CHAPTER 6

Pronate Nation

I believe in keeping running simple and, in regard to shoes, that would mean no gimmicks, unnecessary cushioning, etc.

—Bill Rodgers

I was a bit apprehensive about going to a specialty running store for the first time back in the summer of 2007. At the time I didn't yet consider myself to be a "real" runner, and all of my shoes were typically purchased online or in sporting goods stores largely on the basis of pricing and appearance (cheap and cool-looking meant good!). I vividly remember walking into the store. The fit young female employee asked me if I was training for a race. "Training" was a foreign word to me at the time. Running was just exercise, a way to keep my weight down, and shoes were just shoes. But I was training for a 4-mile race, so I said yes, and we proceeded onward with the shoe fitting. When I told her about my aches and pains, particularly the soreness in my knees and shins, she took one look at my shoes and asked if I ran on roads or trails. My response ("roads") was apparently not the right one in her eyes. It pegged me as a beginning runner, or so I thought. I was tempted to leave. However, her response that I was wearing incorrect shoes for my running needs made me realize that at least I was in the right place if I was going to get serious about the sport.

She asked me to take off my shoes and run across the carpeted store in my socks. She watched intently from behind, and after a few laps back and forth she asked an older guy who had emerged from the stock room what he thought. They agreed that I was a moderate overpronator, and that I should probably opt for a pair of stability shoes. After determining my shoe size, she disappeared into the back room, where I could see stacks of shoe boxes piled high on shelves. She soon emerged with three pairs of shoes: Nike Air Structure Triax, Brooks Adrenaline, and Saucony Guide. I tried on all three, and was shocked when she suggested that I take each for a short run around the block. No shoe store salesperson had ever suggested that I should actually do a test run in the shoes I was going to buy! Weren't they worried that I was going to scuff up the soles?

The Brooks Adrenalines felt too firm, and as a new runner I wasn't really all that familiar with the brand so I crossed them off as a viable option. The Nike and Saucony shoes both felt great on my feet—both were plush and pillowy—but the Nike's fiery red highlights caught my eye, and I liked that they had that familiar little swoosh on the side. I opted to buy them, and for the next two years I was hooked on stability shoes. I didn't dare buy anything else, because the expert at the store had told me that they were what my "moderately pronating" feet needed. The last thing I wanted was an injury that would derail my fledgling running career. Little did I know at the time just how little evidence there was to support my initial running shoe prescription . . . —PML

Let's say that you've decided to embrace your inner persistence hunter and feel reborn as a runner. In a sport that requires very little in the way of equipment, perhaps the only essential piece of gear that you'll need is a good pair of shoes. As the preceding chapters have shown, shoe design has changed dramatically over the years, and the running shoe has gone from little more than a simple leather foot covering to a complex mix of synthetic fabrics, foams, and technological add-ons that are supposed to protect a runner from injury and maximize his or her performance. Furthermore, instead of having a shoemaker construct a customized shoe based off measurements taken from his

or her own feet, the typical runner buys mass-produced shoes from a relatively small number of manufacturers that are typically designed to fit an "average" foot. Unfortunately, your foot shape may not fit the "average," and determining which technologies are beneficial and which are merely gimmicks can be challenging. Given these difficulties, how do you go about buying your first pair?

If you're like most people, your first thought might be to head out to the local discount store, shopping mall, or sporting goods chain store and choose the one that looks and feels the best. As soon as you enter the store, you are immediately faced with what Christopher McDougall has so aptly referred to as the "Bewildering Wall of Shoes." The shoes are brightly colored, plushly cushioned, and openly flaunt the various technological features housed within—often with little windows in the sole that allow the customer to see what kind of ultra-high-tech cushioning material is locked inside. As you scan the display stretched out in front of you, each individual shoe neatly occupying its own small, rectangular perch, you begin the process of deciding which one is worthy of taking up residence on your foot. Will it be the ASICS model with the gel pod in the sole and the shimmering gold overlays, or maybe the neon yellow Nikes with the quartet of coiled springs under the heel? It's a tough decision, and apart from appearance and externally visible technology, there's little information available to help you make your decision.

What should you do?

Well, you could simply go by price—the most expensive shoe surely is the highest quality and will provide the best protection, right? Conversely, those cheap shoes in the bargain bin will probably guarantee pain and suffering. You say to yourself, "There's no way I'm going to entrust my feet to their shoddy protection!" If you're not comfortable going it alone, you might decide to ask a clerk for some advice. Unfortunately, if you're at the local mall or one of those "big box" outlets that sells athletic shoes for just about any type of sport imaginable, you're probably not going to get much in the way of meaningful help. First off, these stores rarely stock a wide variety of shoe types, and most of what you will see are probably thick heeled, heavily cushioned shoes from just a few of the major manufacturers. Virtually all of the shoes that are on display are variants on a common theme that customers are used to and have come to expect.

Furthermore, the salesperson at a generalist store is just as likely to be a college-kid working a part-time job as they are someone who actually has extensive experience fitting a runner for a proper shoe. In many cases you may be dealing with someone who doesn't even run. If you really want helpful advice regarding shoes, you stand a better chance of getting it if you go somewhere that caters specifically to runners—you should head to a specialty running store.

Specialty running shops differ from typical sporting goods stores in that they (should) have knowledgeable staff who are actual runners—that alone is a major plus. However, even in a specialty store you are at the mercy of the bias of the individual salesperson that is there to help you choose the right pair of shoes. Some of these employees might be open-minded and highly experienced, while others might not. They might simply be following the script handed to them by the footwear brand representatives (furthermore, they might working under incentive programs offered by manufacturers to push certain shoes). Others might be strictly following a store fitting policy, regardless of whether that policy has any scientific support for its efficacy in ensuring that a runner is going to be placed in a shoe that will help prevent him or her from getting hurt.

What you will often find at a specialty running shop is that the shoes are typically neatly grouped into three major categories: neutral, stability/support, and motion control. How do you know which category you belong to? That would be the role of the store clerk, manager, or owner. One of them might watch you run across the store or on a treadmill, or if the store is high-tech, you might get filmed, and in the end you will usually be diagnosed as an overpronator (mild, moderate, or severe), a normal pronator, or an underpronator (supinator). (We'll define and discuss these terms in much greater detail in just a bit.) Alternatively, they might examine or measure your foot in some way to assess your arch height. Some shops might even have fancy pressure sensitive pads that you stand on so a computer can analyze your foot, after which it spits out a few shoe recommendations; such is the seductive power and allure of technology! How could a machine be wrong? Not knowing any better, you assume that all of this high-tech poking and prodding will result in the knowledgeable salesperson providing you with the shoe that was made just perfectly for your foot.

One way or another, the goal of each of these tests is to assign you to a shoe from one of the aforementioned categories—high-arched underpronators and normal pronators get neutral shoes (sometimes referred to as cushioning shoes), mild to moderate overpronators are placed in stability/support shoes, and severe overpronators with flat feet are placed in motion-control shoes. These categories are not necessarily fixed, and there can be a bit of overlap. For example, some fitting guides suggest that normal pronators would be fine in a neutral or a mild stability shoe. Once your "needs" have been determined, the clerk then brings you a selection of shoes from the appropriate category, you try them on, and you choose the one that feels best (ideally on a short test run). You are comforted by the expert advice that you received, and you walk out the door with your new pair of shoes, visions of a trimmer waistline or a new personal best time in your next race dancing around in your head.

