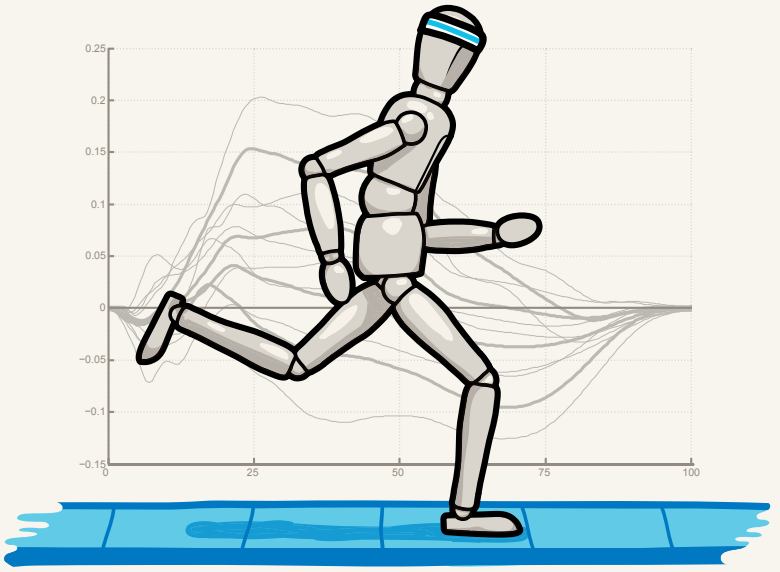
STRIDE SIGNATURE

An Individual's Unique Running Form
Defined by the Body's Habitual Motion Path

BROOKS



01 | INTRODUCTION

Imagine yourself sitting in historic Hayward Field at the University of Oregon, with a front-row seat to witness the 2012 Olympic Trials men's 10,000-meter final. Set to toe the line are 32 of America's finest distance runners. Years of training and competition have culminated in this moment for a chance to represent the USA in London. The gun fires and they are off! The runners glide harmoniously around the track, ticking off laps in unison with the cadence of a drumbeat. Each runner presents a picture of perfection. With long, powerful strides and soft, glancing blows to the track surface, they move with effortless efficiency through the early laps. At first sight it appears that these elite athletes carry themselves with the same impeccable form, crafted from years of coaching and training, and sought after by every runner who's ever laced up a pair of shoes. But is this truly the case? Is there really one right way to run? And can the runners in this very race settle this lasting debate? If these 32 runners are truly mirror images of each other, it would be compelling evidence pointing towards the existence of a single perfect running form. A form that we should all study and copy in order to improve performance and reduce injuries. Are these elite runners all forefoot strikers, relying on strong lower leg muscles to propel them as quickly as possible? Are they all heel strikers, using their entire foot to generate power? Or are they the mysterious midfoot strikers who lightly tap with the forefoot before rocking back on the midfoot to generate momentum into the next step? To answer these questions, you would have to slow time and peer closely at each runner's feet as he whips around the turn. Only then could you see clearly each foot strike and compare how they match up.

Iain Hunter, a biomechanist at Brigham Young University, did just this. Hunter can't stop time, but he did the next-best thing by placing a high-speed video camera at the side of the track during the race. By doing so, he was able to capture each runner's footfall movements and compare them side by side.

Could these images give us the golden key to unlock the secret of the perfect running form? We think so, but the results may surprise you. If you look closely at the images you can quickly see that each runner strikes the ground in a unique way. Some land on their forefoot. Others with their midfoot. And more than half of these elite runners landed with the much-maligned heel strike. Look closer and things get even more interesting. Some of the runners land on the outer edge of the foot, known as an inverted position. Others are more flat, and some have a rotated or twisted forefoot, which we refer to as abduction or adduction. It is a shocking visual. One would expect that a sampling of the fastest distance runners in our country running within a minute of each other over 10 kilometers would show strong similarities in form and foot-strike. If that were true, we could hone in on the commonalities to help everyone better understand proper running form. However, what we take away from Hunter's images is how strikingly *dissimilar* these runners actually are. Not one foot-strike pattern is the same (Fig 1.1). Like a signature or fingerprint, each runner leaves his or her own personal mark of individuality on the track. And the differences in foot strike are just the beginning. The same holds true when you zoom out and examine the nuances of each runner at the ankle joint, the knee joint, the hip joint, and so on. It is this principle of individuality – and not some elusive "perfect form" – that we believe will shift our sport's thinking about training and coaching, and set us on a new trajectory for how we build running shoes.

US Olympic Trials - Men's 10K (2012) | Images captured by BYU Biomechanics Lab - Dr. Iain Hunter

Fig 1.1 | *Like a signature or fingerprint, each runner leaves his or her own personal mark of individuality on the track.*

02 | NATURAL HABITUAL JOINT MOTION

At Brooks our goal is to inspire everyone to run and be active. When designing and developing footwear, our focus is on creating shoes that deliver an incredible experience, improve running performance, and reduce the risk of injuries. This is why we are constantly seeking a better understanding of running biomechanics. During the past five years, running shoes and their benefits have been under the microscope like never before. We can tell you that Brooks has been right there looking at them with the same scrutiny. Like you, we want to understand the truth behind all of the chatter.

