The Ergonomics and Biomechanics of Footwear

By Amanda Carpenter, DPT

You probably think of work boots as a component of personal protective equipment (PPE), but have you ever considered work boots as ergonomic gear? The right work boots for your foot or arch type can optimize biomechanics and reduce the risk of an injury. In this article, we will discuss the importance of appropriate footwear for your foot type and how the correct type and fit of your boot can reduce injury risk.

There are three primary arch types: average, high and low arches. For optimal biomechanics, your footwear should appropriately support your arch type. Some footwear can be purchased for specific arch-type needs.

Normal feet land on the outside of the heel and roll inward (pronate), pushing off the big toe to absorb shock. Normal feet have average arches, which need stability shoes. They provide guidance and cushioning to help guide the foot naturally through each step.

Rigid feet have high arches causing the foot to roll outward (under pronate), ineffectively absorbing shock, and increasing the risk of an ankle injury (Picture 1a). High, rigid arches need neutral or cushioning shoes, which provide minimal guidance so the foot naturally guides itself through each step, but provide cushioning to absorb shock and limit impact.

Flat, flexible feet have low arches, causing the foot to roll inward (over pronate), causing instability throughout the lower body (Picture 1b). Flat feet need motion control shoes, providing maximum support to guide the foot through each step, minimizing pronation to improve stability.

In my experience, I have found that the majority of arborists have average to high arches, requiring stability and cushioning in work boots.

You want to ensure that your work boots are appropriate for your foot type and do not counteract it. Too much stability or motion control in a high-arch foot can cause musculoskeletal problems. To determine your foot/arch type, see Figure 1. Determining your foot type will aid you in selecting the most ergonomic boot for your needs.

Picture 1a/1b: High/rigid arch, left, and low/flat arch, right. Higher arches require footwear with greater shock absorption. Work boots for this foot type should be flexible when you try to bend and twist them. Low arches require footwear with stability and motion control. Work boots for this foot type should be more rigid. All images courtesy of the author.

What to look for

You will need to know what to look for in a work boot, specifically, the heel counter, outsole and insole.

The heel counter is the material forming the back of the boot and can add support to the foot. A stable heel counter is necessary for most foot types, as it will prevent the foot from rolling out too much in the higher, rigid-arch foot and rolling in too much in the lower-arch foot.

The foot bed or insole is the part of the boot that comes in direct contact with the foot. A comfortable insole is necessary for all foot types; it can add a bit of extra cushion for higher arches and support for lower arches.

The outsole is the bottom part of the

Picture 2: Boot fit/width: Make sure the width of your toes fits within the sole of the boot. A boot with a narrow toe box will squeeze the foot causing blisters, bunions and other foot pathologies, causing altered biomechanics and increasing the risk of a musculoskeletal injury.

boot that comes in contact with the ground. Outsoles can offer both shock absorption and additional arch support, depending on how they are made and what material is used.

The shank is the part of the supportive structure between the insole and outsole. It adds stiffness to the boot, which can protect the bottom of the foot on rigid terrain or with the use of climbing spikes, but will limit the normal movement pattern of the foot, reducing shock absorption and altering biomechanics.

Your foot type will impact the wear patterns of your boots. High, rigid arches tend to wear on the outside of the heel and sole from the heel rolling outward, while flatter arches wear on the inside of the heel due to the foot rolling inward. Normal wear patterns should be observed on the outside of the heel and under the big toe region.

It is important that you monitor the wear pattern of your boots. When excessive tread wear is noted in these regions, or is not symmetrical between the right and left feet, it is time to replace your boots. Picture 3 shows tread wear on the bottom of a boot. If you tend to see asymmetrical wear on your boots, you should seek an evaluation by a biomechanical specialist, a physical therapist or kinesiologist, as this is an indication that your body's alignment is out of balance, which will increase the risk of a musculoskeletal injury.

You should be able to wear your work boots for a minimum of six months before you see excessive wear. If you notice wear quicker than six months, you may be wearing the wrong type of boot for your biomechanical needs, or you may want to consider another boot manufacturer or style.