While most shoe store employees are genuinely interested in finding the best shoe for each customer, too often what happens is that their recommendation is driven more by the bottom line than by a runner's actual needs. Retail shops are in the business of selling shoes and related gear, and though the clerk working the floor may have the best of intentions, shoe-fitting philosophies are sometimes set by the parent company that owns the store (especially if it's a chain), and the employees are supposed to follow certain guidelines. Given this, it might be instructive to take a more in-depth look at the fitting process inside a specialty running store. What follows is a representative firsthand account of the fitting process from a former sales manager (who asked to remain anonymous) at a large, national specialty running chain:

> *If you've never been fit before, I'd complete an interview process with you regarding any injuries (past or present), typical training terrain, training goals, current running shoes (I'd take a look at the wear pattern if you brought them in) and ask you if you've worn any orthotics or over-the-counter inserts before. For example, let's say you are a new runner and have been running in a $50 neutral shoe you bought at a shopping mall store based on looks. I let you know that our shoes, unlike the cheap, low-quality pair currently on your feet, have the latest technology and that you will notice a huge difference just in standing in them, let alone running in them.*
>
> *Next we move on to the foot observation. I look at your feet while you are sitting and don't notice anything odd, and I tell you that. Next I have you*

stand and watch to see if your arch flattens out. Let's say that it does. Next is the walk test. I have you walk back and forth barefoot, and listen to hear if your footfalls are loud or soft. I observe whether you are rolling in, or pushing off excessively. I have you stand with your back to me so I can look at your heels and Achilles tendon. I notice that they are bowed toward the inside, which indicates that you are an overpronator.

I take measurements on the Brannock device, first seated then standing. I let you know that from a seated position to a standing position your arch lengthens one full size on the left and a half-size on the right foot. I pull out the Superfeet insoles and foot model to show you how the midtarsal joint "unlocking" lengthens your arches, and I show you on the foot model how the Superfeet insoles help control the unlocking. I explain to you that I will be choosing a shoe with medially posted support built in to help guide the foot to a more central line by controlling your overpronation. I have you try on a pair of Balega socks and you are impressed by the comfort and technology.

I go to the stockroom and choose three pairs of shoes with varying degrees of support. Since I consider you to be a moderate overpronator, I grab the Asics 2160s, Brooks Adrenaline's, and Saucony Omni's. I insert the green Superfeet to see if you can tolerate the support. You like the feel so I watch you run, first in the 2160's with green Superfeet. If the stability level is good, meaning you look like you are not rolling in and you are coming through the center of the foot and it feels great then I'd sell you that combo.

This fitting process seems reasonable, helpful, and practical. Most new runners would be impressed by the level of attention they'd get at a specialty running shop—far more than they would have gotten at a "big box" store. However, it's clear from this description that the process revolves around selling technology that will supposedly "correct" a runner's stride, with the implicit assumption being that this will minimize injury risk. The underlying premise is that many runners are inherently broken in some way, and that a special kind of shoe is needed to allow them to run without getting hurt. There's nothing like the specter of injury to get a runner to open the wallet and shell out the big bucks for an expensive new pair of shoes! Our sales manager agrees:

The complete fitting process is about selling what will appear to make running easier in the new or injured runner's eyes. In fact, this fitting process is

due for a reevaluation. I see feet and runners all day long and honestly the runners most injured in the shop on a regular basis are the ones in the most expensive shoes with the latest and greatest technology. Something is not right. My reason for saying this is not to criticize my employer, but to help other runners. It pains me to see runners missing out on their target race. I've seen new runners run in old cheap 'big box' shoes then get fit at our store only to end up injured in their new insole/shoe combo. I recently told a runner to go back to his cheap old shoes and see how he felt. Pain gone. I was so glad that the owner fit him and not me, but I often think I could be actually hurting the runner rather than helping him/her.

I've been working at the store for one year, and after finishing my training period, I was the top salesperson every month. I was eventually promoted to lead sales manager. I'm not saying that out of pride but only because I know the fitting process in and out. I train the staff, and I can sell it. It's not brain surgery—it's about baffling the customer with shoe, sock, insole and apparel technology. Our individual sales ratios are based off the number of shoes, insoles, socks, and apparel sold per month. We don't receive a commission or bonus, but we are to maintain all of our sales within a particular percentage. After a year of seeing the side of the shoe business that I didn't want to know about, I'm currently looking for employment elsewhere.

Our clerk's experience is not unique. Another former specialty running store manager with many years of experience had this to say: "I have been in workshops with owners and managers of other running companies who refer to insoles as 'lunch money.' The margins are great and it's an easy sell. This is a common selling point by sales reps of insert companies." The question once again springs up—are we being sold what we really need, or what will make the most money for the store. One can only hope that it's not the latter.

The shoe-fitting process just outlined, or with some variation, is standard practice at many specialty running shoe stores (for a different take on shoe fitting, see sidebar on "Finding the Right Pair of Running Shoes" by Dr. Mark Cucuzzella). It is also the basic practice advocated by most running shoe companies, as evidenced by the fact that virtually all of them classify their shoes neatly into one of the pronation-control categories. For example, in its online shoe fit guide (as of February 2012), ASICS advocates first determining arch height, and provides footprint diagrams to which one can compare their own print using a test like the

"wet-test." The wet-test is a simple procedure in which you wet the sole of your bare foot and stand on an absorbent surface like dry concrete or a paper bag. The resulting wet imprint of your foot will reveal something about your arch height. If no distinct arch is visible, you have flat feet. If there is a distinct dry area under the inner side of the arch region of your foot with a complete wet band adjacent to it on the outer side, you have normal arches. And finally, if the outer wet band is separated in the middle by a dry area, or if the wet band is very narrow, you have high arches. Your arch height can then be translated into the appropriate pronation-control category. According to the ASICS shoe fit guide, a high arched foot is said to be an under-pronated foot, and a ". . . runner with under-pronating feet is more likely to experience shock transmission through the lower legs." People with normal arched feet "typically experience minimal biomechanical problems," and people with low-arched, flat feet "tend to have over-pronating feet, which generally result in poor natural shock absorption." Based on the category determined, a runner would then choose either a cushioning (neutral) shoe, a structured cushioning (stability) shoe, or a maximum support (motion control) shoe.

The pronation-control model or paradigm is so ubiquitous and has such a primary place in the shoe-fitting process that one would think that its usage is supported by mountains of clinical and scientific data. The entire shoe-fitting process treats shoes largely as corrective devices after all, with the ultimate goal being to shift all runners into a "neutral" gait by correcting for either too much or too little pronation. What's more, runners often become so tied to their initial pronation control designation that many fear even the thought of trying a shoe outside of their assigned category—quite honestly, they're locked in for life. Belief in the accuracy of the fitting process can be so strong that even some chronically injured runners can be hesitant to change, despite the fact that the style of shoe they have been using for years has not resolved their problems (or, perhaps, might even be causing them). One would therefore hope that the initial in-store assignment is made with great care and on the basis of a strong foundation of clinical and scientific evidence. Sadly, in thinking this, one would be quite wrong.

