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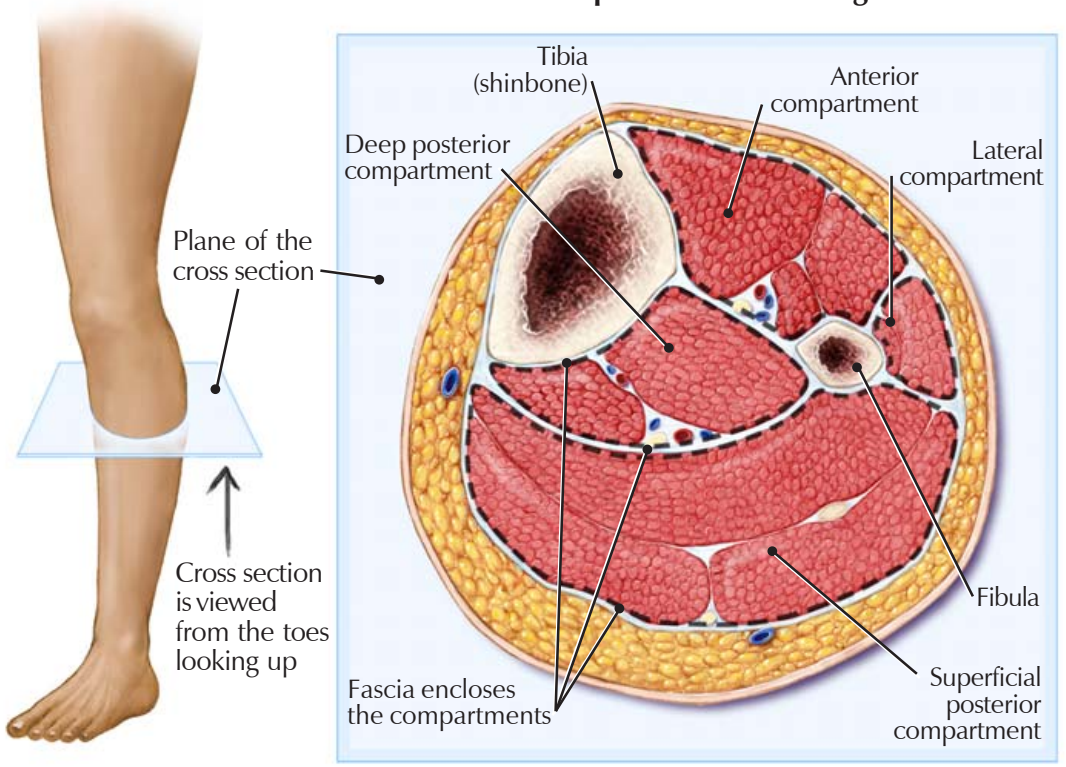
Compartment Syndrome

Swelling out of control

In a few brief hours, an arm or leg can be damaged to the point at which amputation is necessary. Although rare, compartment syndromes can occur without warning, after a musculoskeletal injury or surgery. Once swelling begins, your physician has only hours to intervene to prevent permanent damage. Compartment syndromes literally represent swelling out of control; however, this swelling is not visible to the eye because it occurs deep inside the limb. The painful condition results when swelling occurs within a group of muscles, nerves, and blood vessels within the arms, legs, feet, or buttocks enclosed within a membrane called fascia (Fig. 1). The fascia is tough and does not easily expand; therefore, when swelling occurs it causes pressure to build within the fascial compartment and the contents of the compartment can be damaged quickly.

Fig. 1 Compartments of the leg



Microcirculation

Although present throughout the body, the compartments most vulnerable to compartment syndrome are found in the forearm and lower leg. The circulatory blood pressure in our arteries averages 120 mm Hg, but in the capillaries the pressure drops to about 30 mm Hg. If surrounding pressures rise above that in the capillaries, nutrients cannot flow out to the cells and the byproducts of metabolism cannot be removed. In just hours, unnourished cells are exposed to damage. First they swell, and then they die releasing chemicals that cause further swelling. The additional swelling increases pressure, and a

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dangerous spiral can quickly develop into a serious medical emergency.