> "WE WANT TO PROPOSE A RADICAL SHIFT IN THE RUNNING SHOE PARADIGM"

What is the right way to run? Should everyone run barefoot, or in shoes? How should your foot strike the ground? Does forefoot running make you faster and more efficient? Does heel striking slow you down and hurt your body? Should we all run like the Kenyans? Do the Kenyans themselves all run the same? Should we all run the same? Is "overpronation" really a bad word? Is "neutral" a biomechanical term, or just a frame of mind? Is cushioning evil?

Based on the research described in this paper, we want to propose a radical shift in the running shoe paradigm. ***A shift away*** from trying to come up with a single "right" way to run, to better understanding your unique way to run. ***A shift away*** from starting with broad baselines and generic averages, to starting with your unique individual baseline. ***A shift away*** from using a single parameter like overpronation to judge a runner's form, to considering multiple parameters to gain a holistic understanding of a runner's unique motion patterns. ***A shift away*** from matching the runner to the shoe, to matching the shoe to the runner. This new paradigm is about allowing you to be you and minimizing the problematic shoe hindrances that disrupt your natural running form. It's about optimizing what is right instead of fixing what is wrong.

Stride Signature

We call this concept of identifying the unique and highly individual characteristics of each runner "Stride Signature." It is a revolutionary idea, yet it is based in years of scientific research. A runner's Stride Signature becomes the new baseline or starting point from which we define the runner's perfect form and alignment. Our research leads us to believe that the answer to reducing injuries, enhancing comfort, and improving performance is not to change or fix a runner's "flaws," but to work with the natural and highly individual motion paths of the joints. The focus then becomes keeping the runner in this path of least resistance for as long as possible during a run. For some runners, perturbations such as shoe geometries, midsole hardness or excessive stabilizing technologies can push them outside of their preferred motion path. The task of modern running shoes should be to help these runners stay within their unique motion corridor at all times. One way we hope to create this effect is through a new running shoe technology that we call "Guiderails." By maintaining these habitual motion patterns, the runner will optimize muscle activity and joint motion, and therefore reduce the onset of fatigue and form breakdown. Moreover, the runner will experience the shoe as supremely comfortable, due to the empowerment of this fluid motion and the shoe's harmony with his or her body.

Anatomy 101

So where does overpronation fit in? For 30 years, we have been obsessed with this singular parameter when assessing running form and fitting running shoes. Are we saying that it no longer matters? Not exactly, but we are saying that to truly understand an individual's Stride Signature, we must take a much broader view. This view should look not at just one single aspect of running form, but at the entire physiology of a runner, down to the level of his or her joint geometry. To provide a better understanding of this, let's start with a little Anatomy 101. Our bodies are a complex mechanical system: the foot alone has 26 bones, 33 joints, and hundreds of muscle tendons and ligaments. A joint is simply where two bones meet and movement of the body occurs. Surrounding the bones are ligaments, which connect one bone to another; tendons, which connect our muscles to our bones; and cartilage, which cushions our joints.

BONES: If we look at the knee joint, we see that the bones are shaped to provide a sliding rotational movement primarily in the sagittal plane indicated in red (Fig 2.1). This allows for flexion and extension, or the motions of bending the leg and straightening it. The geometry of these bones dictates the preferred pathway of movement. If we examine hundreds of x-rays, we can see that the distinct geometry of these bones and the way they connect differs between people. These differences will cause the sliding and rotation of the joints to also be different for each person. The variability we see in the shape of these bones alters our desired movement pathways and therefore gives us our first explanation as to why everyone's running movement pattern is unique. We are all literally built a little differently.

Fig 2.1 | *The red shading shows where contact and movement occurs. The geometry of these bones dictates the preferred pathway of motion.*

LIGAMENTS: These soft-tissue structures are viscoelastic, like rubber bands, and connect bone to bone. Their primary function is to stabilize our joints from unwanted movements. You can see in the image that the location of the ligaments reinforces the joints (Fig 2.2). In the case of the knee, they are located on the sides, front and back, keeping the joint aligned and stable. This allows the knee to act in its primary mode of flexion and extension. The stiffness or strength of these ligaments varies from person to person depending on DNA, diet, past injury history, age, and exercise level. If you are someone who has ligament laxity (loose ligaments), the joint may not move as smoothly in the desired pathway as someone who has strong, intact ligaments. It is the strength of the ligaments along with the geometrical shape of our bones that establishes our preferred pathway of motion.

