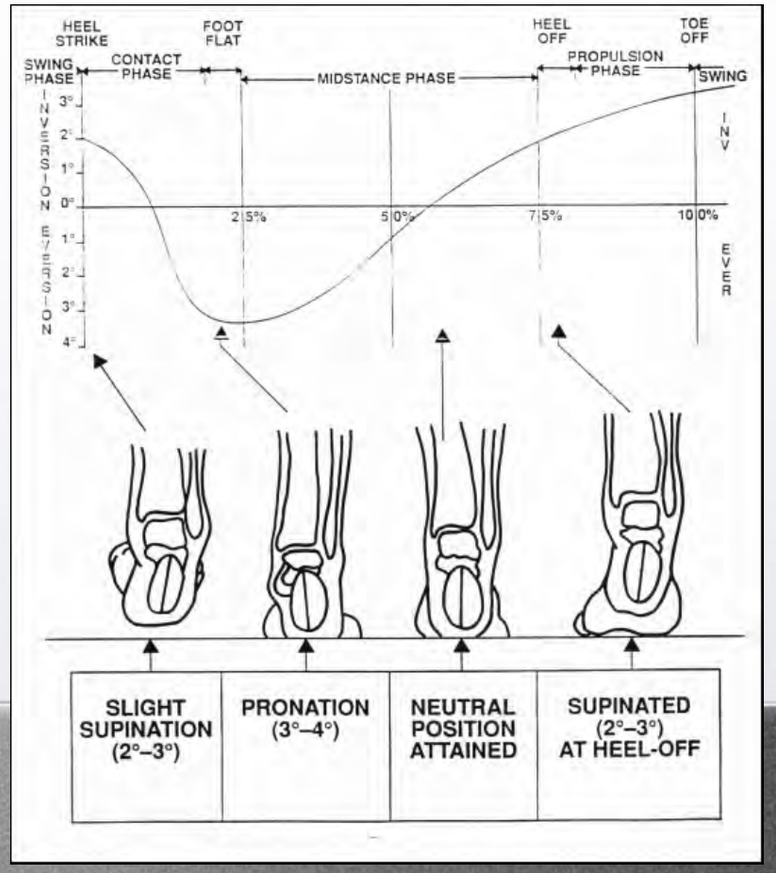
Foot classification may be based on such things as:

1. Relative digit length
2. Arch configuration
3. Biomechanics (the “dynamic foot”)
4. Pathology and pathologic features

Determining the biomechanical pathology of a foot is, in part, looking at the relationship of the forefoot to the rearfoot in the frontal plan, both weight bearing and non weight bearing.

In weightbearing, look at the relationship between the posterior of the calcaneus and the ground.

1. Everted
2. Perpendicular
3. Inverted



Pathomechanics (Biomechanical or functional deformities)