Finding the Right Pair of Running Shoes

Dr. Mark Cucuzzella is a family physician and the owner of the nation's first minimalist shoe store, Two Rivers Treads, in Shepherdstown, West Virginia, which opened in the spring of 2010. A top masters runner, who at the age of forty-four won the 2011 Air Force Marathon outright, Mark is also the executive director and co-founder of the Natural Running Center. He shares his experience, insight, and wisdom about pronation, proper fit, and how to find a "running shoe" that best works for you.

When customers enter our store, questions always arise about pronation. Many of them have been labeled in the past as pronators by well-meaning employees at other running stores. Some claim that they have been classified as supinators. All they really want is shoes that fit, and that will help them to run injury-free. Yet the process of determining which shoe will best meet their needs is not something so simple as watching them walk or jog ten steps across the store floor. This kind of evaluation certainly won't help the runner find the right shoe.

So the first thing we do with these customers is have a conversation. We explain what pronation is. Then, we discuss the shoe-fitting process. We don't rush through this either. Every runner is unique. Some will need shoes with greater or lesser support and mobility control, depending on his or her foot strength.

Pronation is a normal function in the gait cycle, just like bending the knee or extending the hip. Pronation control can be achieved with your foot (ideally), with a shoe/insert (maybe), or both. Maximum pronation actually occurs when your heel is off the ground, so the foot's role in this process is critical.

Let's start with the foot itself, a remarkable engineering feat as described by Leonardo DaVinci: twenty-eight bones, multiple arches, and accompanying muscles and ligaments that move dynamically to balance, stabilize, and propel one forward. Children running barefoot naturally feel the ground and their muscles work reflexively to provide pronation control. Runners (with or without shoes) who have strong feet have the ability to control this motion just fine. The foot works best when it receives sensory information on where it's landing, and a firm surface is best for feedback. Overly soft shoes delay the feedback. Remember that a runner's foot is on the ground for only a few fractions of a second, so the pronation control must be immediate and strong.

Spending a lifetime in stiff, overly cushioned, and supportive shoes has diminished natural pronation control for most modern-day runners. The shoe has done some or all of the work for them. To see for yourself, try balancing on the ball of one foot. Can you hold the position for a second? Ten seconds? Thirty seconds? Can you pop off the ground with springy recoil while jumping rope? If you are having difficulty, then you may need to take certain measures if you want to transition to more natural pronation control and run in a true minimalist shoe.

Why is natural pronation control better? The foot is the magic spring that adds elastic recoil to our stride. This is free energy. When the foot is constricted by being made to "move" within a rigid shoe, it cannot work well as a spring and you need to apply more muscle force to the stride. More muscle use results in greater fatigue and less efficient running.

My recommendation to all runners is to make a gradual transition if you want to strengthen your feet. Do plenty of walking barefoot and in minimalist shoes. Start your transition to running slowly and remember that your muscles, tendons, ligaments, and bones are adapting and do not have the capacity for the added load yet. Do supplemental foot strengthening throughout the day. Stand on one foot, balance on the ball, walk barefoot in the house and outdoors when you can. This can only help your running. You may have a little soreness like with any new training. Tissues are lengthening and strengthening. Extreme soreness means you are progressing too quickly and asking the tissues to do too much too soon.

Proper Fit Explained

Two years before I opened Two Rivers Treads, I had completely rethought how a shoe should fit. It involves much more than just picking a size and sticking with it. Sizes and fit vary from shoe to shoe, and our feet can change size and shape over time. For example, I have started running many more true barefoot miles over the last year and my foot has greatly increased in thickness—I now need to consider this change when choosing a shoe.

At our store, we defy old-school thinking about sizing and narrow-shaped, ill-fitting conventional shoes. Improper shoe sizing and shape are the primary cause of ingrown toenails, bunions, corns, hammer toes, and hallux valgus. Shoes that don't fit your feet correctly can also lead to muscular imbalances in the body, leading to foot, knee, and hip injuries.

A proper fit accommodates the natural expansion of the foot upon ground contact. Excess waste is eliminated, along with everything that in-

hibits your foot's natural motion. Your foot is free to move and work the way nature intended it to; the way of its own barefoot motion. Call it toe-wiggle freedom. We educate on how to safely and gradually make this transition.

Yet, with sizing, most get it wrong. First, abandon the notion that you have a shoe size. Instead you have a foot size. Shoes are made all over the world and apply different shapes and standards. If you measure your foot while seated with a traditional measuring tool like a Brannock device and base your size on that you will likely be off by one to two sizes in a running or hiking shoe. Increasing one full shoe size is equivalent to adding only ⅓ an inch to the length of the shoe. Also critically important is that the Brannock device measures the widest part of the shoe at the ball. Infants and habitually barefoot individuals have feet that are widest at the ends of the toes, not the ball of the foot—this is the natural alignment of the human foot, and shoes should respect this.

Here's why many people are wearing shoes that are too small:

- When a load is applied to a foot by running or with a pack weight your foot will spread in length by up to half an inch.
- You need at least ⅛ inch or more of space in the heel and toe to allow space for a sock.
- You want ⅓ to ½ an inch of space in front of your big toe to allow room for loading and splay.
- Your foot will increase in width by 15 percent due to splay under load.
- Your foot is widest at the toes, and unfortunately most shoes are not shaped this way.

Tips on sizing:

- Do not assume that you are the same size in every shoe.
- Take your time and try several shoes on. Go run in them. Do not try them on while sitting.
- Always try both shoes on. If your feet are slightly different in size then fit the larger foot.
- Take the removable insole out of the shoe and see how your foot fits against the insole as a template. Is there room at the toes or does you foot spill over the insole? If there is no room to spare or if your foot spills over this shoe will not fit comfortably.
- Keep going one half-size up until the shoes are obviously too big.
- Try on shoes at the end of the day when feet are most flattened and swollen.
- Try shoes on with the type of sock you will wear for activity.

- For women, you may fit better in a men's shoe for width.
- Do not lace the shoes up tight. Allow spread in the midfoot and forefoot.
- Go up onto the ball of the foot. Can you put your index finger between your heel and the back of the shoe? If not, the shoe is likely too small.
- Consider not using the soft insole. This takes up space in the shoe and can interfere with ground feel.
- Walk on a firm surface when trying shoes on, not a carpeted one.
- If you are a runner you must run in the shoe. What feels nice and soft when walking is the opposite of what you need when running. Look for firmer base to allow for better sensory input and to facilitate stabilization.

Children's Shoes:

What children wear growing up has a strong influence on foot structure and function when they are adults. Given this, selection of healthy footwear for children is critical. You should select proper shoes for your children based on the following:

- Ultra-thin soles to allow adequate sensory perception, proper neuromuscular activation in the entire kinetic chain, and to complement the body's natural ability to absorb ground reaction forces.
- Low, flat to the ground profile—shoes should not have a slope from heel to forefoot.
- The materials should be soft and supple, thereby allowing natural foot function. The shoe should bend easily at the toe joints—this is where a foot is designed to bend to lock the arch on takeoff.
- The toebox should be wide enough to allow natural toe spread. Foot support is created by the natural arch of the foot with the great toe helping to stabilize the arch. When the great toe is pushed in toward the second toe (a common design flaw in many shoes which come to a tapered point), this stability is compromised. The foot produces the most leverage when the toes are straight and aligned with the metatarsals. A child's foot is widest at the ends of the toes (as should an adult's be if they have been in proper shoes or barefoot).
- A single piece midsole/outsole allowing protection on unnatural surfaces (concrete, asphalt) and natural rough surfaces (rock, trail) while allowing sensory perception and natural dissipation of ground reaction forces.
- Upper material should be soft, breathable, and washable.
- Discourage the use of thick, heavy socks as these can constrict the foot and interfere with sensory perception.

