

# The Running Shoe Prescription

## Fit for Performance

MAJ Chad A. Asplund, MD; MAJ David L. Brown, MD

**In Brief:** Running-related injuries are among the most frequent reasons for primary care visits. Armed with information on the basics of foot types, gait patterns, and running shoe design, healthcare providers can perform a simple, office-based assessment that gives the best possible advice to patients regarding the fit and features of their running shoes. Patients who wear proper foot gear may well have fewer running-related injuries.

When asked how they selected their shoes, patients with running-related injuries may give some surprising answers. Consumer demand, marketing, and the complexity of running shoe design have outstripped the ability of some runners to make the proper shoe choice. In the absence of an expert shoe recommendation, runners often buy shoes based on celebrity endorsement, brand loyalty, style, impressive-looking features, and price. In doing so, they may unwittingly contribute to their own injuries.

In addition to foot type and leg malalignment, research has identified type and wear of running shoes as risk factors for the development of overuse injuries.<sup>1</sup> Proper shoe selection and fit can compensate for biomechanical abnormalities and decrease injury rates.<sup>2,3</sup> Multiple studies<sup>2,4-6</sup> have demonstrated that well-designed and properly fitted running shoes reduce the number of overuse injuries, yet 37% to 56% of the more than 30 million American runners develop injuries each year, and 20% to 70% of those injured seek medical care.<sup>1</sup>

These staggering numbers underscore that physicians need to provide appropriate running shoe recommendations based on a biomechanical assessment. Physicians can use the basics of foot types, gait patterns, and running shoe design to perform a simple, office-based assessment that culminates in the best possible running shoe prescription.

## Foot Basics

To recommend the most appropriate running shoe, a clinician needs to understand foot function. The foot allows the leg to accept vertical impact forces

during heel strike; absorb and, to a degree, dissipate these forces across a flexible mid- and forefoot during pronation; and then provide horizontal propulsion as the foot becomes a rigid lever with resupination and toe-off. The extremes of plantar arch architecture and foot mobility can interfere with this intricate mechanism.

In general, runners with high arches (pes cavus) underpronate and have a less flexible or even rigid foot. Lack of flexibility in the intrinsic joints of the foot leads to reduced shock absorption. Poor intrinsic shock absorption can be further compromised by poor gastrocnemius-soleus flexibility, which contributes to an increased incidence of overuse injuries (eg, tibial and femoral stress fractures, Achilles tendinitis, plantar fasciitis) in runners who have high arches.<sup>3</sup>

Runners with flat (pes planus) or low-arched feet tend to have foot hypermobility that predisposes them to overpronation. When the foot remains in a pronated, unstable position during toe-off, the center of weight shifts to the medial portion of the foot. The ultimate effect is excessive internal tibial rotation that increases medial foot, leg, and knee stress. Overpronation has been associated with patellofemoral pain, popliteal tendinitis, posterior tibialis tendinitis, Achilles tendinitis, plantar fasciitis, and metatarsal stress fractures.<sup>3,7</sup>

## **Anatomy of a Running Shoe**

The running shoe is made of four components: the upper, the midsole, the last, and the outsole.

**Upper.** The main parts of the upper are the toe box, tongue, insole, midpanels, lacing system, and heel counter. The upper is usually constructed from a combination of lightweight nylon mesh and synthetic materials that are flexible and breathable, but also durable enough for daily wear. As the name implies, the toe box is the portion of the upper that houses the distal forefoot and toes. The large nylon mesh panel on top allows for heat and vapor dissipation. The toe box must be deep enough to prevent chafing and long enough so the toes don't abut the end of the shoe.

The tongue is made from padded material to protect the foot from direct contact with the laces. The tongue also assists the lacing system in providing a snug fit across the midfoot. The midpanels of the shoe contribute to midfoot support and may be used in conjunction with the lacing system to provide torsional stability.