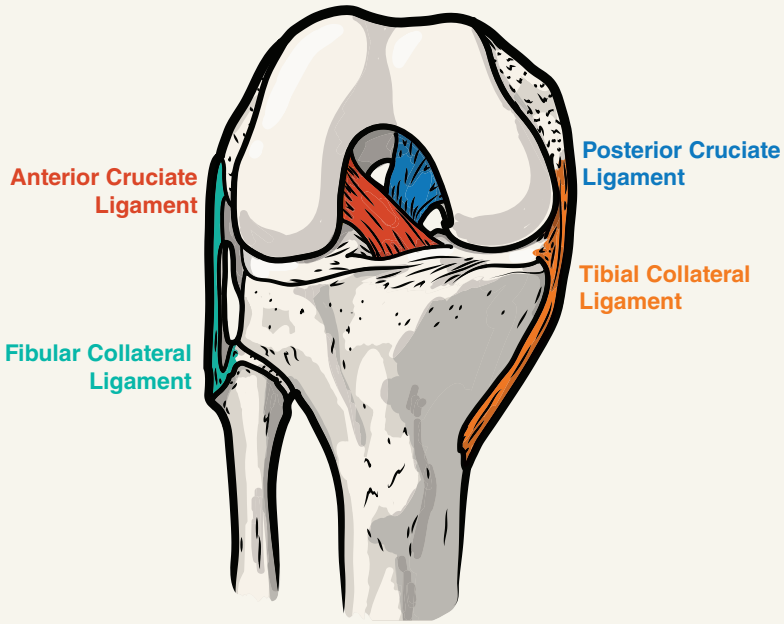


Fig 2.2 | *It is the strength of the ligaments along with the geometrical shape of our bones that establishes our preferred pathway of motion.*

TENDONS: As stated before, our bodies are complex mechanical structures, and luckily there are secondary stabilizers that will react to keep joints moving in their preferred pathways. These secondary stabilizers are our tendons (Fig 2.3). If you recall, your tendons connect your muscles to your bones, and your muscles activate to move your body. When a joint is perturbed and the motion leaves the preferred pathway, it is the muscular system that helps guide it back into the natural motion pattern. Muscle strength determines how effectively the joint returns to the preferred path of motion, so people who are strong and balanced will experience centered and smooth rotation of the joints. But what if you have muscle imbalances or weaknesses? This can result in a different natural pattern, yet one that is still your preferred path. As you train and strengthen your muscles, you will allow your body to better maintain its natural motion patterns.

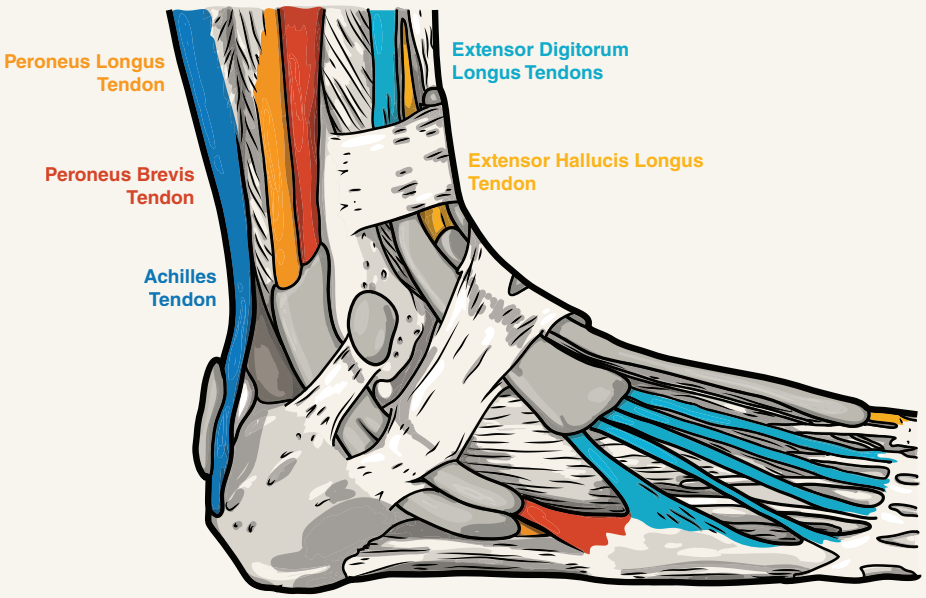


Fig 2.3 | *Your tendons connect your muscles to your bones, and your muscles activate to move your body. When a joint is perturbed and the motion leaves the preferred pathway, it is the muscular system that helps guide it back into the natural motion pattern.*

Utilizing NHJM

The geometry of our bones, the strength of our soft tissues, and our adaptation skills are all different among us. Therefore everyone has unique pathways their joints should travel. Not only is this a natural movement, it is also habitual. Habitual doesn't necessarily mean that it is learned, but simply that it is something performed subconsciously. Armed with this new understanding, should you change your running form? Why not embrace who you are, and enjoy your run? Although you might look different than your running partners, you can be confident in the knowledge that you are all running in your preferred, natural manners.

