In the 1960 Olympics, Abebe Bikila won a gold medal after running barefoot for the entire marathon distance. Prior to this event, all runners either ran barefoot or in light footwear that offered only minimal support. The modern running shoe was introduced in the 1970s. Since that time, distance running has continued to increase in popularity, and now over 16 million people in the United States participate in distance running each year. Recently, barefoot running has become popular, and shoe manufacturers are catering to this new market by introducing “minimalist” shoes.

The effects of barefoot/minimalist running are unclear, however, especially among runners who have made a switch from running in supportive shoes. Running has a broad range of reported health benefits, including weight loss, cardiovascular health, reduced risk of stroke and hypertension, increased positive mood, and increased bone mass. Musculoskeletal injuries are commonly reported, however, with 30 to 70% of distance runners sustaining an injury each year. In an effort to prevent such injuries, running shoe companies have introduced different combinations of cushioning, heel elevation, and pronation control in various shoe designs. Minimalist runners consider barefoot running to be more natural and that it decreases the risk of injury, but no longitudinal epidemiological data exist to support this anecdotal position.

This report provides a review of the effects of different types of footwear from an injury prevention perspective. Because footwear primarily influences the runner’s gait while the foot is in contact with the ground, factors related to footstrike will be the primary focus.

**Minimalist vs. Conventional Shoes**

Conventional running shoes have a heel that is about 10–12 mm thicker than the forefoot midsole. Minimalist shoes have a heel that is approximately 0–4 mm thicker than the forefoot midsole, no arch support, and a thinner and more flexible sole, which is similar to the shoes that were available for runners prior to the 1970s. The common characteristics of the minimalist shoe types are illustrated.

**Key Points**

- Minimalist shoes are increasing in popularity.
- The relationship between shoe type (conventional running or minimalist running) and injury incidence remains unclear.
- Changing from conventional running shoes to minimalist running shoes may alter injury patterns from more rearfoot strike related injuries to more forefoot strike related injuries.
- When transitioning between footwear types, injury risk may be reduced by gradual transitions between footwear, altering running biomechanics by landing under the center of mass and including flexibility and strength training in training regimens.
- Alternating running shoes across days using different shoes for different purposes (e.g., walking, running, sprinting) can reduce cumulative stresses on the body, helping reduce overuse injury risk.

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in Figures 1 and 2, and described in Table 1. The term “minimalist running” is used to refer to running in either minimalist shoes or barefoot. Minimalist shoes are thin enough to mimic barefoot running, but they offer a thin layer of protection; however, the relative value of minimalist running shoes for prevention of injury is unclear, either in relation to running in a barefoot condition or when wearing more conventional running shoes.

**Footstrike**

Footstrike can occur in any of the following patterns: (a) rearfoot landing on the heel first, (b) midfoot landing on the heel and forefoot simultaneously, or (c) forefoot landing on the forefoot first.\(^\text{2,10}\) During a half-marathon, cameras located at the 15 km mark demonstrated that 74.9% of participants were rearfoot strikers, 23.7% were midfoot strikers, and 1.4% were forefoot strikers.\(^\text{18}\) Runners landing with a rearfoot strike typically have a more extended leg at ground contact, which occurs in front of the body’s center of gravity, and they land with a dorsiflexed ankle.\(^\text{10}\) The impact force generated by footstrike is concentrated at the heel and is directed upwardly through the tibia, femur, pelvis, and lumbar spine.\(^\text{12,19,20}\) Runners who land closer to the forefoot (midfoot to forefoot strike) generally have a more flexed knee and a plantarflexed ankle, which disperses impact force throughout the foot.\(^\text{10}\) Researchers have noted that barefoot runners have a shorter stride, which makes them more likely to have forefoot strike at initial ground contact.\(^\text{2,21}\) A study of recreational runners demonstrated that instructions to shorten stride length and increase stride rate resulted in a gait pattern similar to that observed when running.

**Table 1. Comparison of Conventional and Minimalist Shoes**

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Minimalist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sole</td>
<td>Stiff</td>
<td>Flexible</td>
</tr>
<tr>
<td>Heel/Toe Offset</td>
<td>10-12 mm</td>
<td>0-4 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>Heavier (10-14 oz)</td>
<td>Lighter (&lt; 6 oz)</td>
</tr>
<tr>
<td>Arch support</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Landing</td>
<td>Rearfoot</td>
<td>Midfoot or Forefoot</td>
</tr>
<tr>
<td>Common Injuries</td>
<td>Hip/knee/lumbar pain, tibial stress fractures, plantar fasciitis</td>
<td>Achilles tendinosis, calf muscle strain; metatarsal stress fractures</td>
</tr>
</tbody>
</table>

\(^{2}\)
in minimalist footwear. This finding was attributed to the foot making ground contact closer to the body center of mass, as opposed to the more forwardly located heelstrike that is typically observed in shod runners. Many running-related injuries are believed to result from ground impact, so shoe manufacturers design shoes to attenuate the associated force impulse.