Ironically, pulses can still be felt on the other side of an involved compartment because arterial blood pressures are much higher, giving a false reassurance that all is well within the limb. It is, however, the circulation of the capillaries and cells that is being challenged and cut off causing the tissues it feeds to begin to die (Fig. 2). Tissues die at different rates; for example, nerve tissue cannot last more than a few hours without circulation. Beyond that, permanent paralysis results. Muscle tissue is not far behind. Besides the loss of the muscle's function, the dead muscle can release toxins that can cause kidney failure and death.

Diagnosis and treatment

Classic compartment syndromes can be caused by crushing or severe high-energy injuries to limbs in which the skin remains intact, however, they can appear with less serious injury or even after surgical procedures. Physicians suspect a compartment syndrome when the pain of an injury or surgery is out of proportion to what is anticipated. Tenseness and pain can be felt in the involved compartment when the muscles are stretched. If these positive clinical signs of the syndrome are present, the physician will measure the pressures within the compartment.

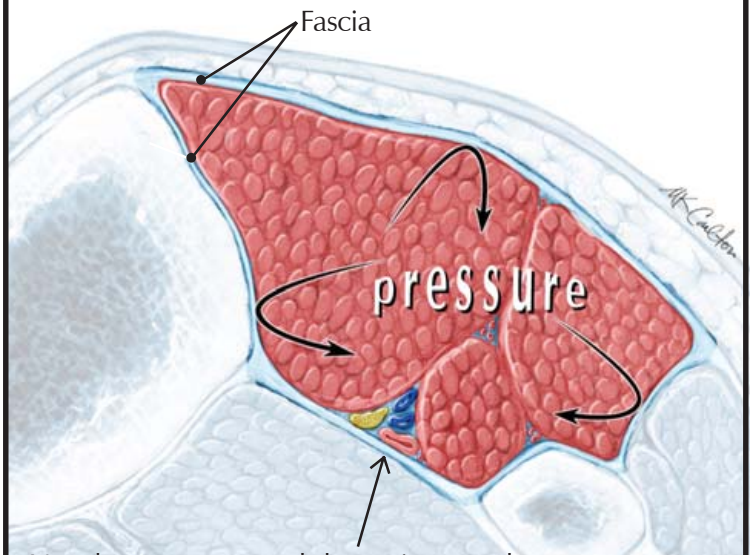
Treatment often involves an emergency surgery called a fasciotomy. During this procedure, the unyielding sleeve of fascia is literally split open to allow swelling to occur and to lower the rising pressures (Fig. 3). After surgery, the swelling subsides, the danger ends, and the fascia eventually reforms.

A curious variant of compartment syndrome, the **exertional compartment syndrome**, is known to affect some athletes. It occurs as a result of swelling to a compartment only during exercise, and it resolves rapidly when the activity ends. The condition rarely progresses to the dangerous spiral described above, but it can be disabling to an athlete by limiting his or her ability to participate. Exertional compartment syndrome can be diagnosed by a direct measurement of compartment pressures during exercise. If pressures in a given compartment rise to dangerous levels during the exercise period, a fasciotomy may be recommended and can be expected to end the condition permanently.

Fortunately, the out of control swelling that is associated with compartment syndromes is rare. Physicians are vigilant to detect them and the treatment is effective.