Frontal plane deformities

1. Rear foot varus
2. Rear foot valgus
3. Forefoot varus
4. Forefoot valgus

Sagittal plane deformities

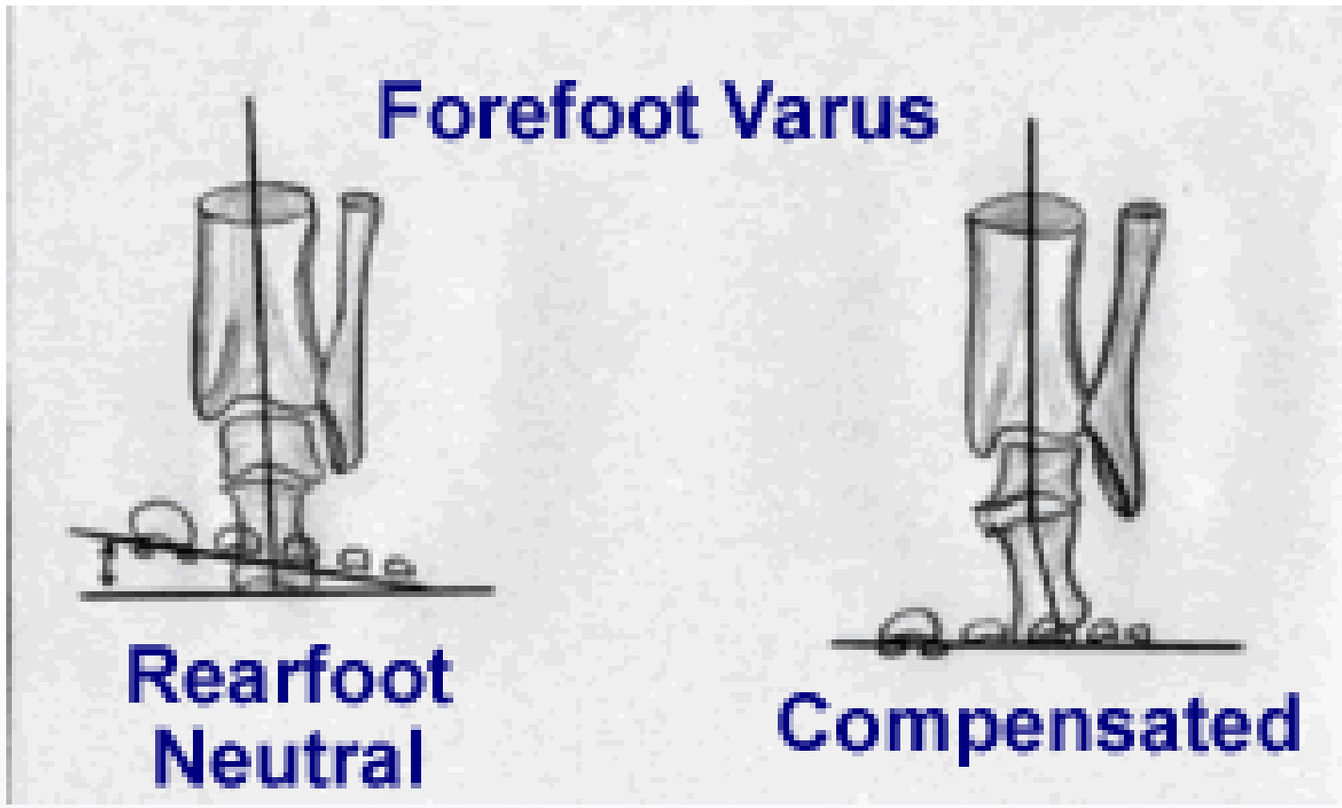
1. Dorsiflexion
2. Plantar flexion

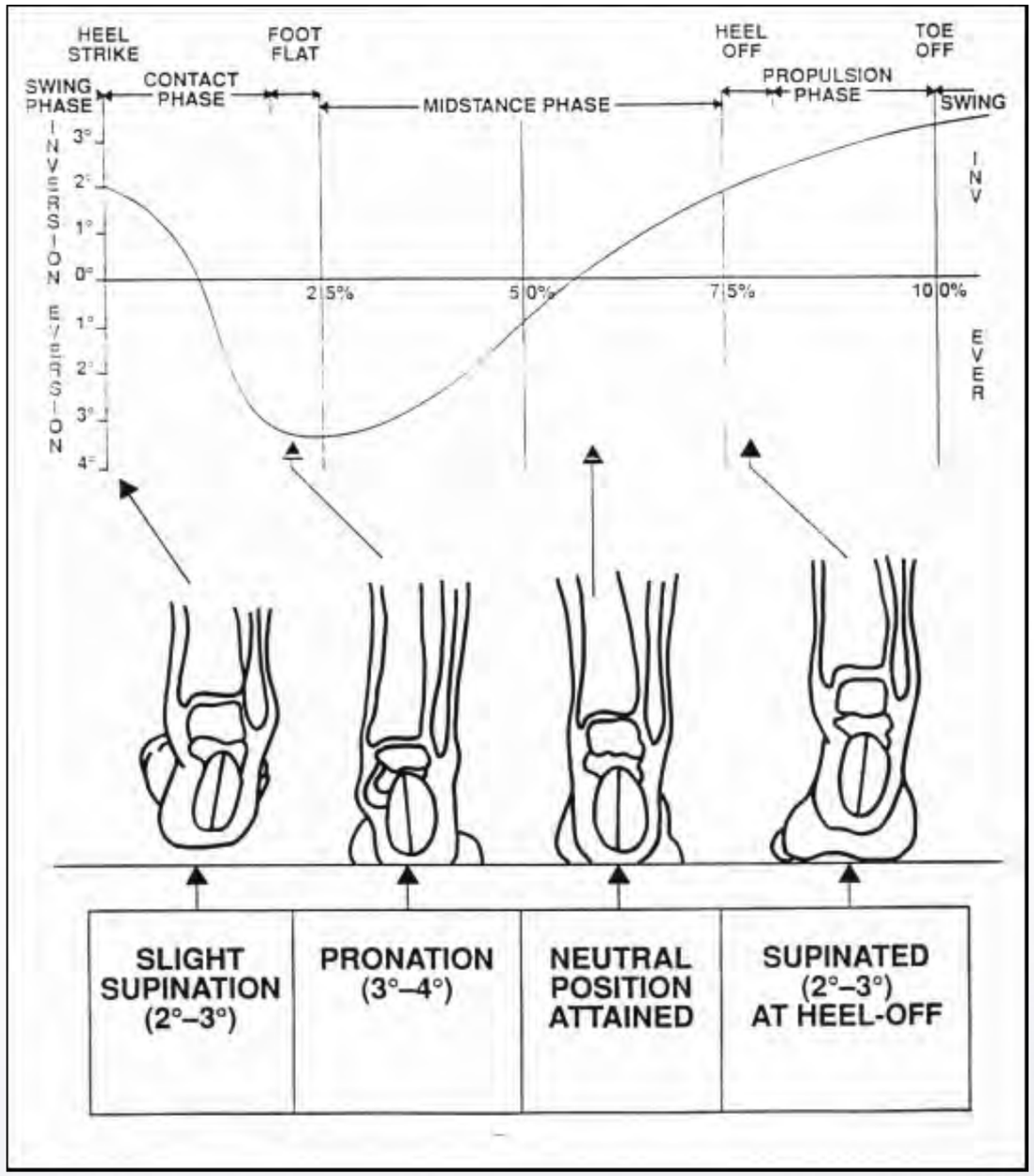
Transverse form deformities

1. Adbucted
2. Adducted

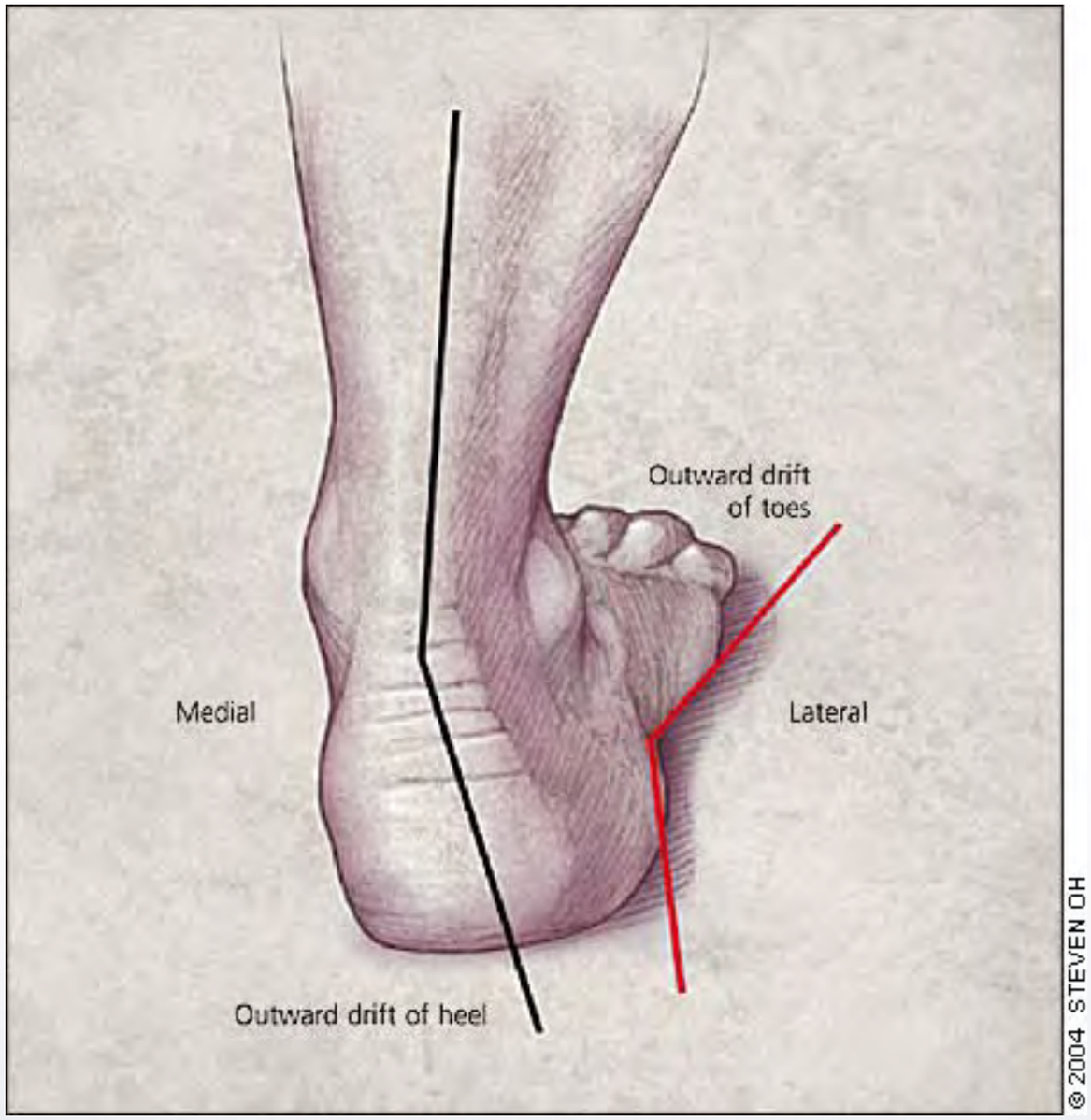
Frontal plane deformities

- Forefoot varus
- Forefoot valgus

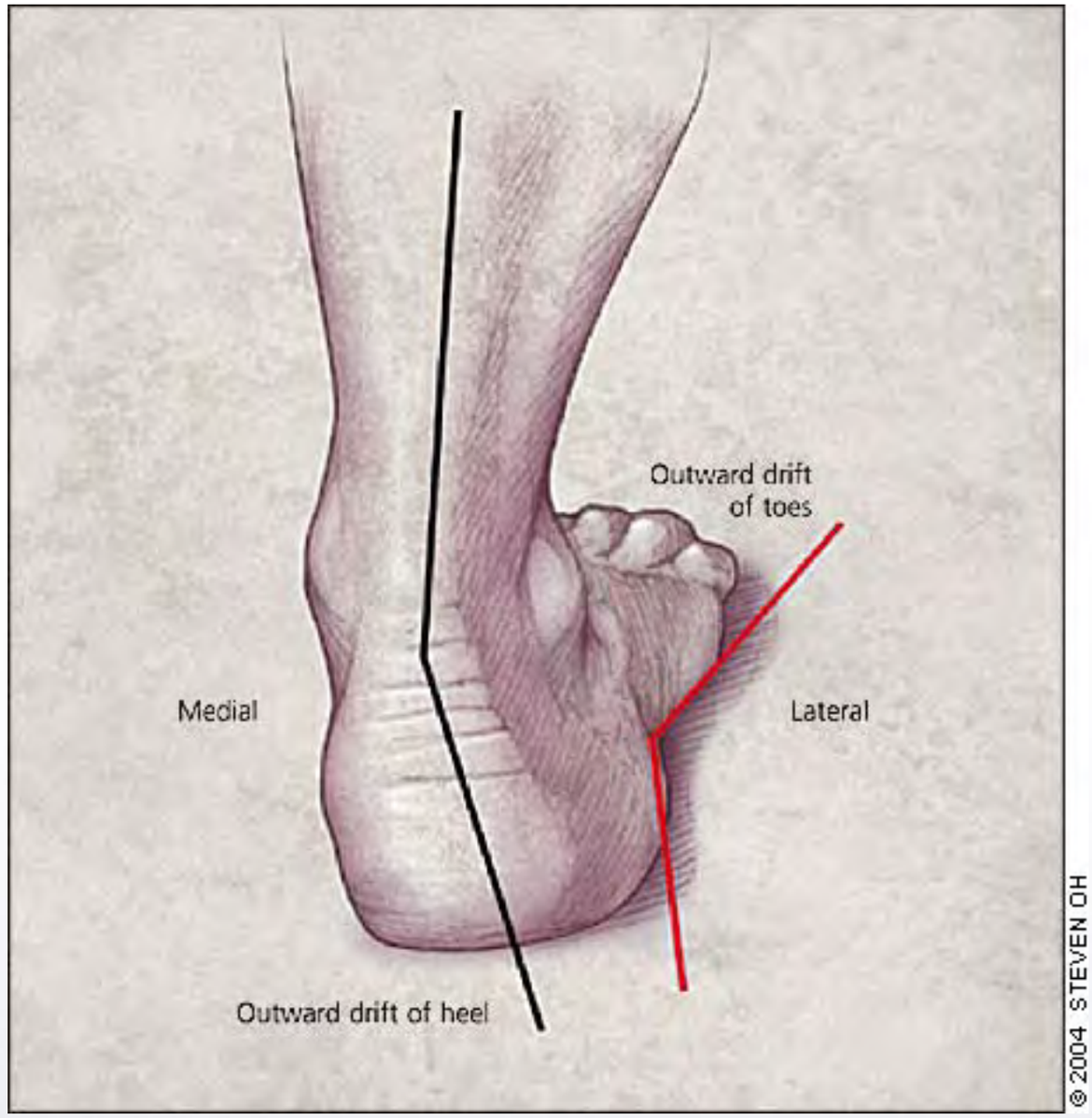

Forefoot Varus
Rearfoot
Neutral
Compensated

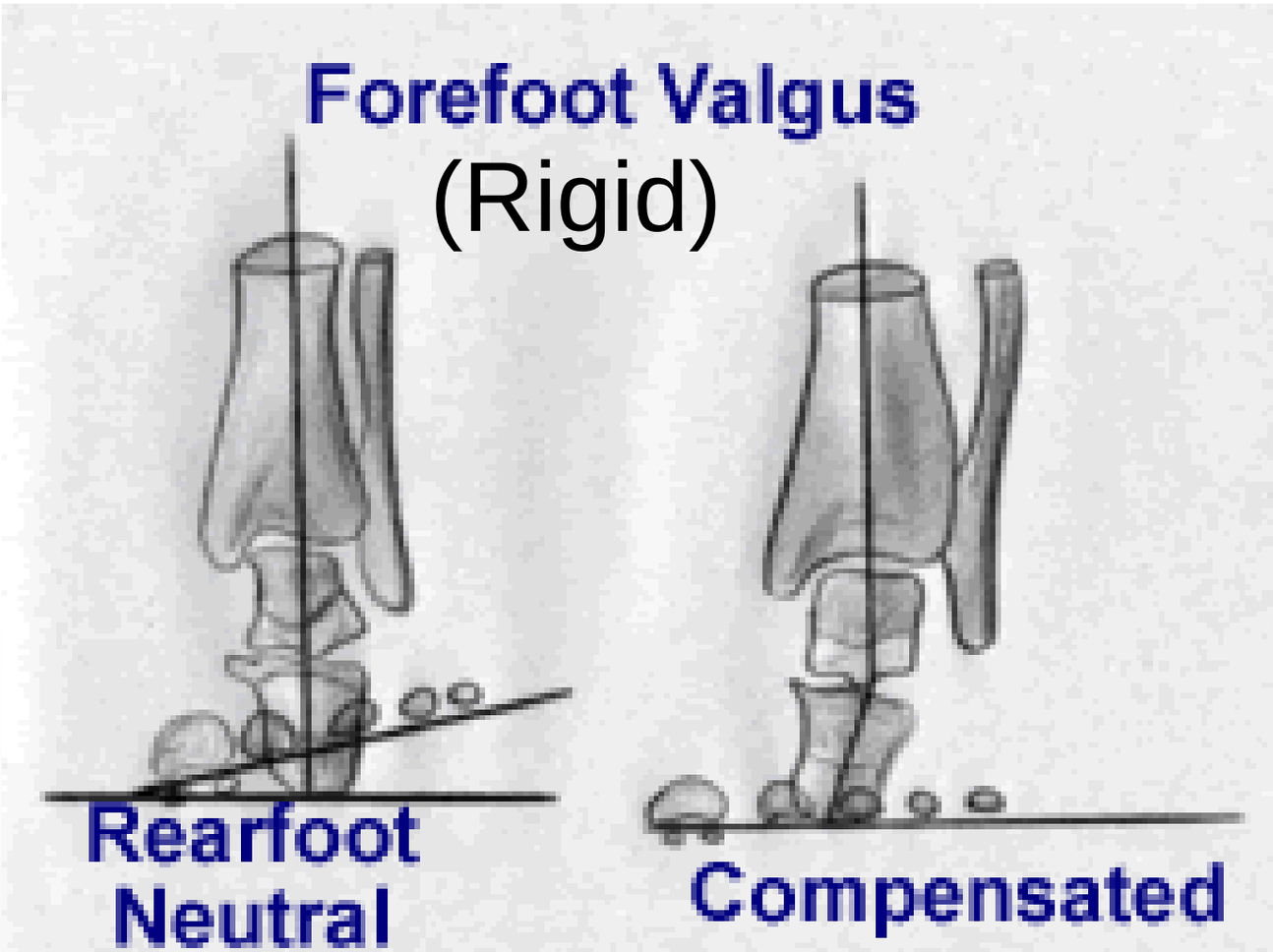

HEEL STRIKE
FOOT FLAT
HEEL OFF
TOE OFF
SWING PHASE
CONTACT PHASE
