The Human Foot

(YI only - not examinable material unless discussed elsewhere in the course material)

You’ve heard the phrase “I have one foot bigger than the other”. A closer truth would be “no two feet are alike”, and yes in many cases one foot is larger than the other. Handling the challenge of properly fitting and advising customers on their shoe choice starts with the basics; the human foot.

The foot is like the foundation of a building. It is small relative to what it supports, yet requires strength to maintain stability. But the foot is more versatile than a foundation. It propels the body upwards and outwards, changes direction, and absorbs shock on landing.

Anatomy of the Foot

**Bones** — there are 26 bones in each foot stretching from heel to toe. Bones provide the base strength to the foot. To sustain mobility, the bones flex at the joints which are held together by connective tissues called ligaments. The toes are made up of small bones called phalanges; these are connected to the foot by a longer bone group called metatarsals. The arch is comprised of a group of bones, the cuneiforms, cuboid and navicular bones, while the heel is called the calcaneus.

**The Three Major Sections of the Foot**

Muscles — muscles in the foot are intricately connected to the bones by tendons. The foot can perform various motions through contractions of the muscles. Muscles help hold the bones in place while supplying the foot with its multi-motion capabilities.
Toes (forefoot) — the toes are the “balance team” of the foot. They add support and stability to all the range of foot movements. Toes are the spring or “toe off” in walking, running and jumping motions.

Arch (midfoot) — the arch is made up of the cluster of bones at the midpoint of the foot. The small muscles of the arch are connected to the heel and ball of the foot by the plantar fascia. This tendon stretches longitudinally across the arch aiding the bones in supporting the foot’s framework. The arch gives the foot stability and shock absorption by spreading out the shock on contact and springing back on propulsion, i.e. a trampoline effect.

Heel (rearfoot) — the heel absorbs the initial impact and stresses the body puts on the foot when engaging in various motions and activities. The thickest fatty tissue in the body lies underneath the heel bone. This tissue provides the natural cushioning necessary to protect the feet from the impact and weight stresses the body puts on them.

The gait cycle

When we speak of the gait cycle we are referring to a person’s range of motions when moving forward. A normal complete cycle is divided into two phases, stance and swing. The swing phase occurs when the foot is totally off the ground and not bearing any weight. The biomechanics of the weight bearing foot during these phases determine whether or not a person is walking or running normally. The stance phase is divided into 3 separate parts. The first stage is contact which begins at heel-strike. Note that some runners land more on their mid-foot, some even on the forefoot. Some coaches try to reduce the heel-strike arguing it break the runner and is therefore not required. Others argue it does help with the shock absorption needed. The second stage is mid-stance which begins with forefoot loading (the front part of the foot contacting the ground) and ends with heel lift. The final stage is called propulsive, beginning at heel lift and ending at toe-off. When jogging at moderate speeds the three parts of the stance phase account for approximately two-thirds of the total gait cycle. The other third is the swing phase. The relative time spent in the support phase decrease with increasing speed so that the support phase is about 54% of the gait cycle in a moderate sprint and only 47% during full-sprint.

The Gait Cycle
Most foot problems develop when something goes wrong during the stance phase, the basic fault occurs when an abnormal amount of weight is brought to bear on a specific part of the foot. These abnormal weight-bearing processes result in **over pronation** and **supination**. Pronation occurs when the foot strikes the outside edge of the heel and rolls inward to toe off. Over pronation occurs when the foot exceeds its natural motion and rolls too far inward. Supination occurs when the foot stays to the outside edge rolling outward.

**PowerPoint Slides from Introductory Lectures**

**Rearfoot Angle**

\[ \text{Rearfoot angle} = \theta_{RF} \]

\[ \theta_{RF} = \theta_{\text{leg}} - \theta_{\text{calcaneus}} \]

Positive angle for supination

Negative angle for pronation
Foot Types

The normal foot functions as a pivot, a lever and a shock absorber. Variations of these functions result in the common abnormal foot types, **pes cavus** and **pes planus**. The pes cavus or rigid foot is characterized by a high arch and instep. This rigid foot type lacks flexibility and cushioning. Pes planus or flat foot is characterized by a low flattened arch. Though having natural cushioning properties a flat foot lacks stability and tends to over pronate.

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**Valgus** Shoe Wedge (outside) forces foot into pronation  
**Varus** shoe wedge (inside and shown above) forces foot into supination
Injuries and Ailments

There numerous foot-related injuries that can result from athletic activities. While many injuries are caused by overuse, poor technique and genetic make-up, some can occur from improper shoe choice and fit.

Common Foot Ailments

**Blisters** — caused by friction, commonly seen above the heel, on the ball of the foot and the bottom of the foot. New shoes, poor fit and stitching at the pressure points are some of the more common causes.

**Corns** — also caused by friction or pressure. These small thickening of the skin are usually found all around the toes. An overly tight fit in the toe box is a common cause for: corns.

**Bunions** — this protruding inflammation of the large ball of the foot joint is a chronic ailment. It can be aggravated by seams and tight fits in the forefoot area.

**Black Toe** -- a bruising of the toes underneath the nails caused by the continuous pressure and sliding of the toes against the end of the shoe (usually too small a fit).