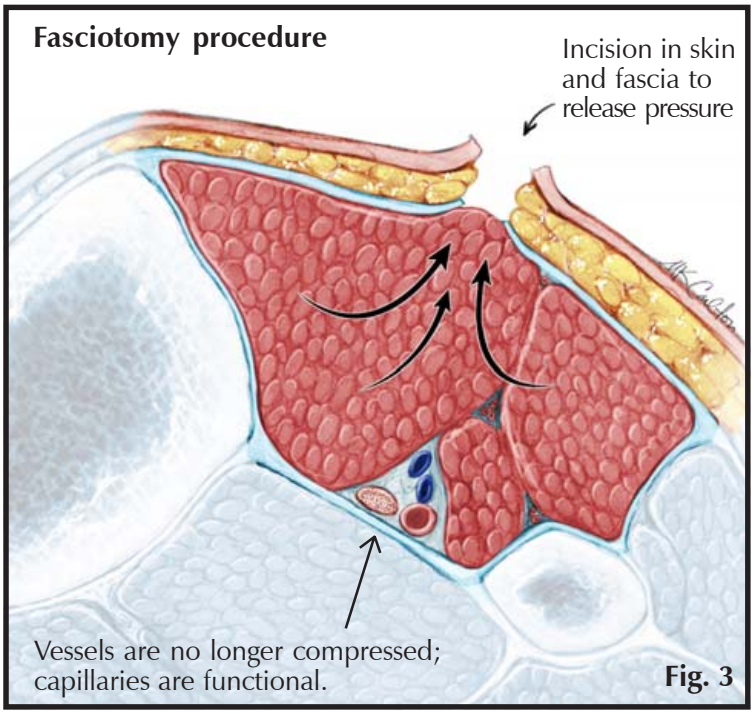
Fred Flandry, MD, FACS
Columbus, Georgia

Compartment syndrome in the anterior compartment



Vessels are compressed due to increased pressure; capillaries are no longer functional. **Fig. 2**

Fasciotomy procedure



Vessels are no longer compressed; capillaries are functional. **Fig. 3**

Runners, Start Your Engines!

To get a good start in your next race, you should warm-up and stretch your muscles. Improperly stretching a cold muscle before running can cause injury. It's like waking up on a cold December morning and not warming up your car. You wouldn't jump in and go 100 miles per hour, especially if you're an older model. Unless you are a 2005 Porsche Boxter you need a warm-up before leaving pit row. A thorough warm-up before stretching heats up your muscles and prepares them for a thorough stretching routine.

Your warm-up should be gradual and last for 10 to 15 minutes. Begin with a slow-intensity jog or a brisk walk to rev-up your engine. Once you feel warm and your heart rate has increased, begin your stretch program. Remember, stretching should not be painful. Focus on the major muscle groups in the legs, back, and arms. You should hold the stretch for 15 to 30 seconds for 3 to 5 repetitions. Your total pre-run stretch time should last approximately 10 minutes.

A good stretching program should include stretches for your buttocks, hips, thighs, and calves, such as the quadriceps, calf, hamstring, and iliotibial band stretches that follow this article. Stretching these main regions can help to reduce muscle soreness after a run. You must also be careful of how you stretch. Technique is very important in injury prevention. Runners should avoid stretching too quickly, because it can cause the muscle to respond with a strong contraction and increase tension. Prolonged stretching is better. Do not stretch past the point at which you begin to feel tightness in the muscle. You should let pain be your guide. If your vehicle starts rattling and making noise, you stop and listen. You should listen to your body, as well. If the stretch begins to cause pain, decrease the amount of stretch. No pain, no gain is an overplayed philosophy that can cause injury and put you out of the race.

Just as you warm-up, you should also cool down with stretching. Use the same stretches that you used to warm-up with to cool down. Cool down stretching increases your flexibility and improves your performance on the next run.

Lisel Wally, PTA and
J. Benjamin Belle, PT
Columbus, Georgia

Photo by Carol Capers

Quadriceps stretch

Stand straight with your left knee bent. Hold your foot with your left hand and slowly bring your heel toward your buttocks. The stretch should be felt in the front of the left thigh. Hold for 15 to 30 seconds and repeat 3 to 5 times. Repeat using your right leg and hand.

Calf Stretch

Stand with your hands against a wall, chair, or other sturdy object. Place your left leg behind your right leg. Keep your left leg straight, heel on the floor, and toes pointed straight ahead. Slowly lean forward, bending your right leg. The stretch should be felt in the middle of your left calf. Hold for 15 to 30 seconds and repeat 3 to 5 times on each leg.

Photo by Carol Capers

Photo by Carol Capers

Hamstring Stretch

Sit with your left leg straight out in front of you and your right leg bent or off the edge of a table. Keeping your back straight and your head up, slowly lean forward at your waist. You should feel the stretch along the back of your left thigh. Hold for 15 to 30 seconds and repeat 3 to 5 times using each leg.

