

Footwear Fundamentals

IT ALL STARTS WITH THE FEET

Most of us take our bodies for granted until the day when something goes wrong. We tend to be more concerned with our minds and so forget what a wonderfully efficient mechanism the body is. It is one which can absorb fuel in the form of food and water and translate it into energy to power the muscles and levers that allows us to perform a myriad of complex functions far beyond the range of even the most advanced robotic systems. Walking and running are but two of these. They are also of supreme importance.

The leg and the foot are the levers that enable us to get around. The foot in particular, while not a particularly attractive part of the body, is nevertheless a highly complex one. It contains no fewer than 26 bones joined by 107 ligaments and linked to 19 muscles by a series of tendons in order to create movement. In addition, there are nerves that link it to the brain, which tells it what to do, and blood vessels that carry the minerals and proteins that maintain the tissues protecting the central bone structure. Understanding how this complex structure operates is essential when producing the lasts on which our shoes are made.

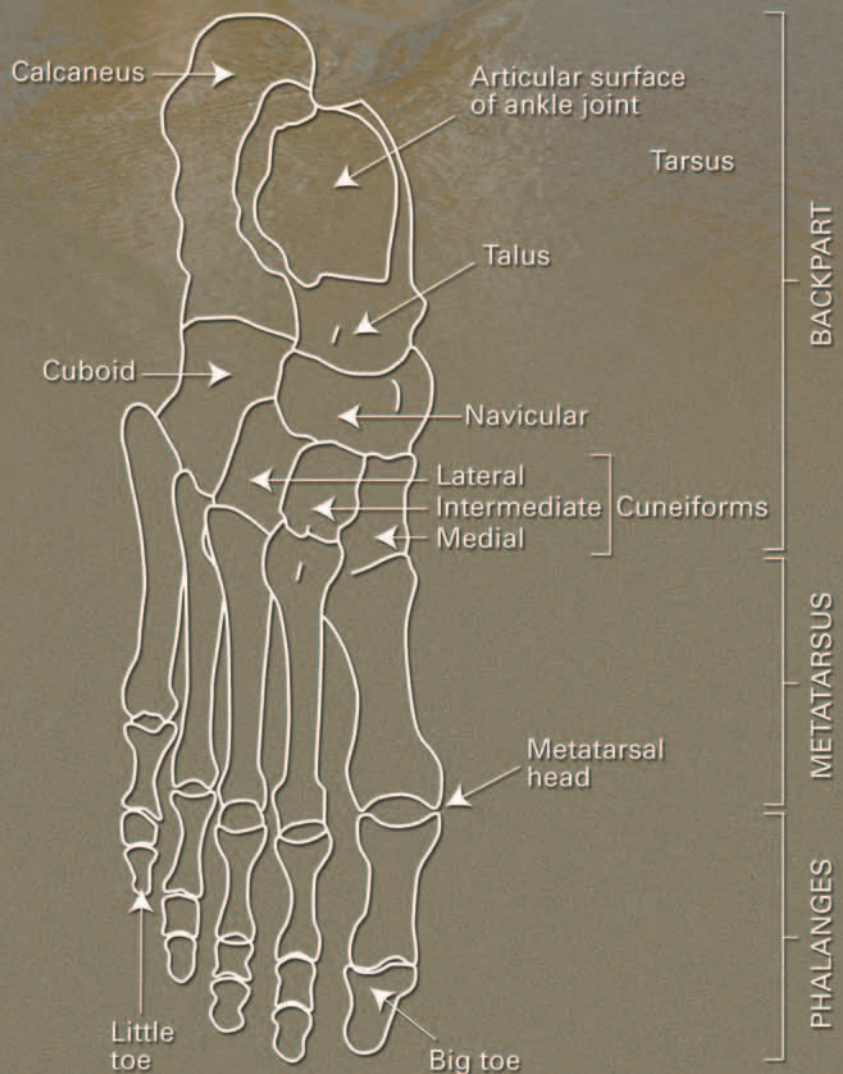


Figure 1: Bones of the foot

FEET AND BONES

The bone structure of the foot is divided into three groups (*Figure 1*).

- Tarsus with seven bones, including the calcaneum or heel bone.
- Metatarsus with five bones and comprising the middle of the foot.
- Phalanges with 14 bones which make up the toes.

Bone itself is formed by the deposit of calcium phosphate, which forms a strong, light, honeycombed structure. This is a long process; it continues into the very late teens. A child's foot therefore has little real structure and cannot detect any discomfort resulting from pressure, so correctly designed lasts and carefully fitted shoes are essential if deformities are to be prevented. All too often, fundamental mistakes are made on much of today's cheap children's footwear and it will take a generation for the results to become apparent.