MIDSTANCE PHASE
PROPULSION PHASE
SWING
INVERSION
EVERSION
INV
EVER
3°
2°
1°
0°
1°
2°
3°
4°
25%
50%
75%
100%
SLIGHT SUPINATION (2°–3°)
PRONATION (3°–4°)
NEUTRAL POSITION ATTAINED
SUPINATED (2°–3°) AT HEEL-OFF

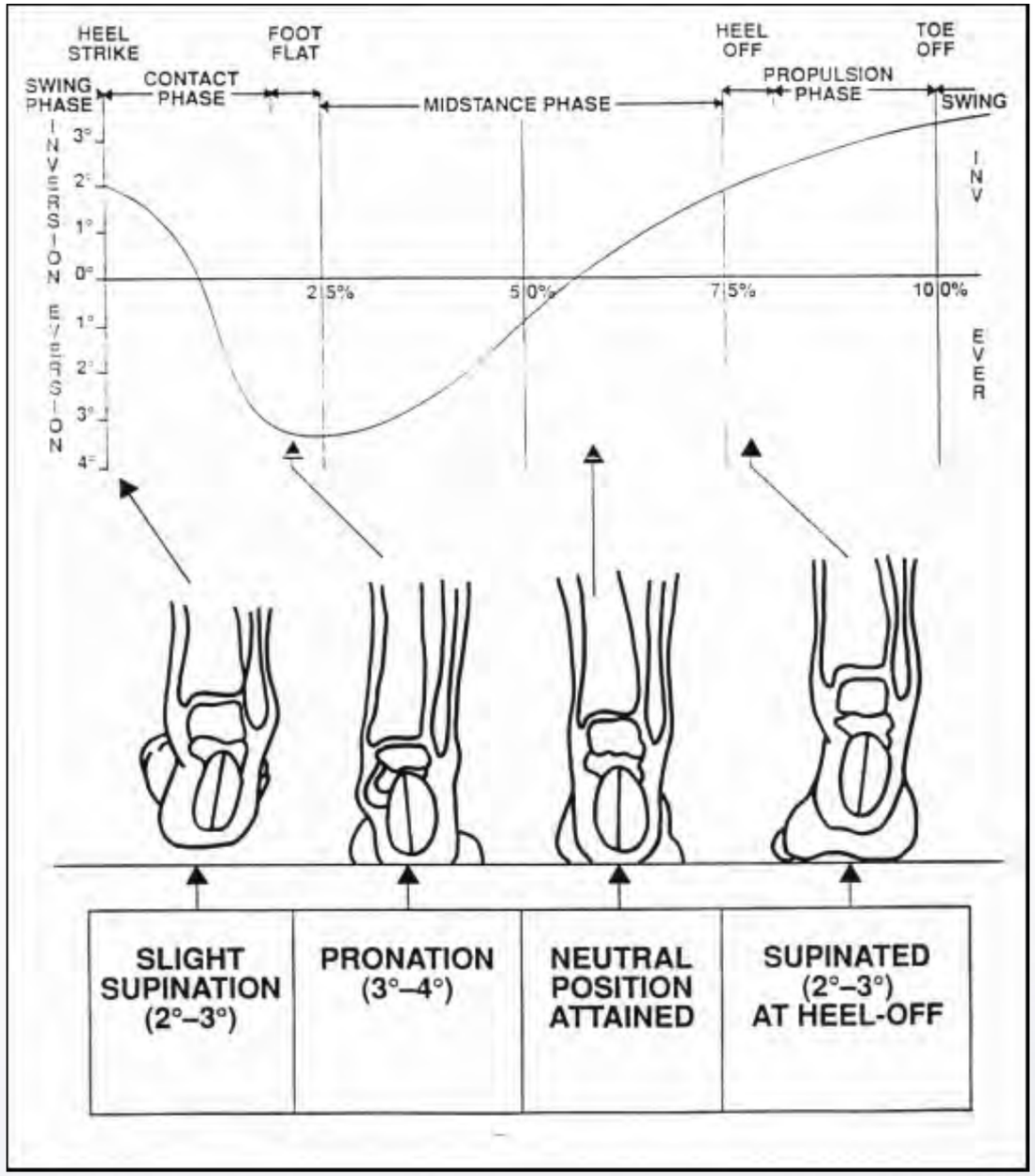
Pronated foot



Frontal view




Forefoot Valgus
(Rigid)
Rearfoot
Neutral
Compensated


HEEL STRIKE
FOOT FLAT
HEEL OFF
TOE OFF
SWING PHASE
CONTACT PHASE
MIDSTANCE PHASE
PROPULSION PHASE
SWING
INVERSION
EVERSION
INV
EVER
3°
2°
1°
0°
1°
2°
3°
4°
25%
50%
75%
100%
SLIGHT SUPINATION (2°–3°)
PRONATION (3°–4°)
NEUTRAL POSITION ATTAINED
SUPINATED (2°–3°) AT HEEL-OFF