Iliotibial Band

Sit with your left leg bent and crossed over your straight right leg. Twist your waist away from the right side and slowly pull your left leg toward your chest. The stretch should be felt in the buttock side of your hip. Hold 15 to 30 seconds and repeat 3 to 5 times. Change legs and repeat the stretch keeping your left leg straight.

Photo by Carol Capers

CHECKLIST: *Before you run*

Check your alignment.
Examine your alignment from your feet to your pelvis. Do your feet or knees lean in? Are your arches flat? Do your kneecaps look at each other? If any of these conditions exist, you should use motion control shoes; build your quadriceps, hip flexors, abductors, adductors, and gluteal (buttocks) muscles with strengthening exercises and low-mileage training (less than 20 miles a week). You should also consider nonweight-bearing activities such as cycling and swimming.

Examine your shoes.
Do they lean in? If so, wear motion control shoes. If they lean out, wear shoes that are flexible and cushioned. Do you have stress points and wear patterns on the heel, midsole, or the outsole of your shoes? Most shoes will begin to show wear and loss of shock absorbency at around 150 miles, but you shouldn't need to replace them until 300 to 350 miles.

Check your stride.
Your normal stride is what feels comfortable to you. Over striding wastes energy and increases your chance of injury.

Test yourself.
What is your goal: fitness or competition?
If it is fitness, running less than 25 miles a week is adequate. Slowly build up your mileage. You should be able to walk briskly for 2 miles during 5 consecutive training sessions before you start running. For example, give yourself the talk test, which means you should be able to carry on a conversation while walking. If you are comfortable after 5 consecutive walks, you can begin jogging or running for 3- to 5- minute intervals with 2-minute rests between each interval. Don't forget the talk test! Continue to test yourself as you go.

Gradually increase your running time until you can jog 30 minutes comfortably. Your ultimate goal is 40 minutes to an hour, especially if you want to lose weight. Be consistent, it's important, so run 3 to 5 times a week. As you approach competition, use hard- and easy-day routines. Do not speed drill more than once a week. You do not have to run mega miles to be competitive, even if you are training for a marathon. Quality runs are recommended over long, slow distances. For example, running at 80 to 90 percent maximum heart rate or 15 to 30 seconds less per mile than your best race time.

Avoid overuse injuries.
Running less than 25 miles per week is your safe zone. At more than 35 miles per week you are increasing your risk of injury. Running more than 50 miles per week is your risk zone. Remember, quality miles are better than mega miles.

Do your stretching.
Stretch at your own stretch level, which means to the point you feel the stretch. Stretch your hamstrings, heel cord, and lower back. Hold stretches no more than 3 to 5 seconds. Over stretching is as dangerous as no stretching.

Choose good terrain.
Run on flat and rolling terrain. Avoid uneven surfaces, stair running, and hills (especially down hill) because it increases your chance of injury. Be sure to change your course frequently.

William C. Etchison, MS, Columbus, Georgia
Bill Etchison has run 17 marathons, including 3 Boston marathons, injury free.

