Defining foot comfort

In numerous shoe surveys conducted over the years, comfort has always topped the list of desirable features for consumers. Comfort, however, is an extremely complex concept to attain as it relies on a mix of tactile, thermal and biomechanical features that have been built into the shoe in order to provide support, shock absorbency and thermal comfort, all packaged in an unrestricted natural shape. The degree of comfort experienced will therefore depend on the shoemaker finding the right mix of these properties for the type of shoe involved.

The natural state

Recent years have seen the growth of 'natural' shoe brands marketing their products as contributing to the overall wellbeing of the body. But, what exactly do we mean by natural when the wearing of footwear is essentially 'unnatural' for the human body? The original reason we took to wearing shoes was simply to obtain a degree of warmth and protection.

In our natural barefoot state, the ideal distribution of weight for the human body when standing is 50% on the ball of the forefoot and 50% on the heel; wearing a shoe with a heel changes this. Depending on the height involved, the split can vary from approximately 40–60% distal on a sports shoe to 20–80% forward on the forefoot for a ladies' high-heel shoe. The latter is therefore clearly not in any sense a natural condition.

However, bearing in mind that propulsion starts with the midfoot, propels the body forward onto the ball of the foot and finally to toe off, it is in fact an advantage to shift the weight forward into the 'ready' position in many athletic activities. For example, tennis players always prefer to receive serve on the balls of their feet rather than back on the heels.

Comfort relies on a mix of tactile, thermal and biomechanical features that have be built into the shoe to provide support, shock absorbency and warmth.

John Norris/Lowe Alpine

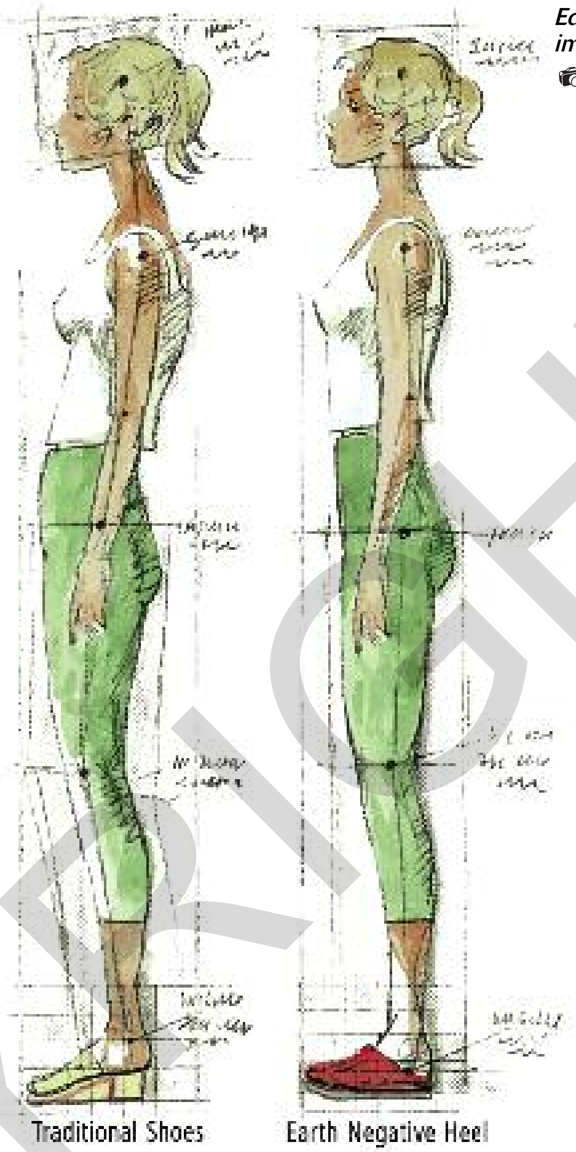
Balance

Whatever their construction, styling or function, all shoes can be categorised into three Sagittal planes:

- Plantarflexed where weight is shifted forward on to the ball of the foot (shoes with heels or wedges)
- Neutral where the foot is essentially kept on a level plane
- Dorsiflexed where a negative or minus heel concept transfers more weight onto the rear of the shoe

While most of the footwear produced today falls into the first category, millions of people around the world continue to wear neutral flat soled sandals or flip-flops. Claims that the latter improve the wearer's posture could well be valid as witnessed by the graceful movement of many Asian women.