**Metatarsal and Heel Bruising** — resulting in poor cushioning in the shoe midsole and overuse on hard surfaces.

**Heel Spurs** — calcium deposits formed at the heel, can be the result of poor cushioning and improper fit.

**Callous** — thickening or hardening of the skin caused by friction or pressure. This is the body's natural healing process following blistering.

**Plantar Fasciitis** — inflammation of the plantar fascia tendon. There are numerous reasons for this ailment including poor shoe choice, stiff hard midsoles, poor arch support and using a court shoe for jogging.

Other Foot Related Ailments

**Shin splints** — lower calf pain caused by poor cushioning, over-pronation, excessive road running etc.

**Runner's Knee** — swelling and pain in the knee cap area. Most commonly found as a result of overuse and over pronation.

**Chondromalacia** — a progression of runner's knee where the cartilage of the knee cap area (on femur and patella) start to degenerate (cell death).

**Achilles Tendonitis** — pain caused by excessive stretching and/or pressure on the tendon attached to the heel. Commonly due to poor stretching practices, but can also be caused by shoe fit aggravations of the heel tab.
Glossary of Terms
(FYI only - not examinable material)

Arches
The bottom portion of the foot that usually absorbs shock when the foot proceeds through the stance phase of the gait. Longitudinal, transverse and metatarsal

Ankle Collar
Interior shoe lining which extends from the top of the eyestay to the interior of the heel counter. It provides protection to the achilles area and is a part of the shoe that plays a significant role in controlling heel slippage.

Arch Cookies
A foam insert that is usually bonded to the sockliner of the shoe on the medial side of the arch saddle to give extra arch support.

Arch Saddle
The structural support system of a shoe that is sewn onto the upper over the instep area of the shoe. This adds extra medial / lateral support to the shoe and usually is integrated into the lacing system.

Board Lasting
A method of shoe construction which is used to increase the stability of the shoe. The board is usually made of a cardboard material and is attached to the inside of the shoe between the sockliner and the insole.

Bumper
An extra a strip of rubber or leather that is attached to the toe of the shoe to protect the toe from extra wear. The bumper is very important in tennis shoes as this is the part that wears out when you drag your toe during a serve or a backhand. If your customer tends to shuffle when they walk make sure that the shoes you sell them do not have toe bumpers on them as they will tend to stub their toe and trip on the bumpers.

Combination Last
The method of construction used inside the shoe that combines a broad last in the heel of the shoe and a slip or sock last in the forefoot portion of the shoe.

Eyestay
The reinforcing material for the shoes lacing system that contains the eyelets. This is the area of the shoe that, when properly used, secures the loot inside the heel counter of the Shoe.

Eyelets
The small holes located in the eyestays through which the laces fit.

Heel Counter
The rigid portion of the shoe which surround the heel and contributes to the support and stability of the shoe.

Heel Collar
The external support system that stabilizes the heel counter on the midsole of the shoe. If a shoe is cupsoled then the material is an integral part of the midsole. If the shoe is not cupsoled then it is usually has a high density insert which is attached to both the midsole and the heel counter.
Insole: A cushioning device that is inserted into the shoe on the top of the sockliner underneath the foot. Arch support technology can be an integral part of the insole. In most running shoes the insole is removable and can be adjusted to accommodate orthotics.

Instep: The upper portion of the foot that is located over the longitudinal / transverse arch area of the foot. Individuals with low insteps can still have high arches and people with flat feet can still have high insteps.

Midsole: The portion of the shoe between the upper and the outsole. This is the area of the shoe that most manufactures spend the majority of their research dollars on. Nike Air, Asics Gel, Reebok Hexelite, etc.

Outsole: The part of the shoe that is the first to come into contact with the ground. This part of the shoe is usually made of durable polymer compounds and depending on the use is reinforced with carbon rubber.

Shank: No this is not my golf shot (well OK sometimes it is) it is the strengthening system in the mid-portion of the midsole of the shoe that is used to increase the stability in the shoe when you are in midstance. A shoe or boot with a strong shank, i.e. a hiking boot or cowboy boots, tend to be less flexible than those with no auxiliary shank.

Slip Last: This is the sock like form that forms the inner liner of the shoe. It is light and flexible and allows the foot to move in its most natural motion. Usually used in very light running shoes or racing flats.

Sock Liner: The cushioned material that is sewn to the inside of the shoe to assist in the fitting if the shoe and to add protection from blisters.

Toe Box: The front portion of the shoe that encases the toes. This is the most important fitting area of the shoe because if the shoe is to short, shallow, or narrow in this area the probability of increased foot discomfort increases.

Toe Box Height: The distance measured between the sockliner and the upper of the shoe. This is usually the depth of the shoe measured one inch from the toe.

Tongue: A padded flap used to protect the foot from lace pressure.

Upper: The portion of the shoe that surrounds the foot and keeps it aligned with the midsole / outsole portion of the shoe. The portion of the shoe where all of the fitting technology is located.

Vamp: The forepart of the shoe that includes the toe box and portions of the arch saddle.

Wedge: An additional portion of the midsole unit, extending from the heel to the arch area of the shoe, which provides additional cushioning and increased heel lift. This part of the shoe can sometimes be customized to help counteract leg length discrepancies, achilles problems and to make varus or valgus adjustments to the shoes.