Finding Your Running Shoe

Matching foot type to shoe type

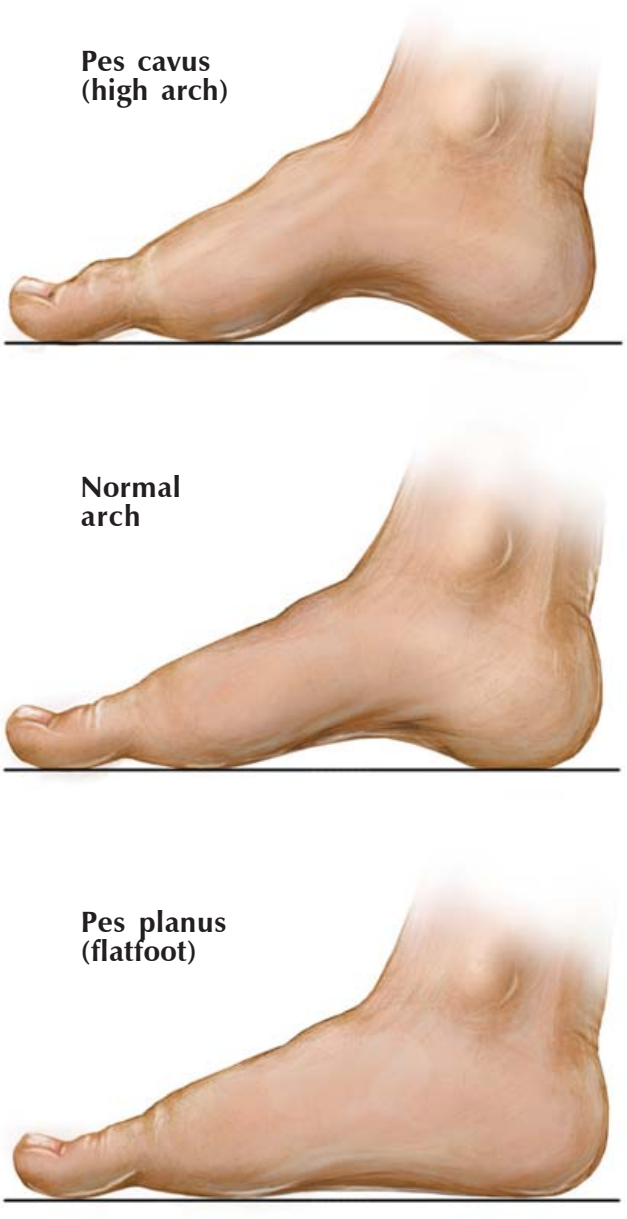
Whether you jog for recreation and fitness or run competitively at a scholastic or masters' level, chances are you have suffered from some type of repetitive stress injury, such as plantar fasciitis, shin splints, or even stress fractures. Although many factors can contribute to a stress injury, you seldom need to look further than your own shoes to find the culprit. It is estimated that impact forces transmitted through the lower leg during running are nearly 2½ to 3 times body weight. Nearly twice that of walking, the stress on the supporting soft tissues is 4 times greater than that imposed during walking.[1] Footwear, however, has been shown to reduce those forces[2], becoming an ally in the prevention of injuries among runners. As advantageous as a properly selected shoe is, an improperly selected shoe can increase the magnitude of undesirable forces, and thus predispose you to injury.

Shoes are often selected based on marketing techniques and an appealing design instead of their functional qualities. So how do you know which shoe is best for you? Before choosing a running shoe, you need to know your foot type and the classification of shoe best suited for your foot. Once you know these two factors, you can match them and make a wise decision in purchasing a shoe.