Pes Cavus

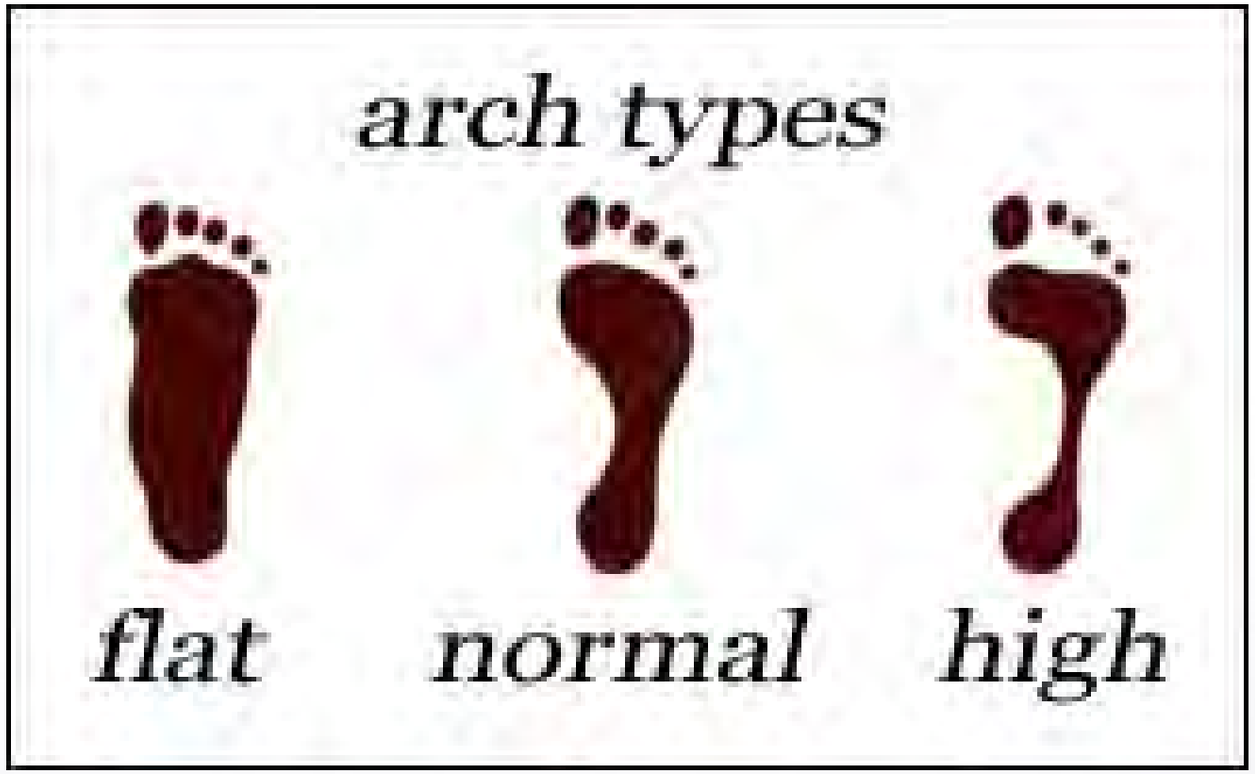
Non weight bearing

Foot print morphology

1. High Arch (Pes cavus)

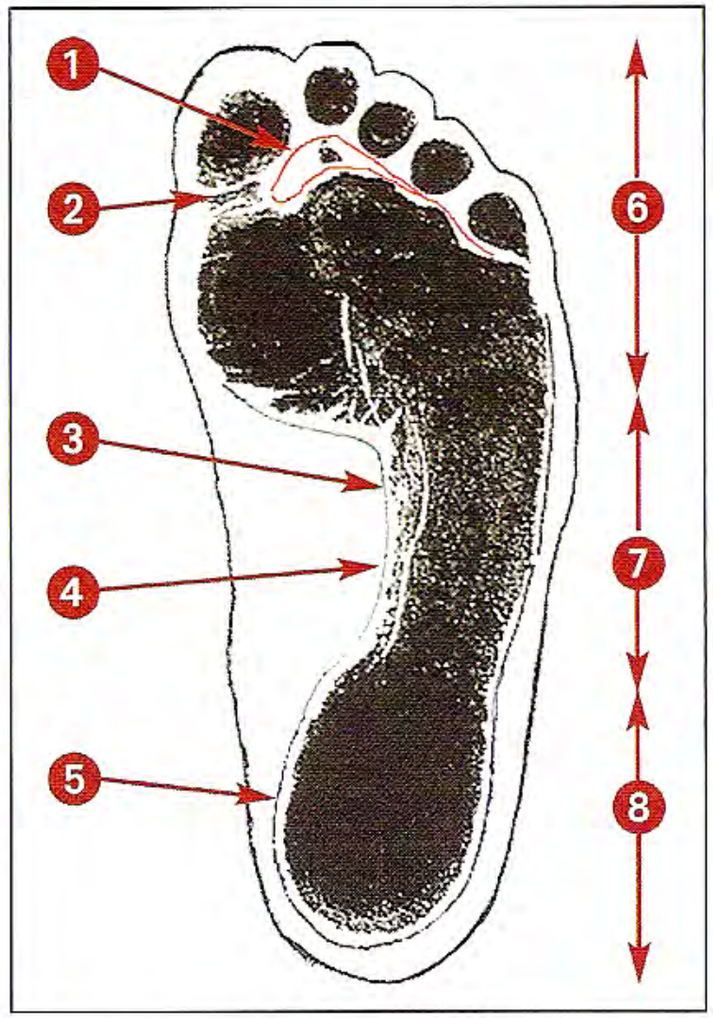
2. Normal arch

3. Flat foot (Pes planus)

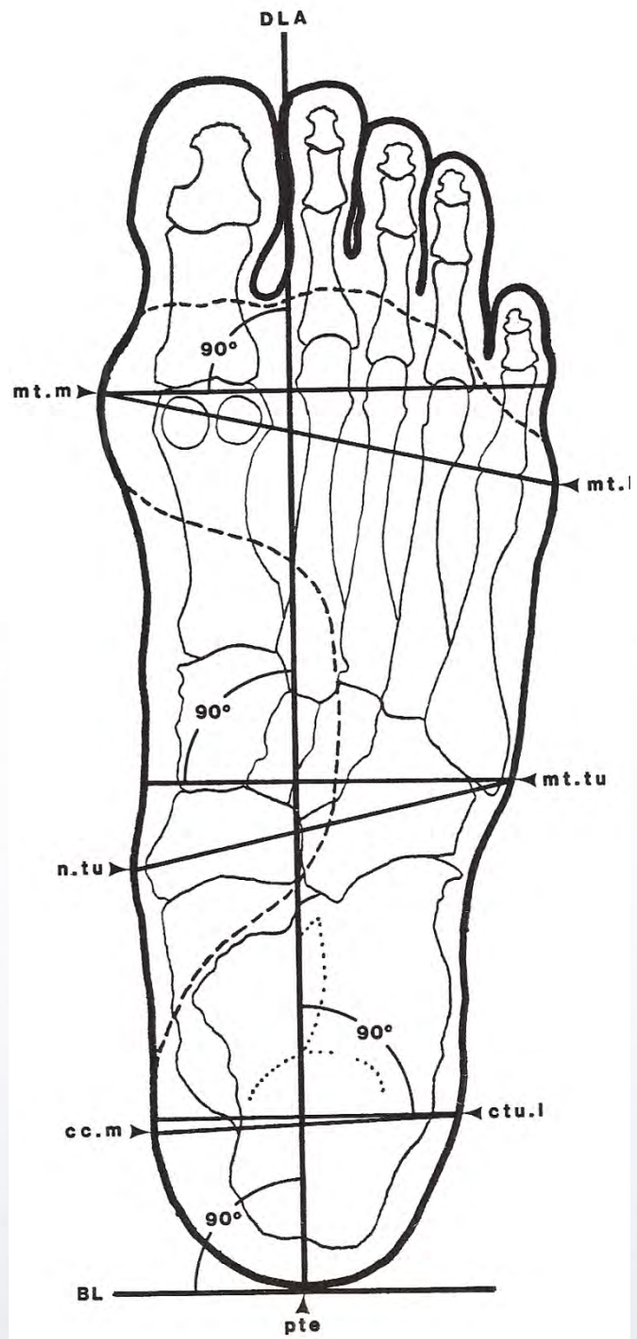


Footprints contain foot impression that give information about:

1. digital length
2. digital position
3. shape of toes
4. Increased areas of pressure (e.g. callus formation)
5. Arch line
6. Heel line
7. web ridge line
8. webspace



This is a diagram of a bare footprint and its outline. On the left are shown identification lines that are used by forensic podiatrists: (1) web space outline; (2) web ridge lines; (3) arch line; (4) lateral foot line; and (5) heel line. On the right are the foot zones and their relative sizes: (6) forefoot—40%; (7) mid-foot—30%; and (8) rearfoot—30%.