The Problem with Pronation Control

You are a pronator. Yes, you read that correctly. Interestingly enough, you are also a supinator. How is that possible? Aren't they opposites? How can one be both? Let's see why.

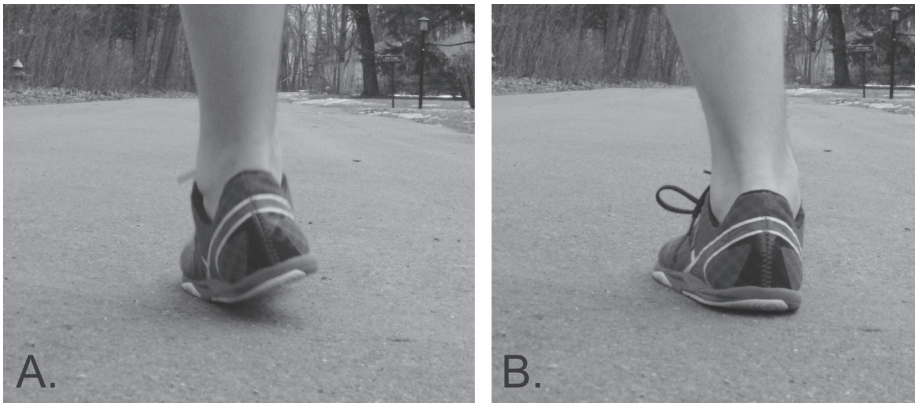

Figure 6-1. Images showing a supinated foot at initial ground contact in a forefoot strike (**A.**) and a pronated foot slightly later in stance (**B.**).

Initial ground contact in running is almost universally made somewhere on the outer margin of the foot, with the foot in a supinated position (see Figure 6-1A). Similarly, after the foot makes first contact with the ground, we all pronate. The foot begins to roll inward, everting slightly, and the arch compresses (see Figure 6-1B). Following pronation, as the foot continues through its gait, supination once again occurs. This results in the foot turning slightly outward then changing from a flexible foot to becoming rigid so that it can propel the foot and push off from the ground. During this phase the foot inverts slightly, and the arches become higher, thus enabling the foot to properly roll over the big toe.

Here's the important point though—pronation is completely normal. It's a motion that occurs in every step in every healthy foot. Pronation creates the situation in which the arch of the foot can compress, thereby stretching tissues like the plantar fascia, which store elastic energy and return it upon liftoff (like stretching and releasing a rubber band). From an anatomical perspective, movement in pronation occurs at the subtalar joint between the talus (ankle bone) and calcaneus (heel bone) located just below it, and as the foot pronates the joints of the midfoot unlock, al-

lowing the foot to become more flexible. This helps the foot adapt to the surface, especially on uneven terrain. This, in turn, also allows the arches to compress and absorb shock. However, because the talus is also coupled above to the tibia and fibula (lower leg bones) at the ankle joint, inward rolling of the foot can also lead to internal rotation of the lower leg, which causes a twisting motion at the knee—hence the suspected link between overpronation and overuse injuries of the knee.

Because runners have long been conditioned by shoe-marketing tactics and advertising to fear pronation above all else, once they are "diagnosed" as falling into one of the pronation categories—overpronator, neutral, or supinator/underpronator—they tend to stick with shoes recommended for that category indefinitely. They are hesitant to experiment out of fear that they might injure themselves if they run in a shoe that doesn't provide the "appropriate" level of support.

Runners place a lot of faith in stability and motion control shoes to protect them from injuries resulting from the dreaded pronation of their feet. What would you say, however, if you found out that there were no data from clinical trials that have supported the use of such shoes in injury prevention? What if the tests employed by the salesperson at the shoe shop weren't very good at determining your pronation "category" to begin with? Even more startling, what if the amount that you pronate wasn't even strongly related to the likelihood that you might get injured? Scientific research has been accumulating that suggests that it may be time to reconsider the pronation-control paradigm.

In 2011, a remarkable paper titled "The effect of three different levels of footwear stability on pain outcomes in women runners: a randomised control trial" was published by Michael Ryan (then at the University of British Columbia) and colleagues in the *British Journal of Sports Medicine*. One of the coauthors of this study, Gordon Valiant, works for the Nike Sports Research Laboratory, and Nike provided footwear and funding for the study. Keep this in mind as we go through the results—the study was supported by Nike, the biggest sports shoe manufacturer in the world, and they allowed it to be published. In their introduction the authors state the following surprising detail: ". . . despite over twenty years of stability elements being incorporated in running footwear there is, as yet, no established clinically based evidence for their provision." Shocking, isn't it—despite twenty plus years of use,

we have no data showing that pronation control elements in shoes are accomplishing anything of value for runners in relation to injury prevention. The study then goes on to point out that "Motion control running footwear has yet to be proven to prevent running-related injuries." Huh? Aren't these the shoes assigned to those who have the greatest risk of succumbing to an injury caused by excessive pronation? But there is no evidence or proof that they actually work to prevent those injuries? So the big question is why has the athletic footwear industry been so long wedded to a shoe-design and fitting model that has never been proven to actually work?

Given the lack of data on efficacy of pronation-control devices in running shoes for injury prevention in runners, Ryan and his colleagues decided to put the paradigm to the test. They designed a study whose goal was to determine how female runners assigned to the three categories of footwear based on their foot posture index would fare in terms of pain and injury experienced while training for a half marathon (note: foot posture index is an indirect way of determining pronation through various measures taken from the foot and ankle).

A total of one hundred and five women were classified as either neutral (fifty-one women), pronated (thirty-six women), or highly pronated (eighteen women). Now here's the really interesting part. In a shoe store, the neutral women would be assigned a neutral shoe, the pronated women a stability shoe, and the highly pronated women a motion control shoe—got it? In the study, however, the researchers took each of the three groups of women (neutral, pronated, and highly pronated), and broke them into sub-groups so that one-third would get a neutral shoe (Nike Pegasus), one third would get a stability shoe (Nike Structure Triax), and the final third would get a motion control shoe (Nike Nucleus). This was done for each of the pronation groupings, so that there would be some women in each pronation category wearing each type of shoe (i.e., many of them wearing the "incorrect" shoe for their foot).

The women in the study were then sent off to take part in a thirteen-week training program to prepare for a half-marathon to be run in Vancouver, British Columbia. Estimated weekly training volumes started around twenty kilometers and rose to a peak of about forty to forty-five kilometers. Over the course of the training program, the researchers recorded the number of missed workouts due to injury by each runner,

and collected reports of pain at rest, during daily living, and following runs. Ultimately, only eighty-one of the women wound up completing the study (for a variety of reasons, twenty-four women dropped out).