From time to time over the years, shoes with negative heels have also appeared with perhaps the best known being the Earth shoe created by Danish yoga master Anne Kalso. This combines an anatomical plantar surface with a negative heel so that the rear of the foot is positioned slightly lower than the rest of the neutral plane sole surface. It is claimed to be both bio-mechanically and anatomically natural as the negative heel simulates walking barefoot in soft sand where the heel sinks lower than the mid and forefoot. Natural or not, it nevertheless does appear to improve posture and allow the wearer to stand and walk in a more upright stance through better alignment of the spine.



Earth Footwear's way to improve posture.

Kalso Earth Shoes

Stability

Stability during locomotion is important for all age groups and two strategies can be employed to this end. One is to strengthen the lower extremity muscles and the other to construct shoes and inserts that provide proper support for the feet. Research has however suggested that shoes which provide stability also cause the muscles contributing to static and dynamic stability to become weaker as they are no longer fully utilised.

Another interesting result from this research surprisingly revealed that there was little change in shock absorption or motion control in shod versus unclad feet. Indeed, in the case of runners, wearing shoes deceives the body's sensory abilities and reduces reaction time as well as weakening the lower extremity support muscles, tendons and bones.

Bio-electromagnetism

Ask a panel of experts whether they feel that making a shoe breathable is a more natural benefit and they would undoubtedly say yes. Ask them if including a shock-absorbing layer in the sole added comfort to shoes used on modern surfaces and, again, they would also agree. Ask them if it would be more natural to make a shoe lighter or heavier for use in lifestyle or athletic footwear and the answer would again be positive. Ask them if feet are in a more natural state when on a plantarflexed, neutral, or dorsiflexed angle and, while there might be some debate, they would most likely settle on a neutral plane as being the most natural.

Now ask them if it would be more natural for the body (through the feet) to be insulated from the ground's electromagnetism or be conductive; there would most likely be total silence. The body is in fact an electro-chemical machine and we now know a great deal about these chemicals in the form of the food and supplements we put into our bodies. In the footwear industry we have, over the past thirty years or so, also learned much from studying the results of biomechanical testing and adapting the results into shoe function. What we have yet to learn is how to rectify the inadvertent deprivation of electromagnetic contact with earth through footwear.

Up until the 20th century, the predominant soling material used in footwear was leather. This is a natural substance that is electrically conductive to the earth in the same way as walking barefoot. By producing almost all modern footwear with soles made from materials with insulating properties we have inadvertently insulated ourselves from the Earth's natural electromagnetic field with unknown effects. Can this be termed 'natural'?

Cushioning

Running shoes have been at the forefront in terms of cushioning shock to the body. This feature has also been increasingly applied to a broad range of every day types of footwear. Despite subjective opinion and objective laboratory shoe testing, opinions still differ widely as to how and why various cushioning systems do or do not work.

The most common approach is to use a material or substance that disperses shock. This material is added to the shoe's midsole, which is itself a primary shock absorber. Most running shoe midsoles are made of EVA with occasionally some additional rubber or polyurethane for greater durability. EVA is a useful material in that it is available in different durometer readings (resistance to indentation) to make it either easier or harder to compress. EVA can also be blended with rubber to create a midsole with a better energy return. Midsoles with different durometer readings can therefore be used in different types of shoe depending on their final use. It is even possible to provide an initial soft 'try on feel' for the wearer which is a strong selling point for comfort shoes.

Factory shoe inserts are a more practical way to add cushioning to everyday footwear. This in turn has led to a huge range of sophisticated after-sale inserts becoming available. While shoe manufacturers can test and select what they consider to be the best price and performance materials to use, the consumer has no such resource and final choice is influenced by price, availability and brand perception. They may not in fact be buying the most suitable product for their particular needs.