DLA
90°
mt.m
mt.l
90°
mt.tu
n.tu
90°
ctu.l
cc.m
90°
BL
pte

Example of footprint techniques

1. Inking the foot (necessary in analyzing gait)

2. Inkless paper

3. Harris and Beath mat

Foot classification may be based on such things as:

1. Relative digit length

2. Arch configuration

3. Biomechanics (the “dynamic foot”)

4. Pathology and pathologic features

- **Common foot deformities** (may be, in part) the result of congenital, biomechanical, traumatic, neurological neuromuscular processes
- (e.g. clubfoot, polio, digital amputations, s/p cva)

- **Deformities proximal to the foot** (e.g. ankle, knee, hip, back, limb length difference) may affect foot function and thus the foot's morphology.

- **Deformities may be unilateral**

Common foot deformities that may distort shoe structure

1. Bunion (Hallux valgus)
2. Hammer toe
3. Bunionette (Tailor’s bunion)
4. Haglund’s deformity
5. Prominent medial navicular
6. Dorsal hypertrophy base of the 1st metatarsal


Bunion


© REX


Hammer toe
Proximal interphalangeal (PIP) joint
Metatarsophalangeal (MTP) joint
© Healthwise, Incorporated

Tailor’s bunion


Saddle Bone Deformity
(met-cuneiform exostosis)


Haglund's
deformity of both
heels

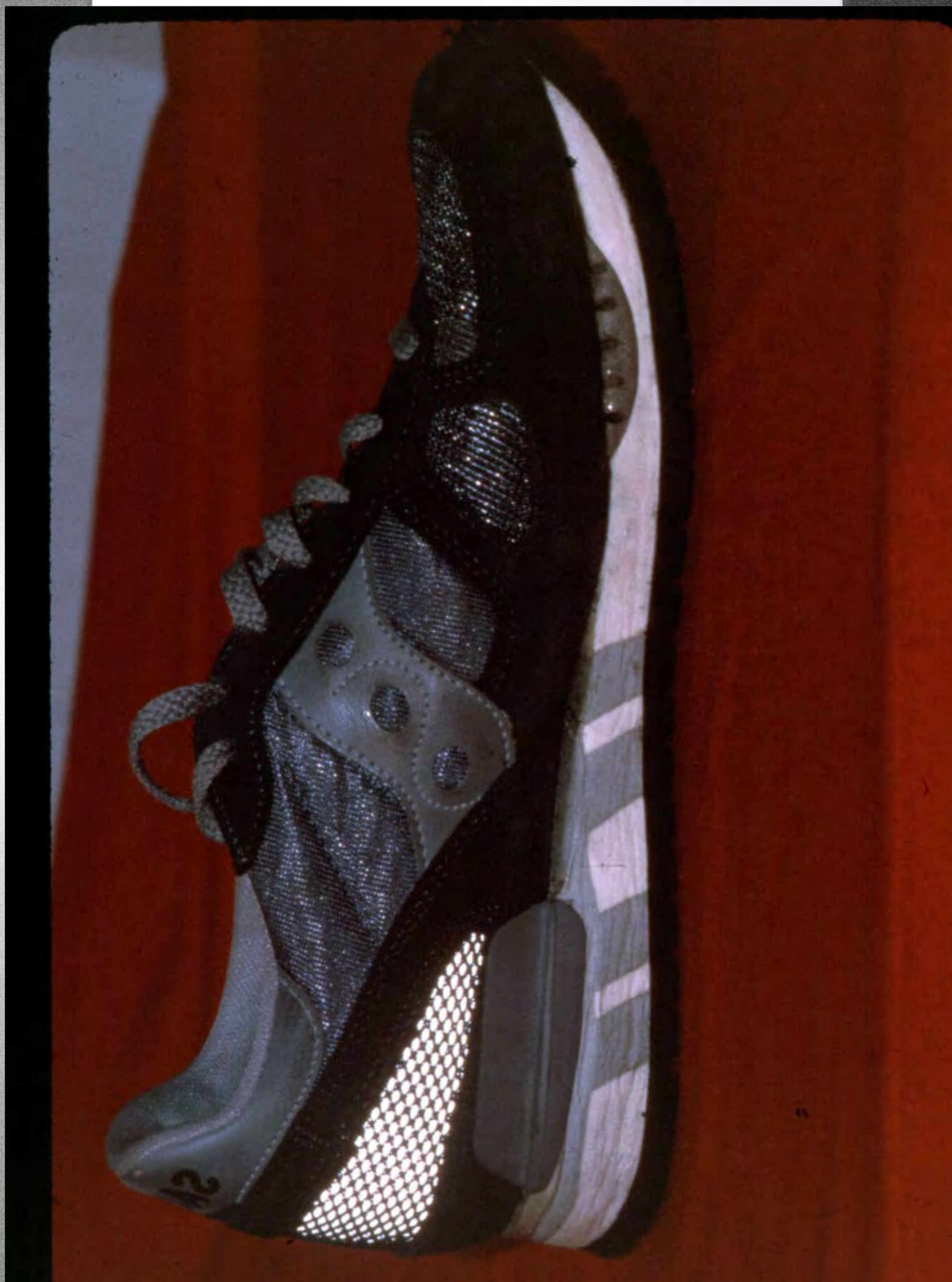
Footwear

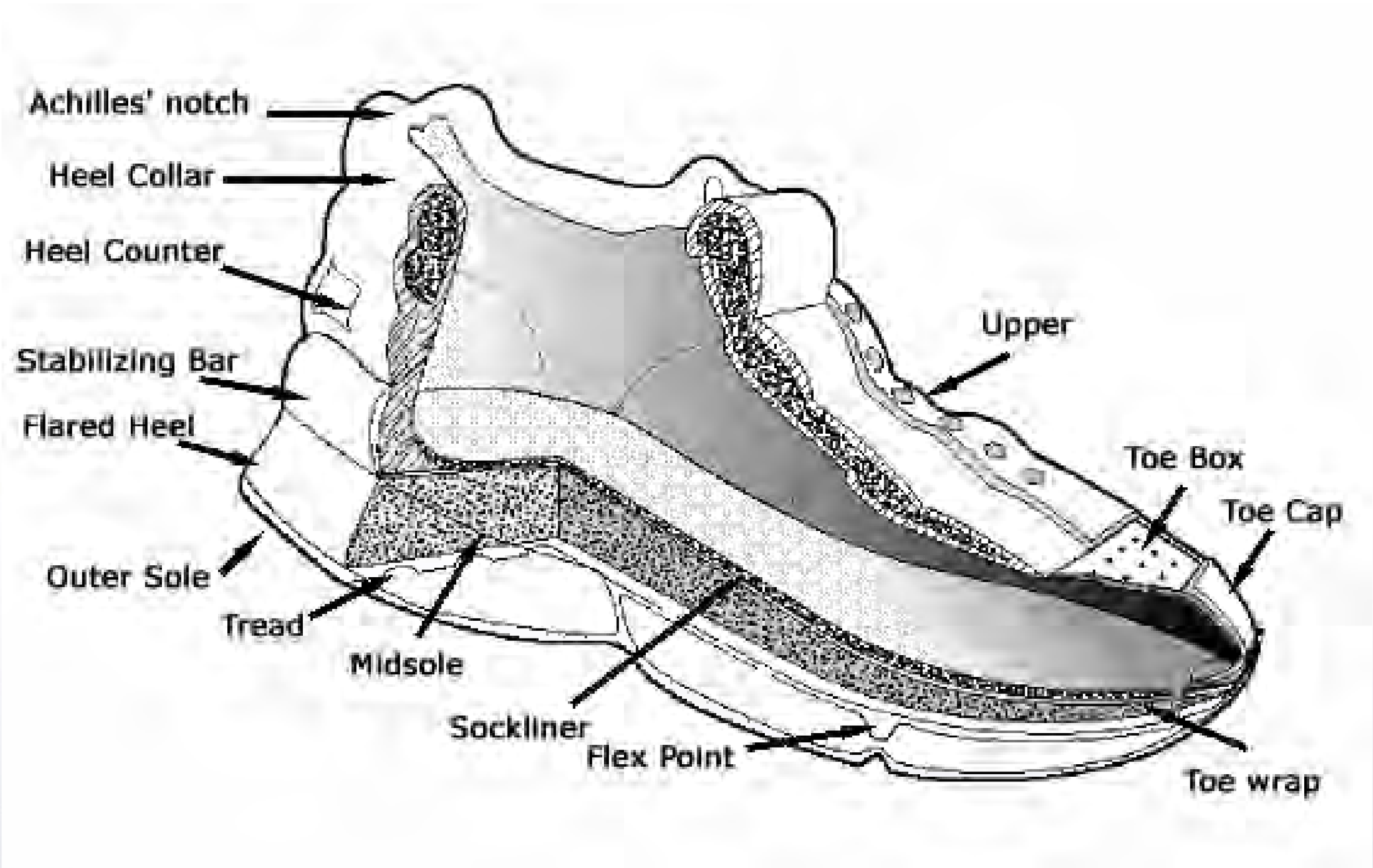
Footwear

A discussion of pedal evidence would not be complete without a discussion of what houses the foot most of the time

The shoe acts as an extension of the foot.