The results showed the following:

1. 32 percent of the women missed training days due to pain over the course of the study. Another way to think of this is that there was an injury incidence of 32 percent in this population of runners, which is in line with other studies on running injuries.
2. Motion control shoes "resulted in both a greater number of injured runners and missed training days than the other two shoe categories." In other words, motion control shoes faired very poorly all-around.
3. Every runner in the highly pronated group who wore a motion control shoe reported an injury. In other words, all runners (yes, all of them . . . 100 percent!) who were supposed to be wearing a motion control shoe based on their degree of pronation got injured. The sample was small, but this is simply astonishing. In fact, highly pronated runners actually fared better in neutral shoes!
4. Neutral runners experienced greater pain during or after runs when wearing neutral shoes than they did when wearing stability shoes. Although the authors point out that the difference may not be clinically significant, it is once again amazing that neutral runners fared better with a shoe that would not have been "prescribed" for them in a shoe store based on their degree of pronation.
5. Pronated runners experienced more pain during or after runs if wearing a stability shoe than if wearing a neutral shoe. Again, they did better wearing the "wrong" shoe for their feet.

So what can we conclude from these findings? Motion-control shoes offered little benefit to the runners in the study, and in fact were more likely to cause pain and injury than any of the other shoe types. The fact that every single severe overpronator experienced an injury in her motion control shoes demands further investigation. In the absence of other evidence, why should anybody wear them for preventing a running injury? The authors themselves conclude, "This study is unable to provide support for the convention that highly pronated runners should wear motion control shoes."

Second, this study showed that neutral runners did better in stability shoes, and pronated runners did better in neutral shoes. Try to make sense of that finding! This is a complete reversal of what would be expected based on the current pronation-control model. This rather startling result calls into question the manufacturer practice of classifying shoes based on degree of pronation control, and it also raises serious questions about the fitting process employed by many shoe stores—should they really be placing runners in shoes based on their degree of pronation?

Ryan's study offered this rather frank assessment of the status quo: "Current conventions for assigning stability categories for women's running shoes do not appear appropriate based on the risk of experiencing pain when training for a half marathon. The findings of this study suggest that our current approach of prescribing in-shoe pronation control systems on the basis of foot type is overly simplistic and potentially injurious." This doesn't instill much confidence in the current system, does it?

By allowing publication of a study that openly states that there is no clinical data showing that shoes designed to control pronation do anything to prevent injuries, Nike took a great risk. It's comparable to a pharmaceutical company selling a drug for over twenty years that has never been shown clinically to be of any benefit to a patient who supposedly needs it. It makes one wonder if the whole pronation-control shoe paradigm is nothing more than a giant marketing gimmick whose goal is to scare consumers into buying shoes based on fear of injury. It's a time-honored marketing tactic—convince consumers of a need, and provide a product that supposedly fulfills it. In this case, the need is a neutral gait in order to reduce injury risk, and the products are the shoes that promise to correct gait to meet the need. Furthermore, in the absence of evidence showing that running shoes either do or don't reduce injury risk (or maybe even increase it), why stop making something that continues to sell and has come to be expected by consumers?

Conspiracy theories aside, the more likely scenario is that the pronation-control paradigm has simply become accepted as dogma by almost everyone, from runners, to shoe store employees, to running magazines, to shoe designers. And we would be remiss if we did not point out that the system does sometimes work—many pronated runners do just fine in stability shoes, and many underpronating runners do just fine in cushioning shoes (even some of those in Ryan's study). The problem is that Ryan's

study showed that the odds of these individuals avoiding discomfort were better if they were assigned the "wrong shoe for their foot," and it is thus difficult to predict who will benefit from a given shoe and who will not.

If this were the only study showing results like this, it could be argued that it was simply an outlier, and that more work needs to be done. But, Ryan's study was not the only one that had looked at the connection between prescribing shoes based on an indirect measure of pronation and injury outcomes. Two years earlier, Joseph Knapik, an epidemiologist for the U.S. Army Public Health Command at the Aberdeen Proving Ground in Maryland, published a study with military colleagues in the *Journal of Strength and Conditioning Research* that investigated whether assigning shoes based on plantar shape (arch height) could reduce injury rates among soldiers entering Basic Combat Training at Fort Jackson, South Carolina. Their goal was to determine whether the practice of assigning shoes based upon arch height reduced injuries relative to providing all recruits a similar type of shoe.

Knapik and his colleagues examined the feet of over 3,000 recruits and categorized them as having either low, normal, or high arches. Approximately half of the recruits were then assigned to a control group and given a stability shoe regardless of their arch type, and the other half were allowed to choose an appropriate shoe for their arch type from a selection offered at the base post exchange or PX. The recruits then completed a nine-week basic training program, and injury reports were obtained from the Defense Medical Surveillance System. Results of the experiment showed that injury rates were essentially identical for the two groups—risk of injury was the same no matter whether the recruit was assigned a stability shoe, even if this was the wrong shoe for their foot, or whether they were assigned the shoe that standard practice indicated was the appropriate shoe for their arch type (and by proxy, level of pronation). In fact, the only group that showed any significantly elevated injury risk were the high-arched runners who were assigned a cushioning shoe, which most shoe fitting guides would deem to be the appropriate shoe for their foot!

Knapik and his colleagues conducted similar studies on both Marine Corps (over 1,000 individuals) and Air Force recruits (over 2,500 individuals), with largely similar results. No significant differences in injury risk were observed between the stability shoe only group and the group

that went through the tailored, arch-height based fitting process. In other words, low arched recruits did just as well in stability shoes as they did in motion control, and high arched runners did just as well in stability shoes as they did in neutral cushioned trainers. In fact, the overall trend gleaned from the three military studies indicated that assigning the "correct" shoe based on arch height generally resulted in a slightly increased injury risk, though statistical differences were non-significant.

In a 2010 article on the *New York Times Well* blog, health and fitness reporter Gretchen Reynolds asked Dr. Bruce Jones, who is manager of the Injury Prevention Program for the United States Army's Public Health Command and coauthor on the military studies, what he thought about the results. "You can't simply look at foot type as a basis for buying a running shoe," said Jones. "The widespread belief that flat-

Arch Height and Injury Risk

Though many studies exist that have associated variation in arch height with certain types of running injuries, patterns are not always consistent or clear, and contradictory data are present. A study published in *Clinical Biomechanics* in 2001 by Dorsey Williams and colleagues examined arch structure and injury patterns in runners. They state that "there does not appear to be a clear relationship between arch structure and injury pattern" and furthermore that "it has been difficult to establish a relationship between a single structural deviation and a specific injury." Based upon the results of their study, they suggested that perhaps only individuals presenting with extremes of arch height deviation might experience increased injury risk.

There is also debate regarding the relationship between arch height and degree of pronation. For example, Benno Nigg, a well-known expert on running biomechanics from the University of Calgary, published a study in the *Journal of Biomechanics* back in 1993 that showed that arch height does not influence the maximum degree of eversion/pronation during running. However, he did find that when higher arched runners do pronate, they transfer a greater amount of this movement into internal rotation of the knee, which may be linked to increased risk of knee injury. Regardless, given that arch height and pronation do not seem to be strongly linked, it is somewhat surprising that the wet footprint or higher tech versions of the same approach continue to be touted as an effective means to assess pronation control needs when it comes to choosing a running shoe.

footed, overpronating runners need motion-control shoes and that high-arched, underpronating runners will benefit from well-cushioned pairs is quite simply, {Jones} adds, 'a myth.'"

So, after two decades of assigning shoes based largely on pronation control without any clinical evidence to support the practice, there are now four studies that all show the same thing: when using static measurements of the foot as an indicator of pronation, this common practice doesn't provide, on average, any real tangible benefit over simply assigning every runner a stability shoe. In fact, assigning shoes based upon arch height or other indirect measures of pronation may actually increase the likelihood of pain and injury in some cases, and some runners do better wearing the "wrong" shoes for their feet!