Another important component of the upper is the insole or sock liner. Insoles are designed to increase cushioning and reduce friction. Most shoes come with a

removable sock liner. Over-the-counter neoprene or viscoelastic insoles may be purchased to replace the original insole, increasing overall cushioning and reducing the shock imparted to the legs. Small modifications, such as new insoles, potentially decrease the risk of injury.<sup>3</sup>

The heel counter, a reinforced section of the shoe that cups the heel, is critical in providing motion control.<sup>8</sup> The heel counter is usually made from thermoplastic or reinforced fiberboard. Stiffer heel counters promote hindfoot stability to help control pronation.<sup>3</sup> A shoe with an overly flexible heel counter lacks resistance to overpronation and can result in injuries caused by increased internal tibial and femoral torsion.<sup>9,10</sup>

**Midsole.** Most of the cushion, stability, and motion control is provided by the midsole, the most important component of the running shoe. The most commonly used materials in midsoles are ethyl-vinyl acetate (EVA) and polyurethane. EVA is lighter, but less durable, than polyurethane. Many companies are now placing an air or gel unit within the EVA midsole, or using encapsulated forms of EVA within the midsole, to increase shock absorption. Midsole components of different densities can be positioned to limit the amount of pronation or supination. Firm plastic pieces, such as footbridges, may also be imbedded in the midsole to further limit motion.

**Last.** In the context of running shoes, the term "last" can have two meanings. When referring to a shoe's curvature, the last indicates shoe shape and is designated as curved, semicurved, or straight (figure 2). Curve-lasted shoes have a forefoot adduction of approximately 25°, are very flexible, and are tailored to runners who have more rigid arches and those who pronate. Semicurve-lasted shoes have approximately 7° to 10° of forefoot adduction and are in between the flexibility and stability of curved and straight lasts. Straight-lasted shoes have little to no forefoot adduction, and are generally made for flat-footed or heavier runners.

When referring to shoe construction, the last is the foot-shaped metal or wood form that gives its name to the method of attaching the upper to the midsole-outsole component (figure 3). Three methods of attachment are used: board lasting, slip lasting, and combination lasting. During board lasting, the upper is pulled over the foot form and cemented to a fibrous board material before the midsole is attached. Board lasting provides more rigidity and enhances motion control. With slip lasting, the upper is stitched together, creating a "sock" that is slipped over the form and cemented to the midsole. Because no board is involved, the shoe is lighter and more flexible. Combination-lasted shoes generally have board material in the heel but are slip lasted in the forefoot.

**Outsole.** The part of the shoe that contacts the ground is called the outsole and is usually made of carbon rubber, blown rubber, or a combination of both materials. Constructed of materials similar to race car tires, the outsole's lifespan will typically far exceed that of the midsole. The outsole may also have transverse flex grooves or longitudinal split grooves to enhance shoe flexibility while potentially sacrificing a degree of stability.<sup>11</sup>

## **Types of Running Shoes**

By fine-tuning different combinations of shape and construction, a shoe is endowed with individualized features. There are four main categories of running shoes: stability, motion-control, cushioned, and lightweight.

**Stability** shoes have a good mix of cushioning, medial support, and durability. These shoes are generally semicurved with a combination last to offer hindfoot stability and forefoot flexibility. They often have a medial post or multidensity midsole to provide a degree of pronation control. Stability shoes are well suited to the midweight runner who has neutral pronation and medium-to-low arches.

**Motion-control** shoes are the most rigid and are designed for limiting overpronation. Many have a straight last and board construction that offer stability and maximum medial support. Typically, they have a medial post and a multidensity or polyurethane midsole. These shoes tend to be the heaviest, most durable, and most expensive running shoes. Motion-control shoes are geared toward the heavyweight overpronator who has flat arches.

**Cushioned** shoes have the most flexibility, the softest midsole, and the least medial support. Their midsoles may include compression molded or encapsulated EVA, silicone gel pads, silicone flow chambers, or other brand-specific shock-absorbing features. They are usually built with a curved or semicurved shape and slip-lasted construction. These shoes are most appropriate for light-to-midweight runners who underpronate and have high arches.

**Lightweight** shoes are designed for speed. They are constructed for basic cushioning and support and are often used for fast-paced training or racing. High-performance, biomechanically neutral runners generally use these, because lightweight shoes may offer a kinematic advantage for training and competition.<sup>7,12</sup>

## **The Office-Based Exam**

In a relatively short office visit, clinicians can use a simple, step-by-step approach to help patients find the source of their current injury and help prevent future injuries .