We call this theory "Natural Habitual Joint Motion." This theory forms the basis for our concept of Stride Signature introduced earlier. Natural Habitual Joint Motion is the idea that everyone has a unique and individualistic way to run. It is a term that will allow the runner to run in a path of least resistance for all of his or her joints. Runners who achieve this goal should see increased performance or efficiency, a reduced risk of injury, provide a healthy load to the body, and be able to stay fit and active.

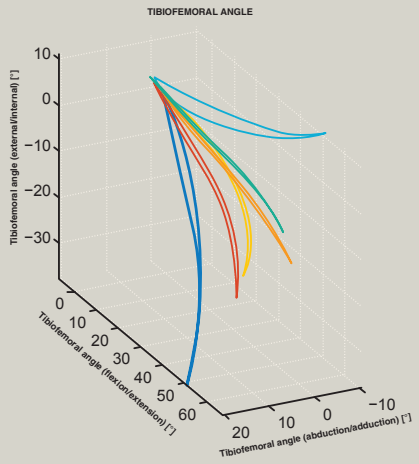
In understanding NHJM, how can we utilize it best? If we are able to maintain the unique preferred pathway of our joints, without the use of our tendons to stabilize them, then that means we can conserve energy. Our muscles will be allowed to work most efficiently in their primary role of propelling our body forward in running. If we think back to the geometry of our joints, we recognize that the junction and shape of these bones, along with the strength of our ligaments, dictate how smoothly the joints will move. Any irregularities in this movement will misalign our joints and cause friction and resistive forces to our joints and bones. This can lead to a risk of injury, so maintaining the path of least resistance is desirable to prevent such wear and tear.

Finally, the body requires a certain level of stimulus or force to maintain its health. If we look at bone formation, a principle called Wolfe's Law shows that when a bone is placed under load, such as through running, it will eventually grow stronger through remodeling. If our body is stagnant, our muscles and bones will weaken and deteriorate. This is not news to any of us runners who have had a prolonged break in activity. That first run back leaves us with aches and pains because we are using muscles that need to be strengthened again. Not only do muscles weaken, but bones will become less dense or deteriorate if not properly loaded. This shows that keeping our bodies properly active will maintain our health and protect us from injuries. It is the underuse or overuse of these load-producing activities that leads to many of the injuries we encounter, and accounting for this helps us fit runners better.

> "SHOES THAT ALLOW US TO RUN IN OUR NATURAL PREFERRED STATE UNDER THE PATH OF LEAST RESISTANCE...SHOULD PROVIDE THE BEST EXPERIENCE "

By finding harmony in the interaction between the runner's needs and the runner's preference, we can suggest footwear that enhances comfort, increases performance, reduces the risk of injury, and increases efficiency. Shoes that allow us to run in our natural preferred state under the path of least resistance, and not attempt to correct perceived problems or deficiencies, should provide the best experience and be the most comfortable.

CASE STUDY: Six leg specimens were obtained for this study and placed in a testing apparatus that moved the knee joints in a flexion/extension path. Each leg underwent 10 cycles, and we graphed the results, shown below. This graph illustrates the motion patterns of the three primary rotations the knee undergoes when in motion. You can see clearly that each leg has a repeatable and stable Natural Habitual Joint Motion. In other words, all 10 cycles of each knee lined up on top of each other, forming a single loop. The fact that they are repeatable and stable shows us that there is in fact a desired pathway that the body wants to move in. While each individual leg is consistent in its motion, we also see that each one moves in a completely different way from all the others. This clearly illustrates that the key to running healthy is to understand your unique anatomy, and to establish an individual baseline specific to yourself. Your shoes should not hinder your natural habitual pathways, but should enhance and help you embrace your unique Stride Signature.



03 | RESEARCH STUDIES

Brooks has been working with two pioneers in footwear research to shed light on this concept of Natural Habitual Joint Motion. Professor Dr. Gert-Peter Brueggemann, Director of the Institute of Biomechanics and Orthopedics at the German Sport University of Cologne, and Prof. Dr. Joseph Hamill, Director of the Biomechanics Lab at the University of Massachusetts Amherst, have studied running biomechanics and footwear interactions for well over 30 years. A quick search for literature produced by these two will return more than 300 peer-reviewed journal articles around these topics. In short, these men are leaders in the running biomechanics research community. Our work with them has been a collaborative endeavor to understand how to match shoes to each runner's individual style. By embracing the idea that everyone has his or her own individual corridor or preferred pathway, and enabling footwear to work within that realm rather than inhibit or control it, it is possible to finally decipher the mystery of running comfort.

Study: How Do You Run?