It's worth considering the possibility that the results of Ryan and Knapik's shoe and injury studies were skewed by the methods used to match shoes to subjects. In other words, maybe the shoes weren't the problem. Maybe arch height is simply an ineffective surrogate for degree of pronation, and alternative methods of shoe assignment should be investigated. One possible method might be to assess foot mobility in terms of the degree of arch collapse rather than just static arch height. A hypermobile foot is one in which the arch collapses considerably upon weight bearing, whereas a hypomobile foot is one in which the arch is very rigid and does not flatten much. You can think of the hypermobile foot as a floppy foot, and the hypomobile foot as a stiff or rigid foot. Conventional wisdom suggests that an arch that collapses excessively will be more likely to overpronate, and thus requires more support in the form of a structured insole or stability/motion control shoe. Conversely, a rigid foot in which the arch collapses only minimally is not good at dissipating shock through pronation, and is thus thought to require greater cushioning.

As our running specialty store sales manager indicated, examination of the degree of arch flattening from sitting to standing is a commonly used method for determining footwear or insole needs—this gives a more direct measure of foot mobility than simply looking at arch height. If the arch flattens too much, you need to prop it up with a supportive insole, right? Sounds reasonable, and the rate at which stores sell inserts is sufficient proof that most runners buy into this logic. However, it would be of interest to know whether looking at arch collapse while standing tells us much of anything about what happens to the arch while one runs, when

muscle activity and joint position are considerably different than when one is standing still. Running, after all, is the activity that runners like to participate in—not standing in their socks or bare feet on a pressure mat.

At the University of Virginia SPEED Clinic, Jay Dicharry heads up one of the most high-tech gait analysis labs in the world. In addition to a complex, three-dimensional high-speed camera setup, Dicharry also has at his disposal a custom-built, $750,000 treadmill that can measure in real-time the forces generated as a runner's feet impact the treadmill belt. Dicharry and his small staff spend their days diagnosing the causes of running injuries in their patients and devising plans for how to correct them. He also does footwear validation work for a variety of shoe companies—if you're looking for an expert on the relationship between shoes, biomechanics, anatomy, and injuries, it would be hard to beat the combined package of expertise that Dicharry provides.

Dicharry published a study with colleagues in the *Journal of Orthopaedic & Sports Physical Therapy* in 2009 in which they attempted to examine whether a static (this is when the body is stationary) measure of arch collapse was correlated to actual foot movement while a person is walking or running. According to Dicharry, "The reason for doing this study was that all of the research out there showing when pronation occurs is based on examining rearfoot motion, and the rearfoot is not a comprehensive index of what the entire foot is doing; it's just the rearfoot. We wanted to do a little bit better job" by looking at what the whole foot is doing.

There are a number of methods employed in clinical settings to assess degree of arch collapse. One of these tests is called the functional navicular drop test. Sounds complex, but it's actually quite simple. The navicular is a bone at the top of the arch of the foot, and it can be felt through the skin as a little bump below and in front of the inside of the ankle. Because it is easy to identify, the height of the navicular above the floor can thus be easily measured. In the functional navicular drop test, a clinician measures the height of the navicular while a patient is sitting, and then has the patient bear weight on the foot (by having them stand) and measures the height of the navicular while the arch is compressed. The difference in height is a measure of the degree of arch collapse when the foot bears weight.

Dicharry and his colleagues used the functional navicular drop test (as well as another, slightly more complicated test) to classify individuals

as having either hypomobile (minimal arch collapse), neutral (moderate arch collapse), or hypermobile (excessive arch collapse) feet. What they found is that ". . . if you look at static factors you get three very well defined, mutually exclusive categories," says Dicharry. In other words, it's very easy to tell the floppy footed, from the normal footed, from the rigid footed when looking at people who are not moving.

They then filmed these individuals as they walked or ran in the lab so that arch collapse could be determined during dynamic movement. Results showed that despite significant differences in arch collapse between the groups during static testing, arch collapse was identical in all three groups during walking, and the only difference observed during running was a small but significant difference between the hypermobile and hypomobile groups (i.e., the extremes). "When you walk there's really no difference between all of the foot types. They all move about the same," says Dicharry. "If you look at running, only the hypermobile foot types move more . . . it wasn't a big difference." So, only people with floppy feet see increased arch collapse while running, but the difference was actually quite small. In fact, hypermobile individuals on average exhibited only a 1.1 mm greater degree of arch collapse than hypomobile individuals during running. The take-home message from this study was that examining an individual's degree of arch collapse while sitting versus standing still is not a particularly good indicator of what the arch does during actual running; it seems that we can now add degree of arch collapse to the list of questionable diagnostic tools used in the shoe-fitting process.

Given that the idea that flat, floppy feet with collapsing arches require added support is so entrenched in the running world, the results of Dicharry's research might come as a bit of a surprise. How is it that an arch that flattens out considerably when standing can maintain its shape to a much greater degree on the run? Dicharry attributes this to the inherent ability of the body to stabilize joints using muscles. "We're trying to get beyond how much the foot moves, and instead focus on how well you control the foot," says Dicharry. "Let's say I do a navicular drop test on somebody and they've got a lot of motion. Well, if it's somebody with a lot of motion and they've got very good intrinsic foot control, they don't really need a whole lot out of a shoe. If they have good stability, good support, they're gonna be fine." In other words, you can have a flat, floppy

foot, but if you can stabilize it well with your foot and leg muscles while you run, you don't need a controlling shoe.

Dicharry goes on: "However, runners with that same foot type, the hypermobile foot type, with poor dynamic control are going to need their shoe to do a lot of things for them. That's kind of what's driven us to get to where we are in footwear. That's definitely something to think about—are the footwear changes that are being done from an industry standpoint actually getting to the root of what needs to be done (which is controlling excessive mobility), or should we all be strengthening their feet? I think everybody should be strengthening their feet." How can this be accomplished? Dicharry thinks that exercises such as practicing standing on one leg, using balance boards, or even skateboarding can more than do the trick. In an interview on the Blue Ridge Outdoors website he goes so far as to say "The stride is all about balance. When you're running, you're always balancing on one leg, so improving that single leg balance is actually the best thing you can do for your running."

Dicharry does believe that shoes can work for those who need them or who don't want to put in the effort and work required to develop internal stability. However, the critical point here is that just because someone has a flat, highly mobile foot does not necessarily mean that he or she needs a motion control shoe. If you combine a foot that is excessively mobile due to loose ligaments or problems with bony articulations with strong muscular support, that person might not need any more shoe than a person with a much less mobile foot. A flat-footed individual who is put in a motion control shoe might be in the entirely wrong shoe when considering that person's ability to internally control stability while running. What's more, wearing a motion control shoe might just interfere with that person's ability to ever develop that internal stability via strengthening of the feet and legs.