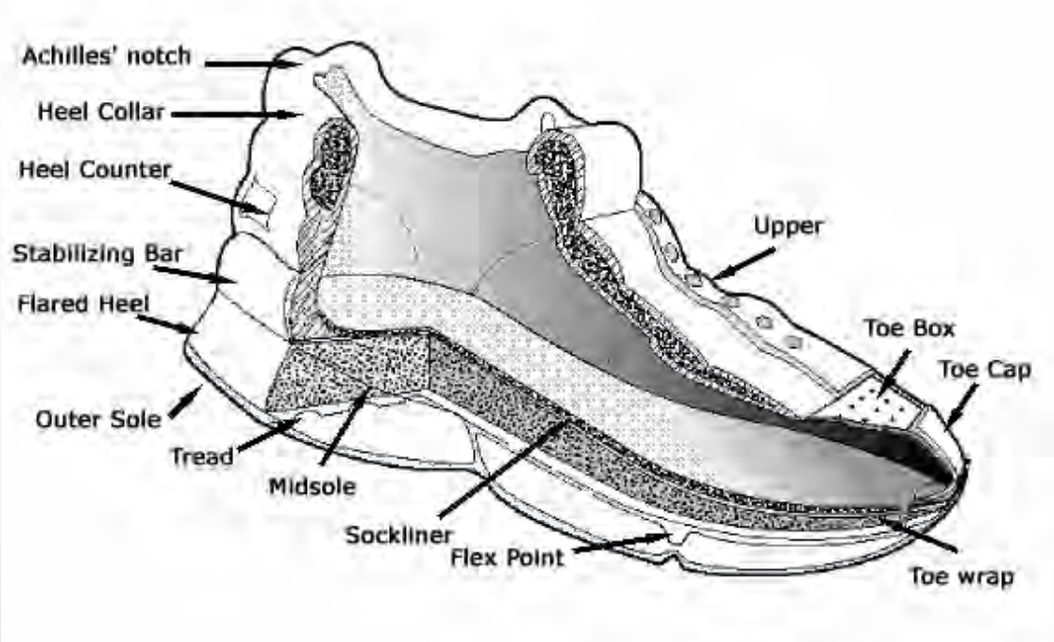
There is a close association between the foot and the shoe; they almost function as a single unit.

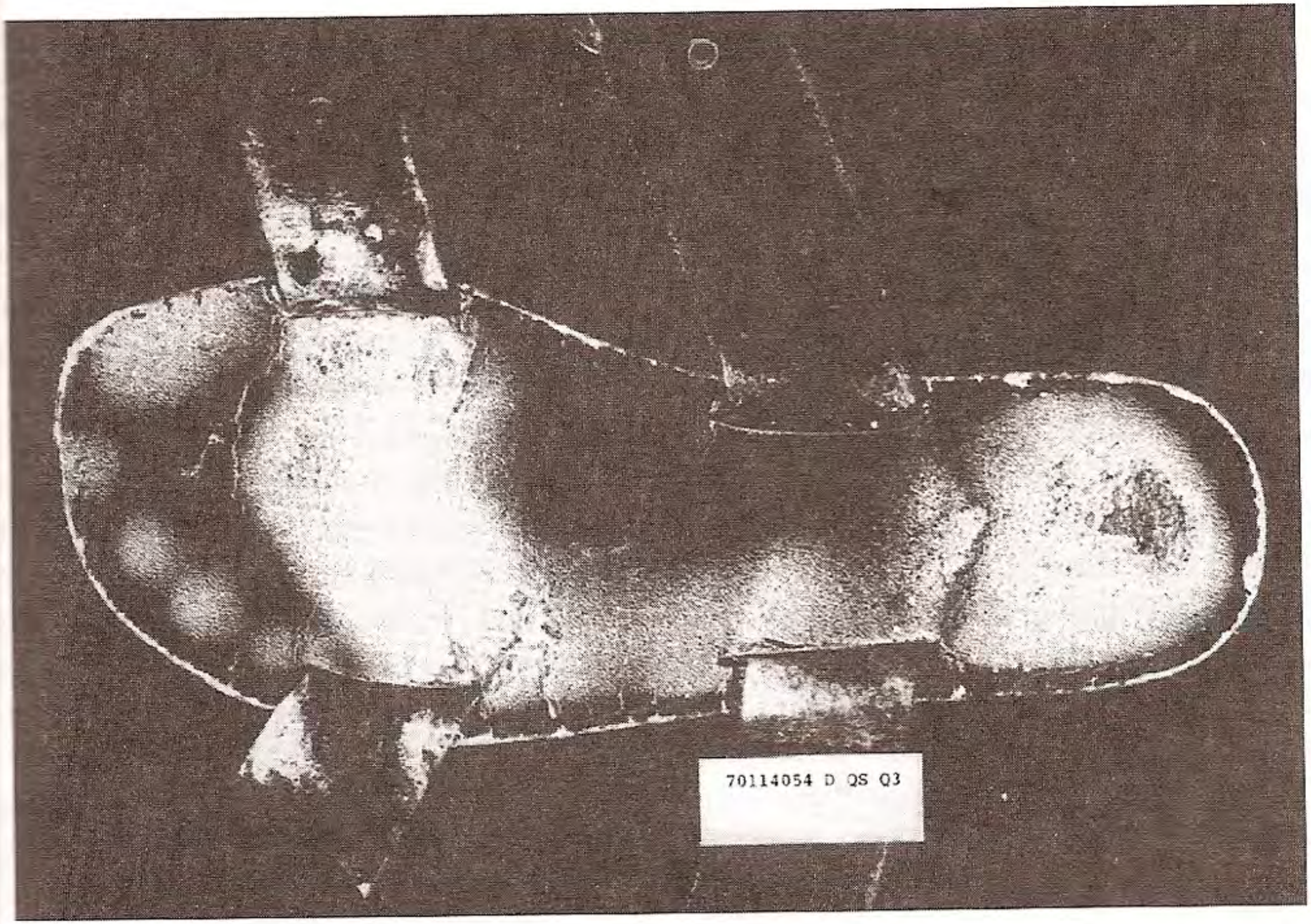



Achilles' notch
Heel Collar
Heel Counter
Stabilizing Bar
Flared Heel
Outer Sole
Tread
Midsole
Sockliner
Flex Point
Upper
Toe Box
Toe Cap
Toe wrap

Sockliner

- Seen in athletic shoes
- Used to absorb perspiration, decrease shock and friction:
- Foot image on the sockliner is formed in the static and dynamic state
- Impression may form within days
- May contain trace evidence: e.g. skin, hair, fibers, fur





12.9 Photograph of insole of sandal, depicted sweat stains, and enhanced with ultraviolet

Arch supports and orthotic devices

1. Used to reduce discomfort and assist with ambulation

2. Arch supports are over the counter; may mold to foot; may indicated underlying foot problems; may be tracible

3. Orthotic devices are custom made. May have individual's, prescribing physician, and/or laboratory name and serial number on it.