**Footwear Designs**

There is little evidence that running shoe cushioning prevents injuries. There is evidence that alteration of leg stiffness modifies ground reaction forces during running. Anticipatory muscle activation prior to footstrike can adjust leg stiffness during running. Footstrike shock absorption is influenced by ankle, knee, and hip kinematics, and alteration of footstrike patterns can compensate for changing ground surfaces. For example, a combination of pronation and dorsiflexion promotes attenuation of heelstrike impact force. Interestingly, shock absorption appears to be more efficient in runners who utilize a forefoot strike, which has the foot in a plantar flexed position when impact occurs. Regardless of increasing or decreasing hardness of shoe components or ground surfaces, both shod and unshod runners appear to adjust leg stiffness to compensate for the ground reactions forces generated at foot impact (i.e., reducing stiffness on hard surfaces or increasing stiffness on soft surfaces).

The elevated heel of conventional running shoes is believed to reduce Achilles tendon loading by decreasing ankle range of motion during running; however, research designed to determine whether this strategy reduces injury risk has produced mixed results. Surprisingly, Achilles tendon injury incidence has actually increased since the modern running shoe was invented. A possible mechanism is elevation of joint torques at the ankle, knee, and hip associated with a heelstrike landing in front of the body center of mass. A comparison of injury incidence between runners with different footstrike patterns demonstrated that rearfoot strikers had twice as many cases of hip, knee, and low back pain, tibial stress fractures, and plantar fasciitis as forefoot strikers. Ankle sprain risk could be increased by the heel cushioning and/or sole thickness of conventional running shoes, which may reduce proprioception. A study of foot positioning error demonstrated an average error of 1.96° for a barefoot condition and an average error of 3.97° for a shod condition during standing. During walking, the error was 1.55° when barefoot and 5.99° when shod. The researchers suggested that the body relies on tactile receptors to make foot placement judgments that may be compromised by footwear.

Conventional running shoe designs have also been influenced by the theory that excessive pronation is directly related to injury incidence. Runners who wore “motion control” shoes, however, were found to have a higher injury rate than runners who wore other types of running shoes. Among patients treated for plantar fasciitis, those who wore a less restrictive shoe design had an earlier reduction in pain levels than those who wore a conventional running shoe. The researchers suggested that this may have been due to the greater range of motion permitted by the less restrictive shoe, which may have facilitated use of the foot’s intrinsic musculature and elastic structural components. Approximately 50% of the work done during running has been attributed to musculotendinous elasticity that stores energy when elongated, which contributes to forward propulsion when it is released. The largest spring-like structure of the foot is the medial longitudinal arch, which may transfer elastic energy through the Achilles tendon. The forefoot landing of minimalist runners may make more efficient use of the spring-like behavior of foot structures, especially the Achilles tendon and the tendons located in the medial longitudinal arch.

Although evidence supporting the basic design of conventional running shoes is not extensive, switching to minimalist shoes may not be a better option for injury avoidance. For example, approximately 20° of dorsiflexion is required for running. A runner with a relatively small range of ankle motion, who transitions from the thick heel of a conventional running shoe to the lesser heel thickness of a minimalist running shoe, may develop an Achilles tendon problem as a result of the wider range of ankle motion that is imposed. Injuries associated with use of conventional running shoes are primarily related to heel impact, whereas switching to minimalist running shoes may increase risk for a forefoot strike-related injury. For example, metatarsal stress fractures have been documented among runners who abruptly switched to minimalist running shoes without a transition period. Further research is needed to define differences in injury types and rates between runners who wear conventional running shoes and those who prefer minimalist running.
Recommendations

Overall, the scientific evidence regarding the differences in injury susceptibility between barefoot/minimalist running and conventional shoe running are conflicting. Conventional running shoes appear to present greater likelihood for injuries related to heel impact, whereas minimalist runners appear to be more susceptible to injuries associated with forefoot impact. Because conventional running shoes are designed for the general population, they cannot accommodate individual variations in running gait. Thus, reduction of injury risk may require consideration of the individual runner’s gait characteristics and injury history.

Running experts consistently recommend that runners who have had no problems when wearing conventional running shoes should continue what they have been doing; however, runners with recurring injuries may need to consider another option, such as minimalist running. Alternatively, such runners may decrease the stride length to make ground contact closer to the center of mass, thereby reducing heel contact. An additional advantage of a shorter stride length is better positioning for propulsion of the body mass.

Runners who choose to switch to minimalist footwear after having worn conventional running shoes for an extended period should transition gradually. Young runners may not have any more problems in minimalist footwear than conventional footwear. Runners who have worn conventional running shoes for years may have an ingrained running style that makes a small change in footstrike location sufficient to cause injury. The forefoot must be capable of withstanding increased impact force, which may require bone remodeling that takes approximately 3–6 months. This amount of time may be needed for a transition from conventional running shoes to minimalist running.

Many competitive runners use different shoes for specific functions (e.g., track workouts, races, cross country running, etc.). By alternating shoes, any minor problem experienced when wearing one particular shoe type will not have the cumulative effect of reliance on a single shoe type. Finally, ankle mobility should be assessed. Runners should be able to easily dorsiflex the ankle to at least 20°. To summarize, both minimalist and conventional shoe running have advantages and disadvantages. Runners and clinicians should be aware of these differences when selecting running footwear.

References


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