**Training review.** Any clinic visit with an injured runner should start with a review of his or her training log. It is important to look not only at weekly mileage, but also for a "transition point" in the training that could have led to overuse. Evaluate the training plan for an increase in distance or intensity and for any change in terrain or running surface. An increase in mileage greater than 10% per week is consistent with an increased injury rate.<sup>13,14</sup>

**Shoe examination.** Information on current running shoes should include the age (when purchased, number of days worn, and total accumulated mileage),<sup>15</sup> replacement frequency, and if they are a new brand or model that could have changed the runner's biomechanics and caused injury. New shoes can lose some of their shock-absorbing cushion—even if they have not been worn—after 12 to 24 months (Robert P. Wilder, MD, written communication, July 8, 2004). All of these are important historical points to consider, even prior to examining the patient.

Even more revealing than asking runners the age of their shoes is examining the shoes themselves. A well-used pair of shoes will show their age (ie, if they are worn out) as well as the runner's foot type, which can be seen by examining the shoe outsole and midsole wear pattern.

Runners normally land on the outside of the heel at initial contact, rotate inward to the midfoot, and toe off from the ball of the foot between the first and second toes. Thus, the typical wear on the outsole from frictional forces against the running surface is primarily on the lateral heel and, to a lesser degree, along the anterior and medial forefoot. The extreme pronator will strike on the inside of the heel and wear out the medial border of the sole, particularly under the great toe. The underpronator (or supinator) will wear out the lateral border of the sole from heel to toe.<sup>16</sup>

A quick test to assess the midsole wear pattern is to place the shoes on a level surface and observe the heels for tilt. A medial tilt indicates overpronation, and a lateral tilt signifies underpronation.

Old running shoes may also reveal that their functional age is much older than their chronologic age. The major areas of decomposition—the heel counter, the midsole, and the outsole—need particular attention. Examining the shoe may reveal a broken-down heel counter or a midsole with excessive wrinkling, tilt, or frank decomposition (figure 5). A shoe with a badly worn medial heel counter or

excessively compressed medial midsole can actually promote overpronation and its associated overuse injuries. Likewise, over time, even a runner who has a normal gait wears off the lateral edge of the heel. This extrinsic abnormality causes an imbalance of impact forces and may increase injuries.<sup>10</sup> If any of these signs are evident, the shoes have reached "retirement age" (see "What Every Runner Should Know About Shoes," box below).

## **What Every Runner Should Know About Shoes**

### **Proper Shoe Fit**

- Know what type of shoe is best for your foot.
- Buy shoes from a specialty running store or knowledgeable Internet retailer to ensure proper shoe type and fit. Running magazines frequently list specialty stores by state, so runners can find a local source.
- Buy shoes that are appropriate for your foot type and training intensity, not for cosmetics, celebrity endorsement, or cost.
- Always get fitted for running shoes in the evening. Feet are larger at the end of the day. There should be half an inch between the longest toe and the end of the toe box.
- Wear running socks when trying on shoes to ensure proper fit.
- If you wear orthotic inserts, bring them along and try them in the new shoes before buying.
- Take a test run in the shoes at the store before purchasing to confirm comfort and fit.
- If the shoes don't feel good in the store, don't buy them. Running shoes do not need to be "broken in" to be comfortable.

### **Running Shoe Care**

- Wear running shoes only for running. Wearing running shoes for walking or playing other sports can break down the motion control and cushioning of your shoes.
- Don't kick off your shoes without untying them. This will destroy the heel counter.
- Avoid running in wet shoes. A wet midsole has 40% to 50% less shock absorbing capability.<sup>1</sup>
- Don't wash running shoes in the clothes washer. This will deform their shape.
- Exposure to excessive heat will degrade the components of the shoe. Let them dry naturally after exposure to water.