The bone structure also forms two arches. The longitudinal arch falls between the heel bone and the head of the first metatarsal. Its height varies from person to person and its absence in some is the cause of flat feet and many other foot problems. The height also varies ethnically, with Italians and Japanese tending to have particularly high arches and insteps. The transverse arch lies across the base of the metatarsals when the foot is relaxed. Under load, it flattens out and the foot becomes wider as the bones spread.

FEET AND MOTION

When we walk, the foot has to provide both support to the body and propulsion to move it forward. It works in a rolling fashion with the outside of the heel hitting the ground first. As the forefoot contracts, the foot rolls inwards and the point of greatest pressure follows the outer edge of the foot up to the outer joint. As the heel lifts to flex the foot, the pressure transfers across to the inner joint and finally to the big toe as the body is propelled forward which explains why it is so difficult to walk if you hurt your big toe. Exploiting this foot action to the maximum is a key factor when designing sports shoes.

FEET AND SHOES

Footwear must always be functional in order to work with the foot rather than against it. This might seem obvious, but fashion often tries to ignore this and the resulting lasts and the shoes that are made on them can cause considerable harm (*Figure 2*).

It is therefore essential that, as well as providing good fit and comfort, a shoe must cause as little disruption to foot function as possible. The last shape in particular has the most profound effect and must therefore take into account



Figure 2: Too tight a fit on a pointed toe may distort the foot and result in health problems in later life. PHOTO: SATRA

the type of person who will wear the finished shoe and the purpose for which it will be worn. Sports shoes, for instance, require a different set of parameters to dress shoes, as do children's to adults, and men's to women's. In addition, today's global market means that lasts must also vary in order to fit a wide range of ethnically diverse feet; these vary physically in size and shape across the world as do their owners.

FEET AND LASTS

You cannot make structured footwear without lasts. The old handmade shoemaker would measure your foot and make a last

to match so that your shoes always fitted. While today's last makers have to make compromises for mass production, they must still take into account the mechanics of the foot to ensure the shoes that will be made on their lasts are functional as well as aesthetically pleasing. While the design of shoe lasts is highly complex, there are some basic facts that apply to any last and govern its relationship with the foot.

First, the last is longer to allow for elongation of the foot under pressure. This will vary with the weight of the person concerned and the physical condition of their feet. For example, a weak foot elongates more than a well-developed one and a child's less than an adult's. The foot also tends to move forward in walking regardless of fit so, in the case of narrow-toed lasts, extra length is needed to prevent squashing the toes as seen in *Figure 2*. Most women unfortunately refuse to accept the actual size of their feet and invariably buy them a half- or even a full-size smaller just so that their feet appear more dainty, which is why so many suffer from corns and even more serious foot problems such as bunions.

Second, the last will not reproduce any of the foot's irregularities as this would look unappealing and also cause manufacturing problems. The exception occurs with orthopaedic footwear where physical deformities must be accommodated (*Figure 3*).

Third, when placed on a level surface to the correct heel height, the toe should be raised. This is called 'toe spring' and is essential in helping the rolling motion of the foot and preventing undue creasing across the top of the shoe.

Finally, the top or 'cone' of a last is narrower than the foot itself. This is because the sides of the quarters are not held together in any way and this narrowness prevents



Figure 3: Pair of lasted orthopaedic shoes being made for a customer with badly twisted feet.

PHOTO: JANE SAUNDERS & MANNING, LONDON

gaping when the shoe is worn.

While a last's border outline corresponds fairly well with that of the foot—except at the toe—it is straighter and the inside joint position further forward. The former allows for a natural inward turning of the big toe when the heel's height or 'pitch' is increased and, the latter, is because the foot's contact point with the ground also moves forward as heel height increases. The bottom shape is also different due to a last having a defined 'feather' edge whereas the foot is rounded.

FEET AND HEELS

Heel height has a marked impact on foot function. When standing or walking barefoot (our natural condition), more of the body's weight is taken by the heel than the forefoot. As the heel is raised, so more weight is progressively transferred from the heel to the forefoot. This in turn influences the way we stand and the way we walk.

In its normal state, the foot bends some 50 degrees during the 'take-off' phase of walking. If the shoe restricts

this by being too stiff, it causes discomfort and fatigue. This can be offset to some degree by adding more toe spring. However, if the heel is high, less toe spring is needed as the foot is already partially flexed and, in general, the higher the heel the less the toe spring. If a high heel is matched to a platform forepart, the latter must have extra toe spring built into the platform itself in order to restore sufficient rolling motion. Similarly, in sports or casual footwear with thick soles, sufficient toe spring must again be included.