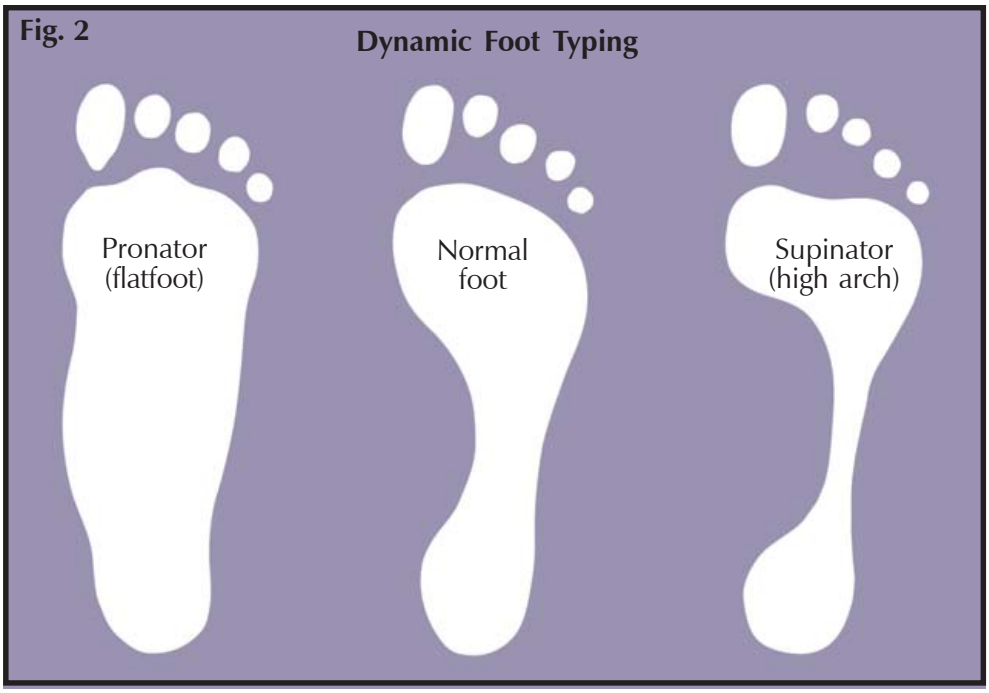
Identifying your foot type

The foot's structure is relatively unique to each individual, and can differ within the same individual from one side to the other. Scientific evaluation of the type of foot one has can be a complicated process, requiring high-tech equipment and slow-motion video; however, most of us can make a general assessment with relative accuracy. Assessment of one's foot type consists of determining the height of the foot's arch, or instep, and then placing the foot in 1 of 3 structural categories. A foot that appears to have an excessively high arch is classified as a **pes cavus** foot, while a flattened arch is classified as **pes planus**, more commonly referred to as a flatfoot (Fig. 1).

Fig. 1 **Foot Type**



You can use static or dynamic conditions to determine your foot type. During a static assessment, your foot is held stationary, and you can either stand (weight bearing) or sit (nonweight bearing). For example, during a nonweight-bearing evaluation, visually assess the arch height while sitting on a table without letting your foot touch the ground. A weight-bearing assessment is performed while standing with an equal amount of weight on each foot. A dynamic assessment looks at the way the arch height is maintained while the foot is moving, such as during walking or running. An evaluation of this kind replicates the actual movements and forces the foot undergoes during activity; therefore, it is considered to be more accurate than the static assessment. An accurate self-evaluation can be done by placing your foot in either chalk dust or water and then standing on a small chalkboard or on lightly colored construction paper respectively. Lift one foot off the ground, and while lightly touching a sturdy object for balance, perform a mini squat by slightly bending at the knee of the weight-bearing leg. Return to a normal stance with both feet on the ground. Then, carefully lift your test foot off the board or paper. Based on the appearance of the outline your foot made, you can classify your foot type (Fig. 2). Under dynamic conditions, the individual who maintains a high arch is classified as a **supinator**, while the individual whose arch flattens excessively is classified



as a **pronator**. Gross assessment of dynamic foot mechanics with the naked eye can be very difficult for even the well-trained clinician; therefore, to ensure an accurate assessment, I suggest a thorough gait evaluation using slow-speed filming performed by a trained professional.

Identifying shoe type

Just as the foot functions differently based on its unique structure, a shoe also functions differently based on its design. Conveniently, shoes are classified into three categories according to their structure and function, and are called cushion, stability, or motion control shoes. When looking at the bottom of the shoe, the cushion-style shoe has a curved appearance from the heel to the toes. Its midsole will have one continuous color and a softer, flexible heel counter. A stability shoe will have a semi-curved shaped, a dual density midsole, which appears as a different color from the rest of the outsole, and a reinforced-sturdy heel counter. The motion control shoe will have a straight shape to it, a dual density midsole, and a rigid heel counter.

Matching foot type to shoe type

Figure 3 can help you determine which shoe is best for your type of foot. As the chart shows, I suggest a motion control shoe only for pronators who are of significant stature or weight. The majority of pronators will do fine with a stability class shoe.

Because the information provided here is little more than a crash course in shoe type identification, you can go to www.roadrunnersports.com or Runner's World magazine for the shoe manufacturer's classification of their running shoes. Also, most sales associates at reputable running shoe stores have access to the specific classification of the shoes they carry.