### **Running Shoe Replacement**

- Excessively worn running shoes may lead to injury. Researchers note a significant correlation between infrequent change of running shoes and injuries.<sup>2</sup>
- Replace shoes every 400 to 600 miles or every 6 months. Estimate your weekly mileage and mark your calendar as a reminder.
- Outsoles are made of durable compounds and are a poor indicator of remaining shoe life. In most cases, the midsoles will wear out long before the outsole, especially for heavier runners.
- Midsole materials last for approximately 400 to 600 miles or 6 to 12 months, depending on the mileage and intensity of training.<sup>3,4</sup> Midsole wear can be subtle and manifest by excessive wrinkles and compression of the sock liner.
- Running shoes may lose between 30% and 50% of their shock absorption after about 250 miles of use.<sup>2</sup> Even sitting on a shelf, their shock absorbing capabilities are significantly reduced after 1 to 2 years (Robert P. Wilder, MD, written communication, July 8, 2004).
- Alternating between two pairs of running shoes will extend the life of the midsole longer than wearing each pair of shoes consecutively.<sup>5</sup>

## REFERENCES

1. Cook SD, Kester MA, Brunet ME: Shock absorption characteristics of running shoes. *Am J Sports Med* 1985;13(4):248-253
2. van Mechelen W: Running injuries: a review of the epidemiological literature. *Sports Med* 1992;14(5):320-335
3. Taunton JE, Ryan MB, Clement DB, et al: A prospective study of running injuries: the Vancouver Sun Run "In Training" clinics. *Br J Sports Med* 2003;37(3):239-244
4. Cook SD, Kester MA, Brunet ME, et al: Biomechanics of running shoe performance. *Clin Sports Med* 1985;4(4):619-626
5. Martin DR: Athletic shoes: finding a good match. *Phys Sportsmed* 1997;25(9):145-146

**Arch appraisal.** After patients remove their shoes, have them stand with their feet shoulder-width apart. Examine the arch contour, then have patients wet their feet and observe the footprints left on a piece of dark paper. These two observations are used to place the runner in one of three arch categories—high, medium, or low/flat. Because of biologic variation in soft-tissue structure, static evaluation does not always correlate with what happens during running. It is essential to combine measurements in static stance with dynamic gait analysis to obtain a clearer picture of whether under- or overpronation occurs.<sup>17,18</sup>

**Gait analysis.** By closely observing the walking gait, the clinician can

establish if the patient tends to under- or overpronate and if significant biomechanical abnormalities predispose the patient toward injury. The patient walks about 15 to 20 m (50 to 65 ft) while the clinician monitors from behind, specifically watching for location of heel strike, foot motion through single-leg stance phase, and which part of the foot is engaged at push-off.

A side view of the patient walking is also important. From the side vantage point, it is possible to observe early heel-off, suggestive of gastrocnemius-soleus muscle tightness, as well as inadequate great toe dorsiflexion in the terminal stance, which is frequently seen with overpronation.<sup>19</sup>

A complete biomechanical assessment would include leg-length inequalities, pelvic obliquities, flexibility, and strength or muscle imbalances. Further discussion of this is beyond the scope of this article.

Some healthcare providers may choose a more sophisticated treadmill-based analysis. The only equipment needed is a standard treadmill and a video recorder. With the recorder filming at surface height, the patient is videotaped while walking, then running barefoot at 4 to 5 mph. The recording can be played back in slow motion, frame by frame, to analyze the features of the running gait, focusing on heel strike, stance, and push-off. This technique is repeated with the patient wearing his or her usual running shoes. The clinician evaluates whether the shoe corrects or worsens the barefoot gait. If the gait is worsened, another type of shoe should be recommended.<sup>20</sup>

Another sophisticated analysis technique uses one of several commercially available force-plate technologies, such as the F-Scan system (Tekscan Inc, South Boston, Massachusetts). With this method, a small sensor is placed in the shoe and measures force distribution to detect gait abnormalities.

### **Running Shoe Prescription**

Based on the results of the exam, clinicians can guide runners toward making the correct shoe selections. Patients can also find helpful information on many Internet sites (see "Consumer Web Resources for Running Shoe Information," box below).

### **Consumer Web Resources for Running Shoe Information**

Those who have Internet access may find the following sites helpful.