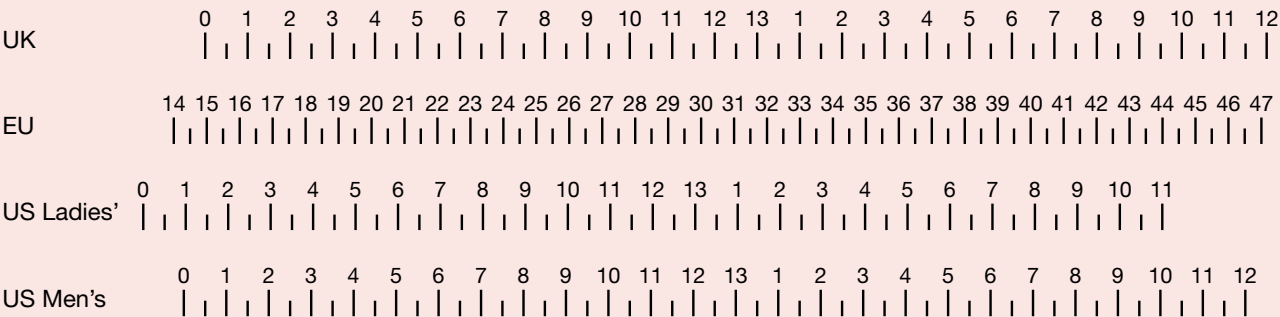
FEET AND SIZES

Feet naturally vary from person to person depending on their sex, size and age. Indeed, most of us also have one foot larger than the other—sometimes as much as a full size in length. Once shoemaking became fully mechanised during the 19th century, last makers had to standardise the differences in length, width and circumference in order to provide a degree of uniformity across the industry. Unfortunately, these measurements or 'grades' varied from country to country. The USA, which pioneered mass footwear production, had two sets of grades, one for men and one for women. The UK had only one but that did not correspond directly with either of the US size scales. The size difference in length for both countries was however the same at a third of one inch (8.4 millimetres). Both also broke at size 13 for children, restarting at size 1. Continental Europe on the other hand used the metric system and so its size length difference was one centimetre and, unlike the other two, it had no break.

The complexity can be easily seen as any UK size is one half size larger than a US men's and one and a half sizes larger than a US ladies. The Continental or Paris Point system has no direct comparison with either.

Amazingly in today's fully global industry, this is still the case and one of the major problems people face now is finding shoes that fit them properly. Shoes in the same shop marked with the same size are quite likely to vary, depending on where they were manufactured. The major brands have overcome this to a large extent through the use of last-production systems, such as Compu-Last from Jones & Vining, which guarantee the same size-grading wherever the lasts and shoes are produced.

Comparative size chart



FEET AND RESPONSIBILITY

The foot is clearly a highly complex mechanism and footwear—which far too many consumers consider a low-priority item in the family budget—is a vital factor in our everyday comfort and long-term health.

Everyone involved in the specifying, sourcing and manufacture of footwear for the global market should do their utmost to ensure the lasts used in the manufacture of their shoes are suitably modelled to permit proper functioning of the foot. There are several testing and research organisations such as CTC, SATRA and PFI, which have extensive data on national foot fitting characteristics, so really there is no longer any excuse for badly fitting lasts.

Likewise, the shoes that are designed around these lasts must also take into account the very same foot considerations—the purely visual effect sought in too many cheap fashion shoes is both irresponsible and short-sighted. Like the old-time shoemakers, brands such as ECCO, Clarks and Munro USA, go to enormous lengths to make sure their products are anatomically correct in every respect. Their successful track record suggests that this is the way to go. It is not that difficult, it just takes a little more thought and a little extra effort. 🍷



THE BARLEYCORN MYTH

Legend has it that King Edward II of England (1307-1327) decreed that three barleycorns placed end to end measured one inch and that 39 measured one foot or the approximate length of an average man's 'foot'. A good story but as it happens the barleycorn can be traced back as a measurement at least as far as the 7th century, although it was not in universal use. Then, in 1324 and under pressure from scholars and tradesmen, Edward established the three barleycorn inch as an official measurement. Shoemakers soon adopted it and so it was they, not Edward, who decided that one-third of an inch (or a barleycorn) would be the measurement for a full shoe size. The early English settlers of North America took it with them, which is why the USA still uses the same measurements (if not exactly the same sizes) as the UK.

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