The first study conducted was a look into how you run. This study recruited more than 300 men and women covering a wide spectrum in regards to age, mileage, and experience. If you run, you fit into the understanding of this research. We collected standard biomechanical measures – kinematics, how our joints move; and kinetics, the internal and external forces applied to our body – to understand how the body moves and functions while we run. In addition, we looked at demographic information such as age, gender, miles per week, number of years running, dynamic and static muscle-strength quantification, flexibility or range of motion of joints, and foot architecture such as arch height. These extra data gives us a more complete picture of your unique biology and physiologic makeup, allowing us to link how you run to who you are. Typically a research study may look at just one of these dependent variables. So having all of this data compiled together with such a large, inclusive population leads us to believe that we now possess one of the largest and most comprehensive running databases in the industry.

The key purpose of this study was to explore different footwear conditions in regards to all the aforementioned variables we measured. Our baseline or control consisted of individuals running unshod on a soft surface. It is important for us to point out that the foam runway was a vital part of this study to create the baseline condition (Fig 3.1). We wanted to capture the biomechanics of an unconstrained foot that allowed the body to move in its preferred manner. What we saw was that individuals who preferred to land on their heels continued to do so barefoot on a soft surface, and same for those with a midfoot strike. Then we compared that motion to when that same foot was shod. This allowed us to see the effects that footwear had on the preferred motion paths. If the subjects for our baseline condition altered their preferred landing patterns, the measures we collected would not represent or compare to their natural habitual patterns. It is critical to understand that our baseline was not “barefoot,” it was running without shoes on a soft surface so that the preferred manner of landing was the same between these conditions and when shod.

For every step each of these individuals took in the lab, we gathered data on more than 200 variables. We conducted an analysis known as a factor analysis, which determines the sensitivity each parameter has on the effect of the test conditions. This helps us determine which variables or measures are influenced or altered when you change footwear conditions. Does footwear affect the knee flexion/extension angle, or the amount of rotation that occurs at your tibia, or the amount of force applied to your ankle joint? The intent of this process was to identify a list of variables that change due to footwear, and then relate those parameters to biomechanic fundamentals in regards to injury prevention and enhancing performance. So we conducted test after test. We accumulated mountains of data. We studied that data. And what we found amazed us. This study clearly showed that one of the most sensitive variables of our analysis was something called the “Free Moment,” as defined in the biomechanical community.

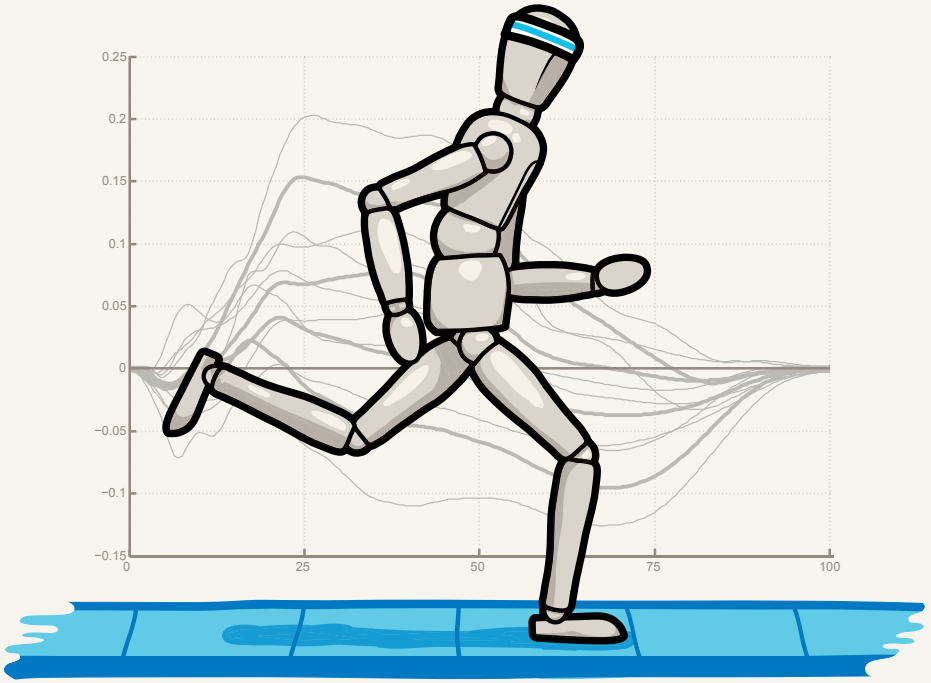


Fig 3.1 | *This study helped us determine which variables or measures are influenced when you change footwear conditions.*

Free Moment

Popular wisdom ties pronation to a vast majority of running injuries, yet study after study has been unable to correlate such injuries to this singular pattern. We know that some runners exhibit excessive pronation and yet have run injury-free for many years, whereas other runners battle continuous injury despite having limited amounts of pronation. Also overlooked is the fact that pronation is an essential motion when running. It acts as a natural shock absorber and allows our foot to transition to the power position essential for a proper push-off. Imagine if we could expand our scope to identify more parameters that are linked to running injuries. We need to know how the body reacts and moves while we run.