Orthotic device

Shoe modifications and custom made shoes

Footwear evidence

1. Remove suspect's shoes as soon as possible after he/she is apprehended

2. Obtain representative sample of suspect's shoes

3. Do not have suspect try on unknown shoes

4. Photograph and cast sockliner

5. Photographs, prints, casts of outersoles


asics
asics

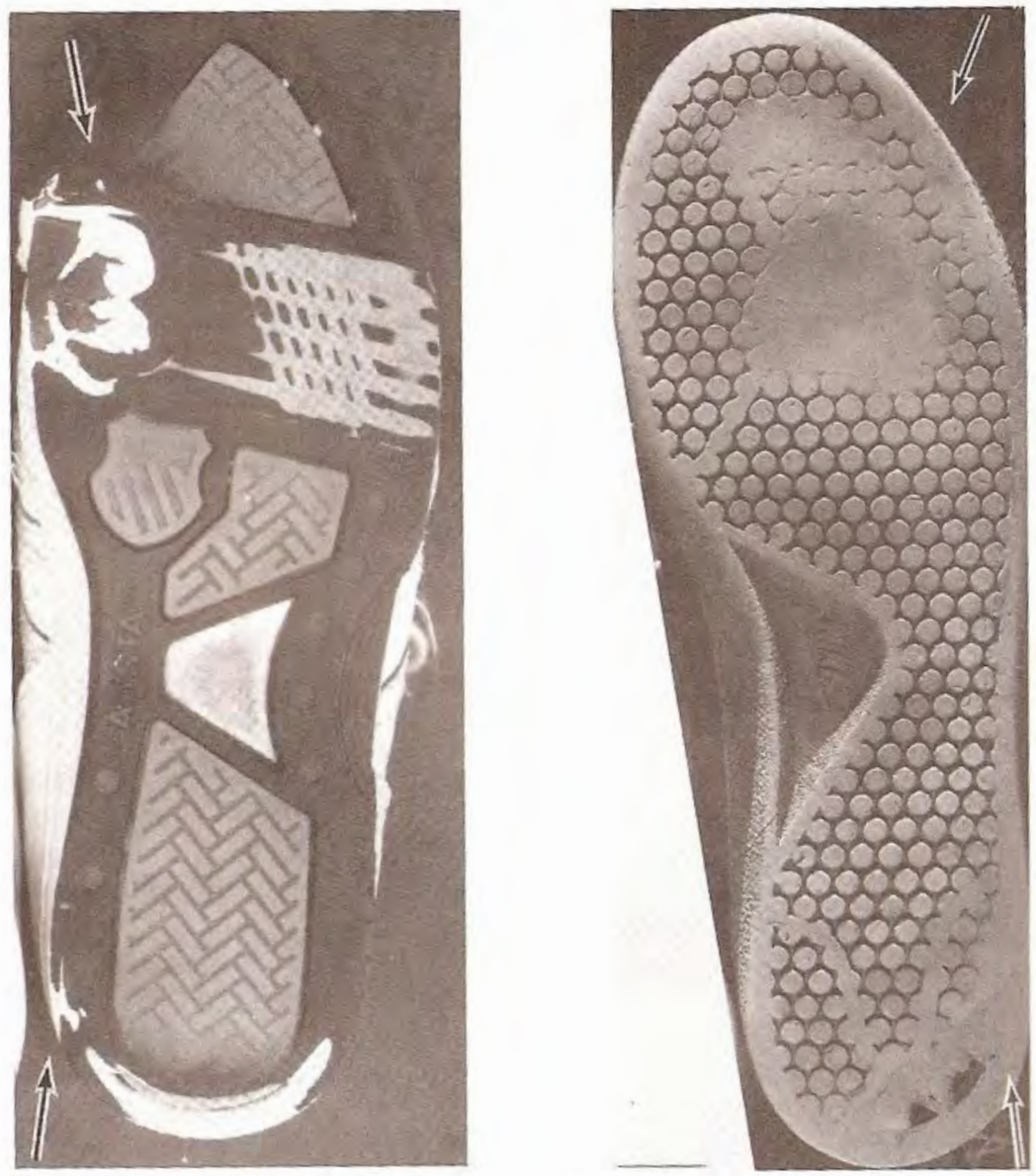
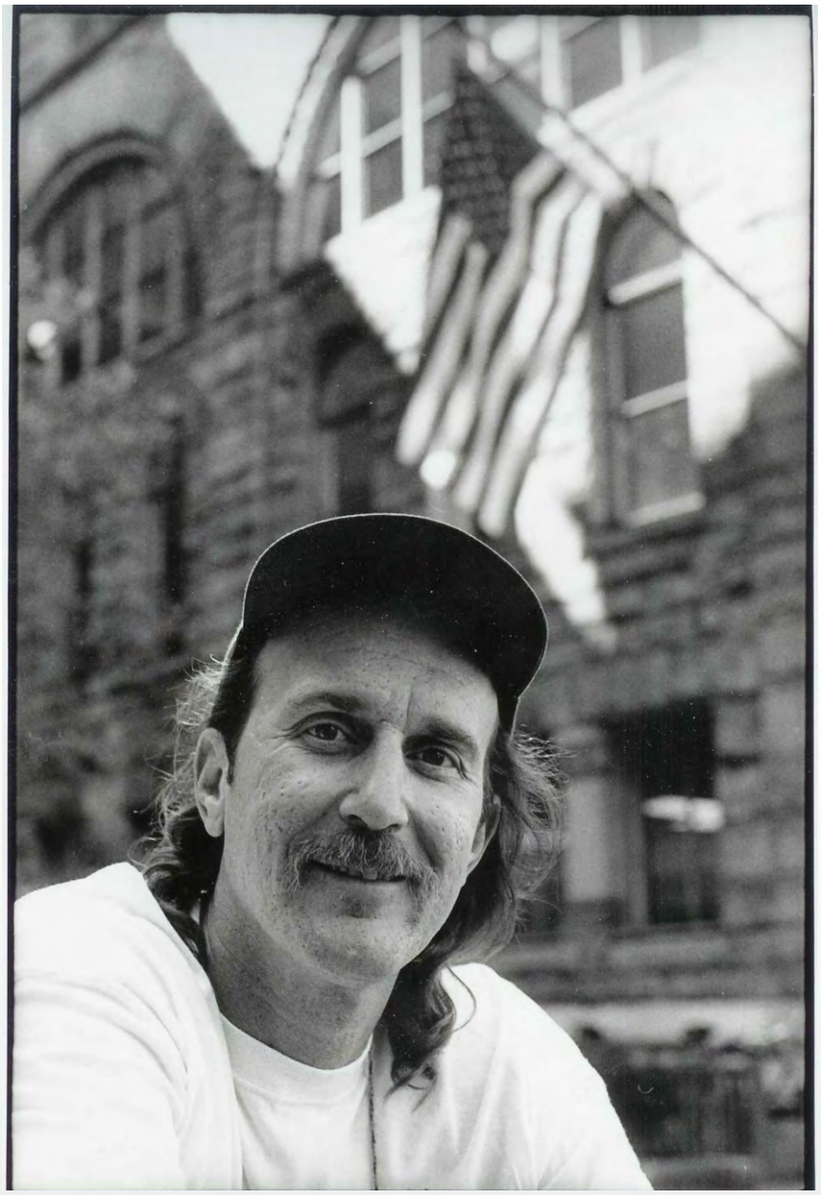


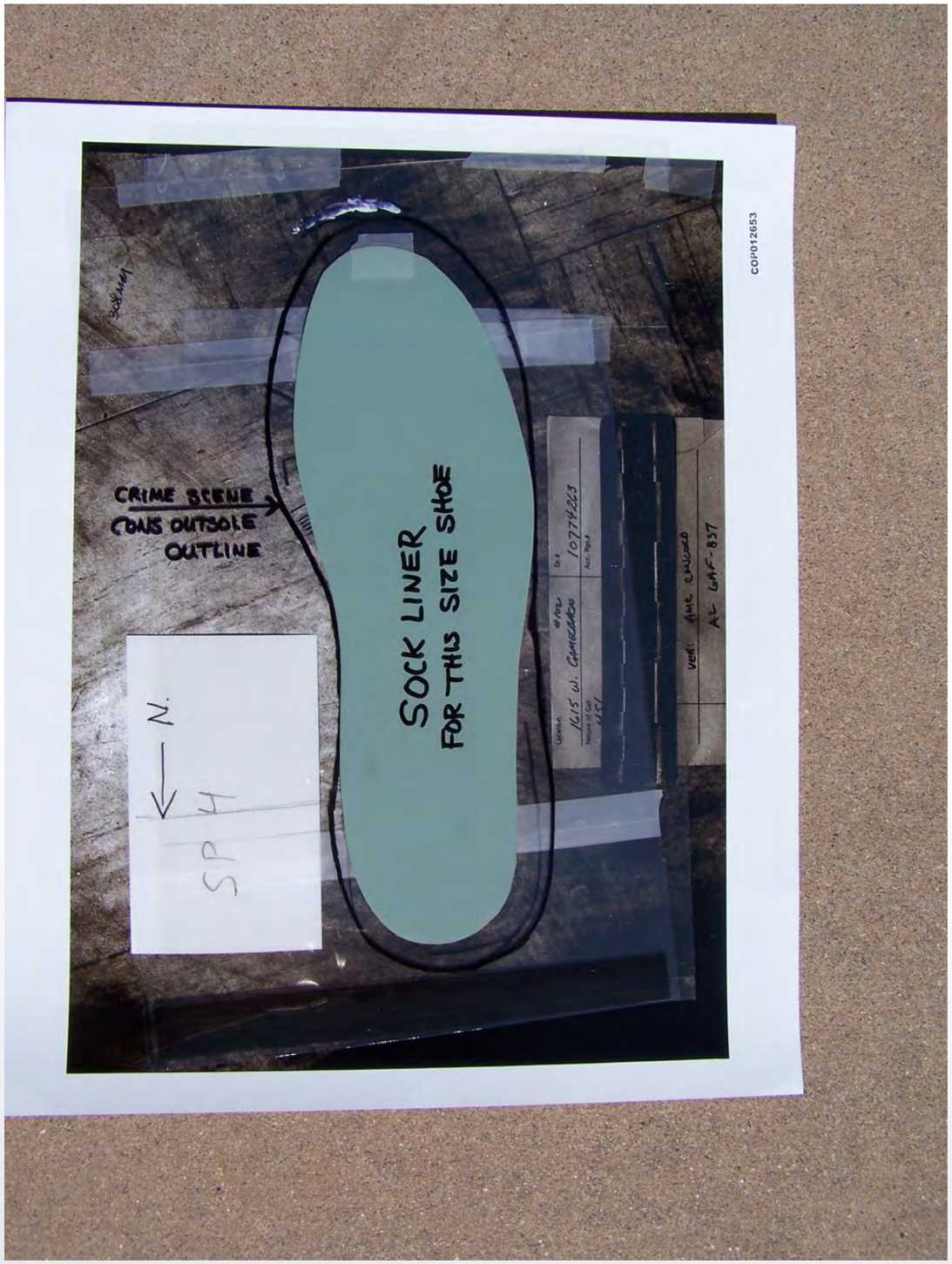
Figure 9.5 A typical wear pattern on a s