Daniel Kraushaar, PT, CSCS
Columbus, Georgia

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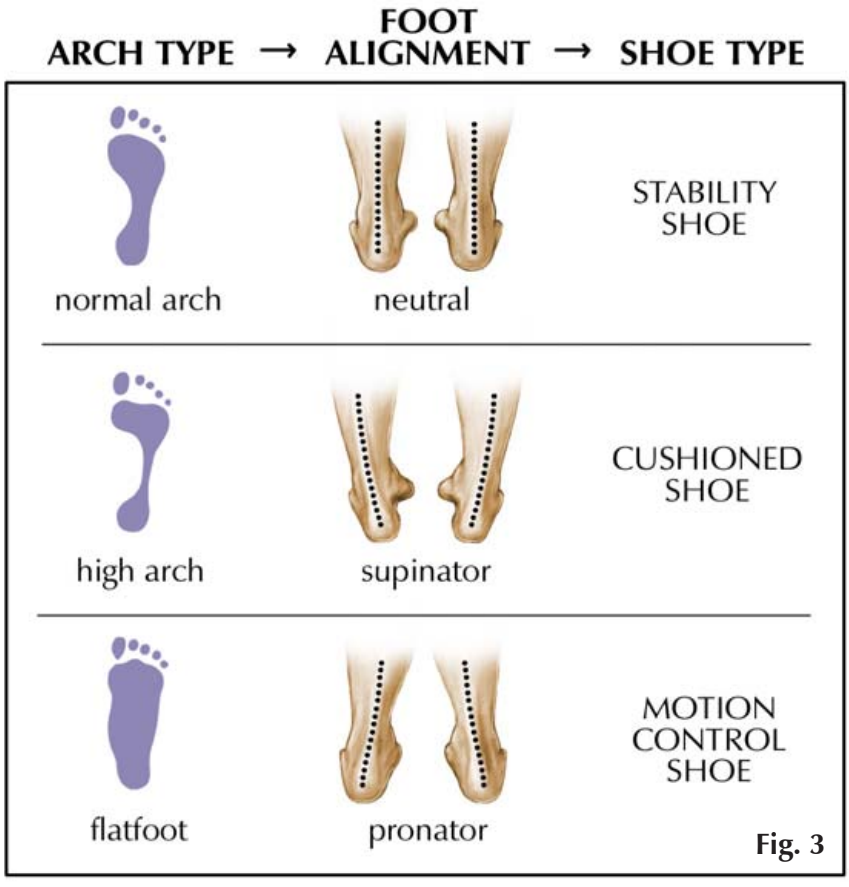

Fig. 3

Fred Flandry, MD, FACS, graduated from Tulane University and earned his medical degree from Tulane University School of Medicine. He completed his residency in orthopaedic surgery through Tulane University Affiliated Hospitals. After his residency, he completed a fellowship in sports medicine and arthroscopic surgery at The Hughston Clinic, and, thereafter, he studied traumatology at major centers in the United States, Canada, and Europe.

Certified by the American Board of Orthopaedic Surgeons and the American Academy of Pain Management, Dr. Flandry holds fellowships in the American Academy of Orthopaedic Surgeons, American College of Surgeons, and American College of Sports Medicine. He serves on the North American faculty for teaching techniques of the Swiss AO Group. In all, he holds memberships in 16 national and international specialty societies for orthopaedic surgery, orthopaedic research, sports medicine, traumatology, and arthroscopy.

Dr. Flandry was involved in the creation and development of the *Hughston Health Alert* and served as its first editor.

The *Hughston Health Alert* is a quarterly publication of the Hughston Sports Medicine Foundation, Inc. The Foundation's mission is to help people of all ages attain the highest possible standards of musculoskeletal health, fitness, and athletic prowess. Information in the *Hughston Health Alert* reflects the experience and training of physicians at The Hughston Clinic, PC, of physical therapists and athletic trainers at Hughston Rehabilitation, of physicians who trained as residents and fellows under the auspices of the Hughston Sports Medicine Foundation, Inc., and of research scientists and other professional staff at the Foundation. The information in the *Hughston Health Alert* is intended to supplement the advice of your personal physician and should not be relied on for the treatment of an individual's specific medical problems.

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HUGHSTON
6262 Veterans Parkway
P.O. Box 9517
Columbus GA 31908-9517
Hours of Operation:
M-F 8:30-5:30
Appointments:
706-324-6661
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