> "FREE MOMENT IS A SUMMATION OF THE AXIAL ROTATION OF YOUR ENTIRE BODY AS YOU RUN"

Understanding our discovery of the Free Moment, and how highly sensitive it is to footwear conditions, is incredibly exciting as it takes a holistic view of your body. To define it, the Free Moment is a summation of the axial rotation of your entire body as you run (Fig. 3.2). When you land on the ground while running, your foot exerts forces in three directions. A downward force, also called the vertical force, is the amount of force associated with the landing motion. This can be altered through cushion technologies. The foot also applies frictional forces in the side-to-side (medial/lateral) and forward (anterior/posterior) directions. Along with these forces acting on the foot, our body is twisting as we run. Our trunk rotates, and our swinging limbs cause rotation of our body. We also measured the rotations caused by our free leg along with that caused by our arms. If these swinging rotations change, so does your Free Moment. Try running with your arms behind your back. Not so easy, is it? That's because the rotational movement of our body is part of who we are and how we run. By looking at the Free Moment, we are essentially quantifying how much your leg and arm swings influence how you run, how your trunk is orientated in space, and how stable your foot is during contact with the ground. Therefore, we describe Free Moment as a holistic measure of how you run.

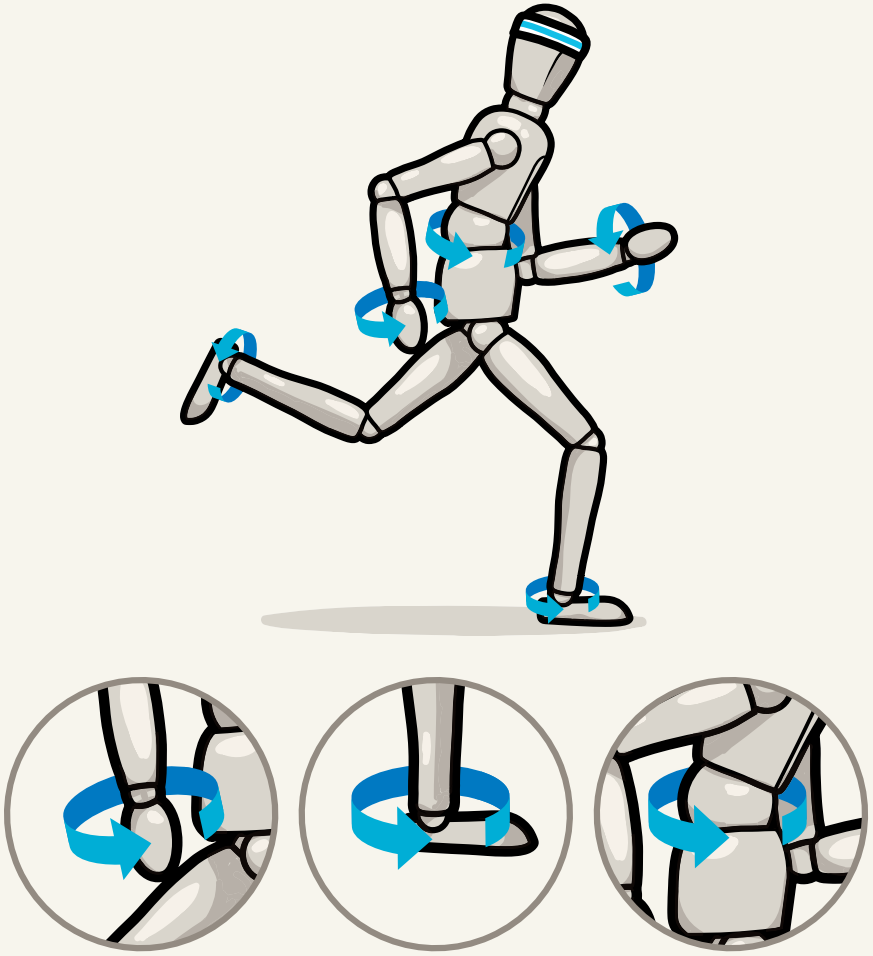


Fig 3.2 | *The rotational movement of our body is part of who we are and how we run. Free Moment gives us a holistic view of the entire body.*

Cluster Analysis

Once the Free Moment was identified, we then performed a cluster analysis. This is a statistical technique that looks at all of the runners in the study and groups like individuals into clusters. It was determined that the more than 300 participants fell into four distinct Free Moment patterns. Once each runner was classified into a cluster, we could then look at all of the demographic data and things like muscle strength, joint flexibility, and foot shape to understand what the runners in each group looked like (Fig 3.3). This analysis can form the foundation of a new paradigm for fitting shoes. Instead of looking at one single measure like pronation, we can now look at how strong you are, how flexible your joints are, how old and experienced you are, and how your body moves at the ankle, knee, toes and hip while you run. With this we can predict what your Free Moment looks like and choose shoes suited to your Free Moment.