Given that examination of arch height and degree of arch collapse may not be effective diagnostic tools for determining pronation, is there any real benefit observing a runner on a treadmill or as he walks or runs across the store's floor? First off, doing an informal exam like this without video is essentially meaningless, as the motions of the feet during running are far too rapid to accurately analyze with the human eye. It's difficult even to assess whether the foot strikes the ground on the heel, midfoot, or forefoot without the assistance of a video camera. Furthermore, even

if video is employed, a typical video camera filming at 30 frames/second will only give a limited amount of information—a high-speed camera that films at a minimum of 120 frames/second is best, but few stores have this type of equipment. When Dicharry was asked if he thought that clerks in a shoe store have the ability to effectively determine how much a runner pronates, his response couldn't be more clear: "No, no. Not at all. There's no way that someone can objectively define the pronation state of the foot at all in any shoe store with any of the systems that are out there." This is coming from a biomechanical expert who has a gait lab with 3-D imaging that is far beyond anything you will find in a shoe store.

Dicharry goes on to express frustration with how entrenched the current shoe-fitting process is: "There's sort of the old school hierarchical model of how to match people to shoe types. So the store owner has taught the high school kid who's working there after school how to do the same thing, and they're doing it with you. It's funny—I've literally sent people to stores with a list of shoes. I'll rarely ever send somebody to a store and tell them to buy 'this shoe.' I'll typically tell them, 'Try these five shoes on and see which one you like best.' It cracks me up, you know, I've had folks who've come in for evaluations and they'll say, 'I went to my shoe store and I brought the list that you gave me and the guy wouldn't sell me the shoe. He said I need this.' And I say, 'Well, fine, call the store owner and say thank you for your help, I'm not giving you my business and I'm going to order the shoe on-line.' Shoe store owners need to educate themselves and respond to this. I'm all for supporting the local guy, but they need to educate themselves."

The current pronation-based shoe-fitting paradigm is outdated. Just because it has been standard operating procedure in the past doesn't mean that its use should continue, particularly since there is evidence which suggests that the status quo is ineffective. Individual store owners should be willing to question what they are told by shoe companies, and should investigate the science (or lack thereof) behind the shoe fitting process. Health care professional should do the same, and scientists should put more effort into determining better ways to pair runners up with appropriate shoes, while at the same time doing a better job of educating the public about best practices. It can be hard to change, but with injury rates still at remarkably high levels, perhaps change is what runners need. Indeed, this has already begun to happen, judging by *Runner's World*'s Spring 2012 Shoe Guide.

Runner's World Steps into the Future with Its Revised Shoe Guide: Does This Mark the End of the Pronation-Control Paradigm?

> *For nearly three decades, we organized shoes and reviews into categories: motion control, stability, neutral-cushioned, and performance-training. The format was rooted in the prevailing science, which held that flat-footed runners needed stability features, high-arched runners just needed cushioning, and everyone else fell somewhere in between. But . . . over time that model has grown outdated.*
>
> —Runner's World 2012 Spring Shoe Guide

In his opening letter titled "A Big Step Forward," in the March 2012 issue, *Runner's World* Editor-in-Chief David Willey introduced the new direction that the magazine would be taking, indicating that the publication would be moving "away from shoehorning runners into the familiar categories (neutral-cushioned, stability, etc.) that RW codified in the '70s." Willey further writes that "instead of the old categories (so twentieth century!), we are focusing on, well, you. Each quarterly shoe guide will now open with a shoe finder flowchart that quickly takes you to the 'neighborhood' of three to five shoes, depending on your personal needs and likes."

And just what are these "needs and likes" that the new shoe-choice system is based upon? They include the following:

1. Shoe style: traditional vs. minimal.
2. Within the minimal category: some cushioning or very little cushioning.
3. Body Mass Index—above 27 or below 23.
4. Weekly Mileage: less than 18, 18–32, more than 32.
5. Arch Type: low, medium, high.
6. Injury Prone: yes or no.

While the above criteria are a step in the right direction, it's somewhat puzzling to see arch height included in the list, especially since the "Shoe Finder" flowchart in the shoe guide describes the wet-footprint test as a way of determining this, and relates arch type to pronation category. Didn't the above quote indicate that this is a "model that has grown outdated." It's also no certainty that large runners need a special kind of shoe, or that any particular shoe is better for an injury prone runner than any other.

In any case, it's to *Runner's World*'s credit that they were willing to step away from a system that is still widely employed by shoe stores and manufacturers, and one that many runners remain tied to. The magazine should also be praised that it undertook the obviously daunting task of trying to come up with a new method for recommending footwear. There are kinks that still need to be worked out, and there may never be a perfect system for matching shoe to runner, but the new approach represents a seismic shift, especially when a large-circulation publication like *Runner's World* is willing to abandon a system that has been in place for the past thirty or more years. Could this signify the abandonment of the "pronation-control paradigm"? Quite possibly, and the fallout will be incredibly interesting to watch.

Do Shoes Control Pronation?

Let's assume for a moment that a clerk at a shoe store accurately determines that a runner is an overpronator, and fits that runner in a stability shoe. The assumption is that the stability shoe will limit the runner's pronation and thus reduce the risk of injury that overpronation might pose. This begs the question of whether shoes can even effectively control pronation.

In his 2010 book titled *Biomechanics of Sport Shoes*, Benno Nigg provides an extensive review of the literature on the ability of running shoe interventions to control pronation of the foot. He reports that research has shown that shoe interventions can substantially reduce aspects of initial eversion (eversion is an element of pronation that specifically refers to the inward roll of the foot) that occur during the first one-tenth of ground contact, but that these interventions do not substantially reduce total eversion. In a 2001 paper in the *Clinical Journal of Sports Medicine*, Nigg emphasized that results of studies looking at the effects of shoe interventions on running mechanics often yield non-systematic results, meaning that individuals often react differently to a given change in shoe structure. This, combined with the typically small observed effects of such interventions, led him to conclude that "experimental results do not provide any evidence for the claim that shoes, inserts, or orthotics align the skeleton," at least in any consistent manner. Basically, Nigg is suggesting that the ability of shoes to control pronation appears to be small

and inconsistent, and that they are not particularly effective at changing the alignment of the skeleton. However, he does acknowledge that "it is known that different shoes do have different total eversion results. Thus, there must be shoe-related characteristics that influence total eversion. These characteristics have not, however, been identified in systematic biomechanical studies." So, some shoe modifications can impact how much the foot rolls inward, we just don't have any good data on which work best. Let's take a look at some of the candidates.

Perhaps the most commonly employed method of attempting to control pronation by running shoe designers is incorporation of a structure known as a medial post into the midsole of a shoe. The midsole is the cushioned portion of the shoe located below your foot that is typically made out of ethylene vinyl acetate (EVA) foam or some type of similar material. The midsole is not to be confused with the outsole, which is the more durable rubber on the bottom of most shoes that directly contacts the ground (the tread). A medial post is a region of the midsole composed of a firmer material on the inner side of the shoe, and a shoe with a medial post is often referred to as having a "dual-density" midsole. If you have a stability or motion control shoe, the medial post can usually be easily identified as a region where the midsole is of a different color, often gray if the rest of the midsole is white. The idea is that you will land on the softer outer margin of the shoe, and as the foot pronates it rolls onto the medial post, which limits further rolling of the foot.

Given his experience evaluating runners in his gait clinic, Jay Dicharry believes that medial posts are not effective tools for controlling pronation:

> *In fact, they can change things for the worse. There are a number of studies out there that show that medial posts actually shift the ground reaction force medially, and increase varus knee torque. {See Chapter 3.} There are a number of publications that show that increasing the varus knee torque increases the risk of medial compartment osteoarthritis. I've not seen a single piece of evidence anywhere that a medial post does anything.*
>
> *Peak deformation/pronation of the foot as defined by the midfoot, looking at the foot in its entirety and not just at the rearfoot, occurs after the heel has left the ground. So if you want to think that your medial post is stopping pronation, it's not even on the ground at the time that you theoretically need it*

Do Feet Pronate Inside Shoes?