Ray Krone

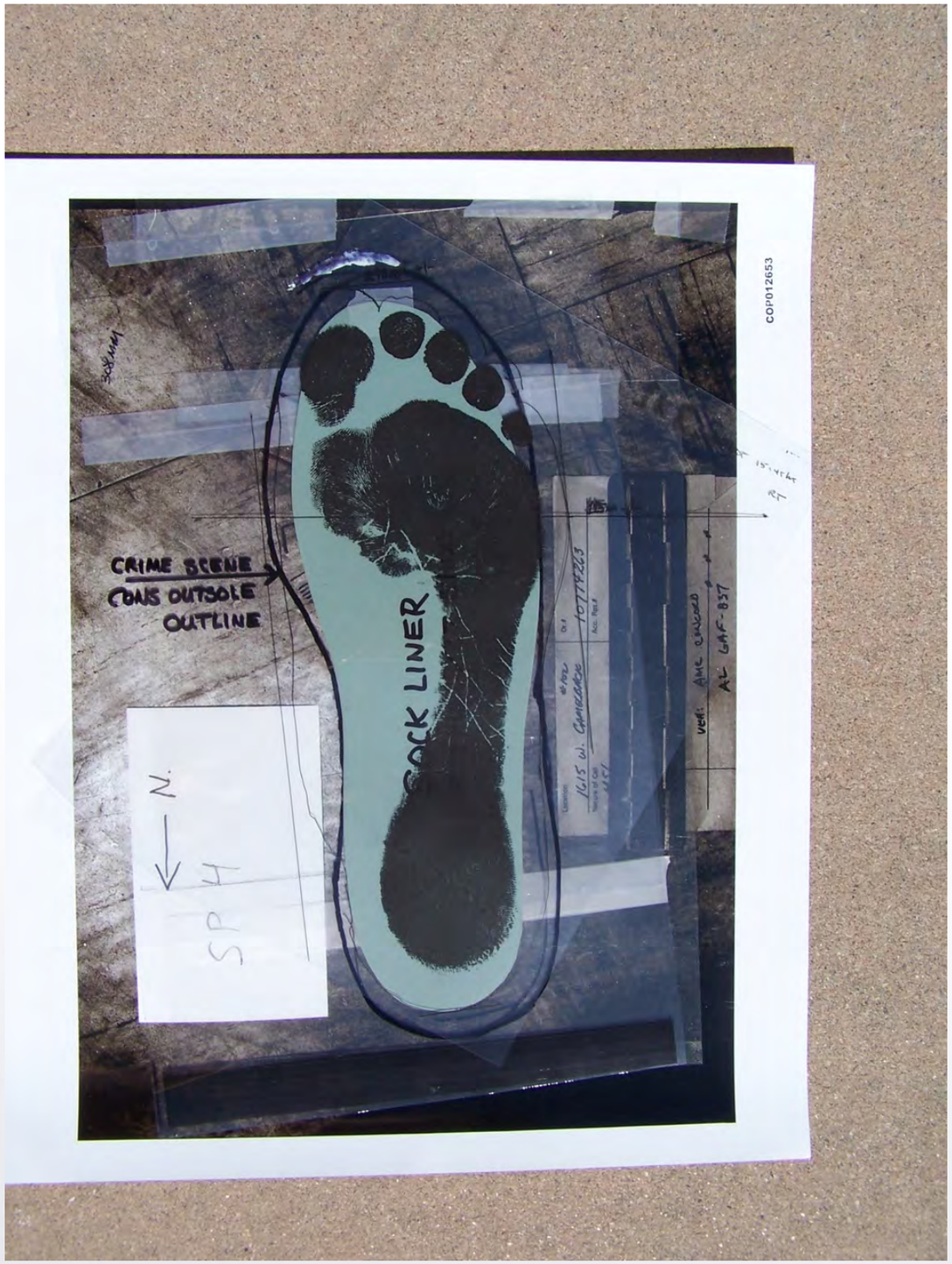


Crime scene photo with shoe outline.

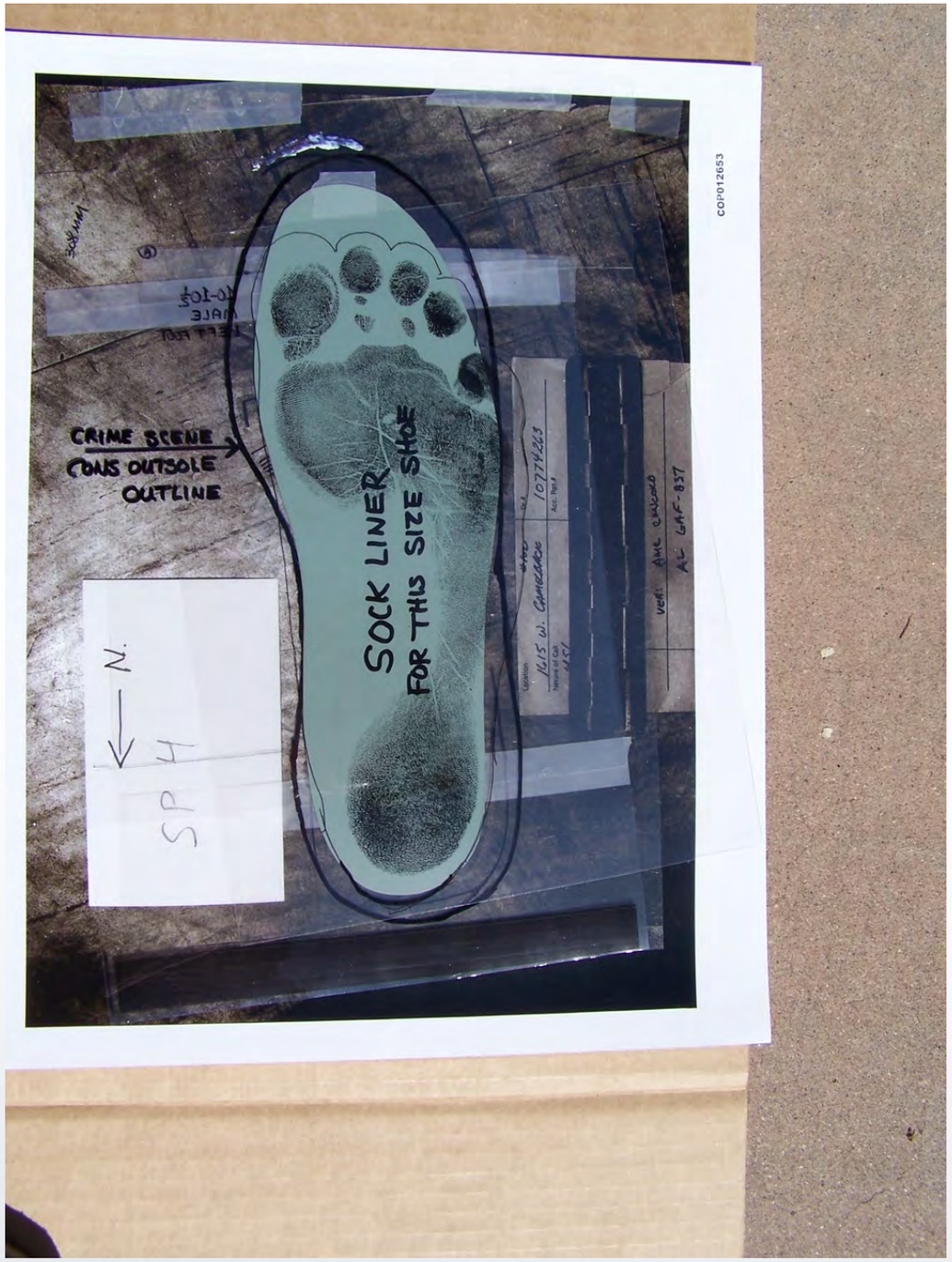
Estimated size 10



Sockliner fit for shoe



Suspects foot fit; too big.
Overlaps sockliner



Shows proper foot sizing

Dirkmaat et. al. (2008)

Two key factors that that have significantly affected the discipline of forensic anthropology

1. Development of DNA analysis technique undermine role of forensic anthropology as a field almost exclusively focused on victim identification

2. Introduction of the Daubert criteria in the courtroom presentation of scientific testimony

“Despite the long history of the foot’s being considered an identification factor, there has been little research development in this field until recent times. The research undertaken to date has indicated that there is much potential for the use of the human foot in identification.”

- Wesley Vernon P.318

Questions? dagoada@bu.edu