<http://www.runnersworld.com>

An excellent resource for shoe information, location of specialty running stores, training, and general running information.

<http://www.runningtimes.com/shoes>

Shoe guide with excellent self-fitting instructions and other running information.

<http://www.roadrunnersports.com>

Comprehensive mail order shoe guide with knowledgeable support staff who can assist with shoe recommendations.

<http://www.brooksrunning.com/sportsmed/index2.htm>

Information about common running injuries as well as information about Brooks running shoes.

<http://www.nike.com>

Nike running shoe technology resource with tips on shoe selection and fit.

<http://www.saucony.com/>

Saucony running shoe information with helpful tips on shoe selection.

<http://www.asicstiger.com>

Information about Asics running shoes arranged by shoe type.

[http://www.newbalance.com/techcenter/getting\\_fit.html](http://www.newbalance.com/techcenter/getting_fit.html)

Shoe fitting information from New Balance.

All sites accessed September 16, 2004.

A patient who has a high arch will often underpronate and will benefit from a curve-lasted, cushioned-type shoe. These runners should avoid motion-control or stability shoes that will tend to further minimize their foot mobility.

Runners who have flat-arched, hypermobile feet are predisposed to overpronation. Low-to-flat arches are best fit with motion-control or stability shoes with firm midsoles and straight-to-semicurved lasts. Overpronators should avoid cushioned-type, curve-lasted shoes.

Runners who have normal arches can wear either cushioned or stability shoes. If patients have a normal arch and no biomechanical abnormalities, a cushioned shoe is appropriate. If they have some mild-to-moderate pronation, a stability shoe is probably a better choice. Lightweight runners who have no biomechanical problems could use lightweight trainers, but this should be

discouraged except for races, as these shoes provide less shock absorption.

## **How Orthoses Can Help**

Orthoses (commonly called "orthotics") are inserts placed in shoes to influence the pattern of leg movement through a combination of mechanical control and biofeedback.<sup>21</sup> Although "orthotics" is the branch of medical science that deals with the design and fitting of orthoses, use of the word "orthotics" to mean shoe inserts has gained widespread acceptance.

Orthotic devices are commonly used to reduce the frequency of movement-related disorders, to correct skeletal alignment, to increase cushioning, or to improve comfort. Some runners may notice symptomatic relief from overuse injuries.<sup>22</sup> Orthoses may be an option for runners who have anatomic problems (eg, moderate-to-severe pes planus, excessive heel or forefoot angulation, leg-length discrepancy) if standard running shoes provide inadequate correction.<sup>6,23</sup> They may also be used if one foot needs more correction than the other.

Podiatrists or orthotic labs generally fabricate orthoses after referral from primary care providers or sports medicine physicians. If orthoses are prescribed, the runner should be wearing shoes that are combination or board lasted. Runners using orthoses who subsequently develop or sustain recurrent overuse injuries should have their inserts inspected for proper fit, wear, and breakdown.

## **Consumer Confidence**

A multitude of different running shoe models are marketed. Uninformed consumers may unintentionally choose the wrong shoe for their foot type or body habitus. Physicians can help runners avoid preventable overuse injuries by taking the time to do a step-by-step exam and making a running shoe prescription. By applying the information gained from the exam, clinicians can help runners learn to confidently and consistently select shoes that are fit for performance and help prevent injury.

*The opinions or assertions contained in this article are the views of the authors and should not be construed as official or reflecting the views of the United States Army or the Department of Defense.*

*The authors acknowledge COL Francis G. O'Connor, MD, and the Madigan faculty development fellows for their review of this manuscript.*