Next, we looked at the biomechanical measures we collected in these four groups. We saw that there were large differences in regards to these measures, and that each group of runners responded to footwear differently. We put these descriptions of runners and how they related to footwear onto a continuum (Fig 3.4). This allowed us to develop an understanding of the different needs for footwear. It allows us to match shoe performance to each runner's unique form to harmonize the experience and comfort of the runner.

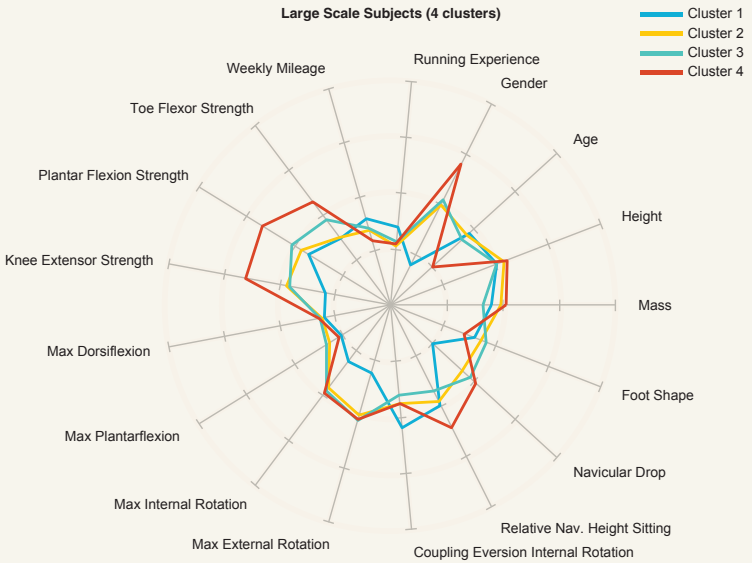


Fig 3.3 | *No longer should we look at a single measure like pronation when fitting shoes – this analysis can form the foundation of a new paradigm.*

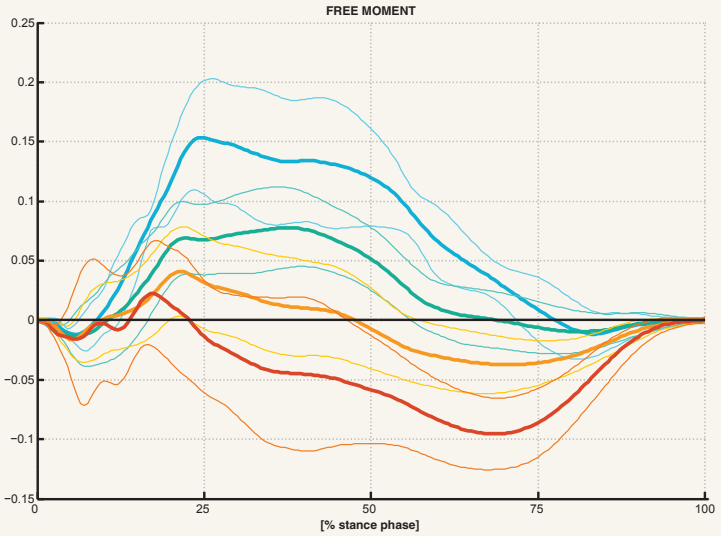


Fig 3.4 | *Different runners respond to footwear differently; therefore, shoe performance should be matched to a runner's unique form.*

Study: Body Adaptation

We have already talked about how the structure or geometry of our body affects how we move. But to fully appreciate the natural habitual motion of a runner, we have to further our knowledge in how a runner adapts. We have all run on the street, on grass, maybe on that favorite trail in a local park or at a beach. These different surfaces may be hard or soft, and may pose challenges like roots or rocks that cause our feet and body to shift or adapt to these conditions. Our bodies have a natural ability to adapt to perturbations we encounter when running. This adaptation is mostly handled by our neuromuscular system and the activation of muscles to keep our bodies stable and moving forward. That means we want to remove any hindrances a shoe may exert on a runner and cause them to deviate from his or her Natural Habitual Joint Motion corridor. Then we must focus on giving each runner the shoes that match his or her unique Stride Signature, we must give them shoes that help them return to their individual motion corridors. It is not about correcting runners, but embracing who they are.