Boot types

There are a few different styles of work boots that I typically see in the green industry; these include logger boots, hiking boots and mountaineering boots.

Logger boots are usually tall boots, designed with soles providing extra traction, a high heel, and a stiff shank. The stiff shank protects the foot from sharp objects, but limits the natural movement of the foot, causing an altered gait. Logger boots can provide the necessary traction and support when working on rough terrain, but the wear of the heel and outsole needs to be closely monitored. The heel counters tend to stretch, which allows the ankle to roll causing wear on the sole and increasing the risk of an injury.

Mountaineering boots are designed to be rigid to protect the foot and ankle on uneven and rough terrain, but they limit the natural movement of the foot, tend to have a narrow toe box and can increase the risk of arthritis in the foot and ankle over time.

Figure 1: Determine your foot or arch type by performing a wet foot test. Wet the bottom of your foot, stand on a paper bag or piece of paper for a few seconds, then match your footprint to the closest one to it in the picture.

Hiking style boots have softer soles and shanks, allowing for better shock absorption and movement, and are best for higher arches.

A good work boot for the typical arborist with a medium to high arch will have a stable heel counter to prevent the ankle from rolling out too much, and a well-designed, shock-absorbing outer sole and cushioning insole. People with high, rigid arches have the tendency to have a toe-out gait. The correct work boot will slightly decrease this tendency. Hiking-style boots have softer soles and shanks, allowing for better shock absorption and movement, and are best for higher arches. Logger boots can be dangerous for the high/rigid arch, due to the tendency for the ankle to roll outward. If you wear a logger boot, watch for wear on the outer heels.

Boot fit

In addition to the arch support needs, a work boot should also fit properly, including the length and the width. A wide width will be wider throughout the entire boot. Many people need a wide toe box without extra-wide width throughout the entire boot. To ensure that your forefoot does not get squeezed, hold the bottom of the boot up to your foot, making sure that your forefoot is not wider than the sole of the boot. See picture 2. Some boot brands are known for having a wider toe box in their normal width boots, therefore allowing for adequate room for the forefoot without having to purchase a wider width boot, which sacrifices stability through the arch and the heel.

Orthotics or arch support

Pre-fabricated arch cushions can be purchased to replace a worn insole, but are not designed to support the foot because they do not have any significant stability. Custom orthotics should be considered for foot deformities or altered biomechanics as a result of pathologies such as severe arthritis, injuries or surgeries of the foot/ankle causing significant mechanical differences between the right and left foot.

Steel or composite toes

Composite or steel toes protect the toes from heavy impact and may be required by the employer, but they do prevent the foot from bending easily, causing altered foot and gait mechanics. Steel-toe boots can also increase the weight of the boot, which will increase fatigue and decrease balance, contributing to increased injury risk. Therefore, if steel- or composite-toe boots are required for your occupational duties, do not also wear them for personal use.

Picture 3: Tread wear.

Appropriate footwear can aid in the prevention of a musculoskeletal injury. Work boots should be for your arch type and should fit correctly. Wearing the right boot for your foot type and work duties and replacing worn boots can reduce your risk of injury by allowing the foot to be appropriately supported to optimize biomechanics at the knee, hip, pelvis and back. Just as tire wear on a vehicle can be an indicator of poor alignment, excessive or uneven wear of boots can indicate a problem with your body's alignment, increasing your risk of a musculoskeletal injury.

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When purchasing a new pair of work boots:

1. Look for a model/style designed for your arch type.
2. Make sure the toe box is wide enough for your forefoot.
3. Stand on one leg to see if the boot causes you to roll excessively in or out.
4. Scuff your foot in the boot to make sure your length is sized correctly. Your toes should not feel jammed forward into the toe box, and your foot should not slide more than one finger width down the back of your boot. If your boot is too big, your foot will slide, preventing the arch from being supported correctly and allowing for sheering, which will cause blisters.
5. Consider purchasing a separate pair of insulated boots for winter if you work in colder climates.
6. Try boots on with the socks you typically wear for work.