Absorbing loads

A load on the body is generally transferred to the skeletal system. Soft tissues like skin, underlying fat and muscle act as a cushioning interface for the transfer of such loads to the bones themselves. These transmitted forces have the potential to damage soft tissue and the critical factor is not simply the force but the ratio of that force to the surface area over which it acts.

Bone extremities at the heel and ankle are covered by a relatively thin layer of tissue and, as they support so much body weight, are critical in terms of support technology. The support or shock-absorbing systems generally used have traditionally fallen into three categories.

Orthosole footbeds by Athena Pacific have interchangeable support options.

Athena Pacific

Solids - solid cushions such as PU and latex foam or high-density gel which have a 'springing' type action. For various reasons there is said to be no uniform pressure distribution over the cross-section but rather an unequal pressure build-up with the maximum occurring in the centre.

Liquid - fluid media such as water or gel that have to be separated from the body by a membrane. The aim of this type of support is to keep the body 'floating' and therefore its density must be greater than that of the human body (approx. 1000 kg/m^3). In order to separate the body from the medium, an enveloping cover is used. Again, there is said to be no uniform pressure distribution.

Air - gaseous media (mostly air) in a closed cushion system which also has to be separated from the body by a membrane. Even this method has been described as lacking true uniform distribution due to the tension of the membrane.

At places in the body where the mechanical load on bone, muscle or other tissue can become too high, bursae (sacs or pockets filled with synovial fluid) are found. They occur where muscles, tendons, or bones rub against each other. They lubricate these points of friction and dissipate force by distributing it through the synovial fluid present and normally produce just enough of it to reduce friction by reducing tissue bonding. From an engineer's point of view, the advantage is the fact that it achieves this by actually separating the moving tissue.

Liquicell

One of the more innovative principles for body support is a bursa-like interface sac called LiquiCell. Developed in the USA. by Birchwood Laboratories Inc., it closely resembles the actual bursae found in the human body. It consists of a pouch containing a low viscosity liquid and one or more baffles to channel the liquid within the pouch as pressure is applied or shifted across its surface. The theory is that the shear force on the body contact surface is very low and that the small layer of liquid equalises that pressure.

As the volume of liquid used is so small, there is no pressure build-up due to body weight imprint on the cushion. Instead, the liquid provides a thin layer of fluid over the entire contact surface that has a friction coefficient of 0, which is comparable to that of a layer of ice. The covering membrane is allowed to move freely with the body, so even a thin layer of the fluid equalises pressure at the surface contacting the foot. In this way, the bursa-like LiquiCell sac is said to resemble the natural response of the body when mechanical loads on bone and muscle tissue become too high.

This is still a comparatively new technology but is being increasingly used in footwear. At 1mm thick, the sacs are so thin they can be used in a wide range of shoes and incorporated into a variety of components including insoles, heel counters, straps, tongues and vamps. Furthermore, they can be applied using adhesives, stitching or by compression moulding.

After-sales heel pad versions are also available which are designed to reduce internal muscle and soft-tissue damage by relieving stress within the muscle, increasing blood flow and absorbing impact. They come in the form of self-adhering liquid-filled urethane capsules to fit any shoe and footbed combination. The aim is once again to also reduce shear force. In this instance it refers to the parallel movement between the foot and the shoe which, combined with the friction occurring between these two surfaces, is the number one cause of foot blisters as well as sores and general discomfort.

Correct fit

One problem that does not arise by going barefoot is that of ill-fitting footwear. We can buy expensive shoes containing all the technology possible to increase comfort and foot health, but if they do not fit properly, all is wasted. The vast majority of people fail to have their shoes properly fitted mostly, it is sad to say, due to the fact that very few retailers continue to provide such a service.

There are of course self-measuring systems around but then again, how many people know how or when to measure their feet? For example, they may well get the length right but what about the girth measurement or fit around the heel, both of which are fundamentally important? Furthermore, how many think to measure their feet at the end of the day rather than the beginning? Depending on what one is doing, feet can grow surprisingly in both length and width during the course of the day. Ask any woman after a long day's shopping whether her shoes feel tight. Foot comfort is a complex subject but it helps to get the basics right in the first place.