In what will likely go down as one of the more gruesome studies of the effects of footwear on running mechanics, Alex Stacoff and colleagues published a paper in a 2000 issue of the *Journal of Biomechanics* that addressed the question of whether measuring pronation through the use of markers on a shoe or on the skin surface (as is typically done) could accurately provide insight regarding the actual movement of the bones inside the foot and leg. This question is of importance as both the shoe and skin can move (or not move) and slide independently of the underlying bones, and measurements of pronation taken from markers placed on these external surfaces might thus be subject to considerable error.

To address this question, Stacoff and colleagues recruited five brave subjects and inserted bone pin markers directly into their calcaneus (heel bone) and tibia (shin bone) under local anesthetic. They then had these subjects run barefoot or in one of several footwear variations {a shoe with three different types of sole—single density foam, dual-density foam, and laterally flared heel—and the dual density shoe with two types of orthotic inserts}. After taking biomechanical measurements during each running trial in each footwear condition, the researchers determined that "differences in the study variables of eversion and tibial rotation between barefoot and shod running were small and not systematic across subjects. The differences between subjects were larger than the differences between shoe and barefoot conditions." This means that variation among individuals was greater than any variation caused by footwear type within a single individual. Thus, they conclude that other studies that have measured aspects of pronation with shoe or skin mounted markers and that have shown differences between barefoot and shod running "did not reflect the movement of the underlying bone."

In practical terms, what this study showed is that although you might observe what appears to be reduced pronation in a motion control shoe, the foot might still pronate inside the shoe just as much as it would inside a neutral shoe or when barefoot. This is in part why gait experts like Dicharry don't believe that it is possible to determine pronation accurately with a simple treadmill and camera setup as commonly employed in a shoe store. It also raises the possibility that what most pronation-control devices in shoes accomplish is limiting movement of the shoe and not of the foot (for example, a medial post might prevent caving in of the midsole as the foot pronates). As with so many aspects of running mechanics, things are not always as simple and straightforward as they seem!

the most. So a medial post is not going to stop motion of the foot—we actually just did a study where we looked at motion of the foot inside the shoe when people are running, and it doesn't stop the foot from moving.

This being said, there are a lot of factors you can change in footwear design that do produce effects. We do validation work for a number of different shoe companies, and I can tell you that when you make changes to the design of footwear, they can have either positive or negative results. Footwear can make a difference; we've got proof to show that. But the medial post is not something we've manipulated to make those changes.

So which aspects of shoe anatomy, so to speak, are actually effective at controlling pronation? Dicharry suggests that some of the most effective variables are the specific location of midsole flex grooves, heel geometry, relative height of the rearfoot vs. forefoot (which determines amount of heel lift), and increased stiffness of the midsole to provide better sensory feedback. He's also quick to point out that shoes can and do work, but that better criteria need to be identified to adequately address the unique needs of each person, and that we need to more deeply investigate which of these aspects of shoe design might work best in a given situation.

Does Pronation Cause Injuries?

It would be quite a shame if you've managed to make it this far through this chapter only to find out that overpronation is not even a significant factor in causing running injuries. After so much time, money and effort spent developing shoes to control this dreaded "wayward" movement of the foot, and with so much angst suffered by runners trying to find the perfect shoe that will prevent their feet from rolling in too much, what if overpronation is really a phantom menance? What if it's not the cursed bogeyman that everyone has been fearing all these years?

Multiple studies have found little if any association between lower extremity alignment or degree of pronation and running injuries, though some have found relationships to specific injury types (it should be noted that study design and method of determining pronation vary widely among studies). In a 1998 review of the scientific literature on the relationship between pronation and running injuries in the journal *Sports Medicine*, Beat Hinterman and Benno Nigg write that the ". . . belief

that runners who overpronate have an initially higher risk for sustaining a running-related injury is still widely held by runners and coaches, although there has been no reliable study supporting this." They go on to emphasize that although overpronation might be causally related to running injuries in some instances, they estimate this relationship to be present in "no more than 10% of cases." Once again, Benno Nigg summarizes the current state of knowledge regarding overpronation and running injuries quite well in his 2010 book *Biomechanics of Sports Shoes*:

> *. . . the perceived dangers of overpronating and the expectation of resulting injuries resulted in technologies (e.g., dual density midsoles and orthotics) being developed to decrease both the maximum pronation as well as the time to maximum pronation. These products were (wrongly) assumed to be methods for the treatment and prevention of pathologies such as plantar fasciitis, tibial stress fractures, and patella-femoral pain syndrome. Evidence for the effectiveness of such strategies is currently unavailable. It is speculated that there is no such evidence because "overpronation," as it occurs in typical runners, is not a critical predisposition for injuries.*
>
> *Pronation and supination have long been the "danger variables" hanging over the sport shoe community, but their time as the most important aspects of sport shoe construction is over. Pronation is a natural movement of the foot and "excessive pronation" is a very rare phenomenon. Shoe developers, shoe stores, and medical centres should not be too concerned about "pronation" and "overpronation."*

So after this rather long journey through the world of shoe fitting and pronation control, runners everywhere are left to conclude that the methods employed in shoe stores are not very good at determining whether one overpronates, and that the shoes one buys to control overpronation might not be very good at doing so; in fact, for some people these shoes might even be more likely to cause an injury than prevent them. What's more, if Benno Nigg is correct, overpronation might not even be causally associated with the vast majority of running injuries anyway. One is left to wonder why pronation control retains such primacy in the shoe fitting process. Fortunately, driven in part by recent interest in natural running and minimalist footwear, times are slowly changing and footwear innovation is increasing the diversity of options available to individual runners. The days of the pronation-control paradigm, let's hope, are numbered.

Conclusion

After reading this chapter, you might be left asking: "So how do I choose the right shoe?" It's a great question, and one for which there is no easy answer. Matching shoe to runner is complex, and everyone is a bit different. There are guys weighing over 200 pounds who run almost all of their miles barefoot, and fleet-footed folks who have run Boston-qualifying marathons in bulky motion control shoes. Neither should be criticized for their choice; they have found what works for them, and that's all that matters.

The best thing you should do is experiment. Don't be afraid to try what stores or manufacturers might say is "the wrong shoe for you." Consult knowledgeable friends, online sources, and open-minded store clerks who are not tied to broken models. Get to know your personal preferences. Do you like firm cushioning, soft cushioning, or perhaps no cushioning at all? Do you like a flexible sole, or do you prefer a sole that is somewhat stiff? Do you like a shoe that has a heel lift or do you prefer one that is flat? Do you like the narrow fit of a performance racer, or do you prefer a wide toebox that provides freedom of movement for your toes? Do you like a structured upper, or an upper that consists of little more than a layer of fabric to cover your foot? These are all questions to consider, and often the answers can only be determined through experience. Try shoes out—many specialty shops will let you test-drive shoes, and some will let you return a pair that is not working out. If something doesn't feel right, don't ignore it—a shoe should feel comfortable, like it was made just for your foot, and it's better to find another pair than risk doing damage. Searching for the right pair of shoes can take some time, but it can also be a lot of fun. Enjoy the ride!