**References**

1. van Mechelen W: Running injuries: a review of the epidemiological literature. *Sports Med* 1992;14(5):320-335
2. Milgrom C, Giladi M, Stein M, et al: Stress fractures in military recruits: a prospective study showing an unusually high incidence. *J Bone Joint Surg Br* 1985; 67(5):732-735
3. Johnson JA: The running shoe, in O'Connor FG, Wilder RP, Nirschl R (eds): *Textbook of Running Medicine*. New York City, McGraw-Hill, 2001, pp 589-594
4. Frey C: Footwear and stress fractures. *Clin Sports Med* 1997;16(2):249-257
5. Gardner LI Jr, Dziados JE, Jones BH, et al: Prevention of lower extremity stress fractures: a controlled trial of a shock absorbent insole. *Am J Public Health* 1988;78(12):1563-1567
6. Nigg BM: The role of impact forces and foot pronation: a new paradigm. *Clin J Sport Med* 2001;11(1):2-9
7. Reinschmidt C, Nigg BM: Current issues in the design of running and court shoes. *Sportverletz Sportschaden* 2000;14(3):71-81
8. Barnes RA, Smith PD: The role of footwear in minimizing lower limb injury. *J Sports Sci* 1994;12(4):341-353
9. Cook SD, Brinker MR, Poche M: Running shoes: their relationship to running injuries. *Sports Med* 1990;10(1):1-8
10. Cook SD, Kester MA, Brunet ME: Shock absorption characteristics of running shoes. *Am J Sports Med* 1985;13(4):248-253
11. Prichard AE: Running shoe design, selection, and care: does it make a difference? *Army Med Dept J* 2000;PB 8-01-4/5/6:43-51
12. Stefanyshyn DJ, Nigg BM: Energy aspects associated with sport shoes. *Sportverletz Sportschaden* 2000;14(3):82-89
13. Brill PA, Macera CA: The influence of running patterns on running injuries. *Sports Med* 1995;20(6):365-368
14. Yeung EW, Yeung SS: A systematic review of interventions to prevent lower limb soft tissue running injuries. *Br J Sports Med* 2001;35(6):383-389
15. Taunton JE, Ryan MB, Clement DB, et al: A prospective study of running injuries: the Vancouver Sun Run "In Training" clinics. *Br J Sports Med* 2003;37(3):239-244
16. Noakes TD: Shoe choice, in *Lore of Running: Discover the Science and Spirit of Running*, ed 3. Champaign, IL, Human Kinetics, 2002, pp 489-498
17. Saltzman CL, Nawoczenski DA, Talbot KD: Measurement of the medial longitudinal arch. *Arch Phys Med Rehabil* 1995;76(1):45-49
18. Cashmere T, Smith R, Hunt A: Medial longitudinal arch of the foot: stationary versus walking measures. *Foot Ankle Int* 1999;20(2):112-118

19. Dananberg HJ: Sagittal plane biomechanics: American Diabetes Association. *J Am Podiatr Med Assoc* 2000;90(1):47-50
20. O'Connor FG, Hoke B, Torrance A: Video gait analysis, in O'Connor FG, Wilder RP, Nirschl R (eds): *Textbook of Running Medicine*. New York City, McGraw-Hill, 2001, pp 59-66
21. Subotnick SI: Foot orthotics, in O'Connor FG, Wilder RP, Nirschl R (eds): *Textbook of Running Medicine*. New York City, McGraw-Hill, 2001, pp 595-603
22. Gross ML, Davlin LB, Evanski PM: Effectiveness of orthotic shoe inserts in the long-distance runner. *Am J Sports Med* 1991;19(4):409-412
23. Mundermann A, Nigg BM, Humble RN, et al: Orthotic comfort is related to kinematics, kinetics, and EMG in recreational runners. *Med Sci Sports Exerc* 2003;35(10):1710-1719

**Dr Asplund** is a family physician in the department of community and family medicine at Eisenhower Army Medical Center in Fort Gordon, Georgia. Dr Brown is the director of primary care sports medicine at Madigan Army Medical Center in Fort Lewis, Washington. **Address correspondence to** Chad Asplund, MD, 791 Osprey Lane, Martinez, GA 30907; e-mail to [Chad.Asplund@us.army.mil](mailto:Chad.Asplund@us.army.mil).

**Disclosure information:** Drs Asplund and Brown disclose no significant relationship with any manufacturer of any commercial product mentioned in this article. No drug is mentioned in this article for an unlabeled use.

Copyright (C) 2005. The McGraw-Hill Companies. All Rights Reserved  
[E-mail Privacy Policy](#)