> "IT IS NOT ABOUT CORRECTING RUNNERS, BUT EMBRACING WHO THEY ARE"

This novel concept led us to conduct further research to shed light on some of the questions around our natural ability to adapt to our environment. We first conducted a tilted-walkway experiment. In this study, the subjects ran over a level walkway to create baseline movement patterns. We then tilted the walkway medially or laterally and asked the subjects to run on the tilted walkway (Fig. 3.5). With each step, you can see that the foot has a tendency to want to roll inward on the lateral tilted walkway for the left foot, and to roll outward for the medial tilted walkway for the left foot. We then measured the muscle activity and the amount of ankle eversion and inversion (inward and outward tilt) for these runners while running on the different walkways. What we found was that the amount of ankle rotation was fairly consistent in all three conditions. As the possibility of increased motion (inversion/eversion) was introduced to the ankle, the muscles responsible for inversion or eversion were increasingly activated to keep the ankle joint aligned. This means that along the laterally and medially tilted walkways, the ankle rotation did not match the tilted surface rotation. Why was this?

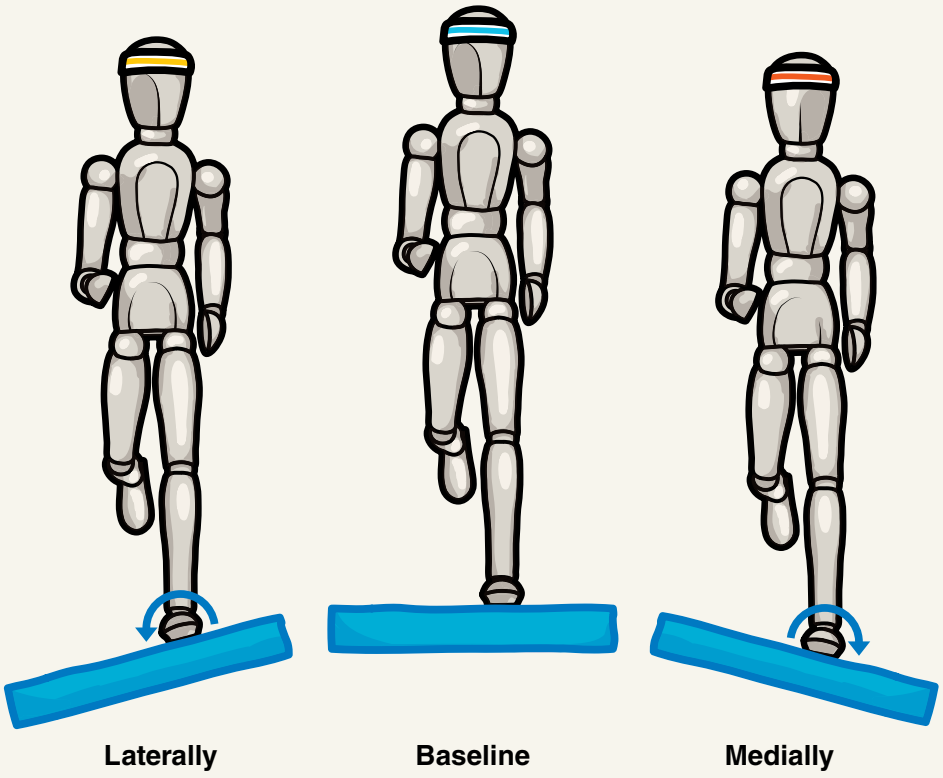


Fig 3.5 | *Our bodies have a natural ability to adapt to perturbations we encounter when running.*

We discovered that the muscle activity of the foot evertors on a laterally tilted surface fired with increased magnitude, keeping the foot aligned. Likewise, on the medially tilted surface, the muscle invertors increased their activity level to keep the foot aligned. This was clear evidence of how our body adapts our muscle activation levels to try to maintain a path of least resistance, or our preferred motion path, despite the perturbations of the environment. This also suggests shoes interacting with our body adaptations in an appropriate way leads to; increased performance, reduced risk of injury, and increased comfort.

Study: Preferred Pathway of Our Joints

Based on geometry, ligament laxity, and muscle strength, it is quite easy to determine the path of least resistance under no loading conditions. But what happens to the body when you go from simply swinging your leg freely and determining this path of least resistance, to running, where we exert more than 2.5 times our body weight onto these joints? Once again, this was a question that led us to develop more research studies. In this next study, we had runners run under different loading conditions and looked at how their bodies reacted. We put them on a treadmill while fitted with a harness that could lift their body partially or fully off the ground (Fig 3.6). What this system did was allow us to look at how a runner moved when he or she only exerted partial body weight to the ground. This system let us look at any percentage of body weight we wanted, and we selected a load range from 20% to 100%. We found that the ankle motion pattern and COMP serum (COMP serum is a biological indicator that may indicate increased stress to our body's cartilage) concentration in the runners was relatively stable when they ran at up to 60% of their body weight. As we increased loading to 100% of body weight, the impact the joints had to absorb rose up to 2.5 times body weight. In this range, we found increased ankle angle rotation and increased COMP serum concentration. The conclusion of this study was that the Natural Habitual Joint Motion is stable in a relatively unloaded environment, but once we move to activities like walking and running, this motion path is altered due to the increased demand on our joints from the higher loads exerted on the body. Simply stated, running alone causes an alteration to our natural movement patterns, and this

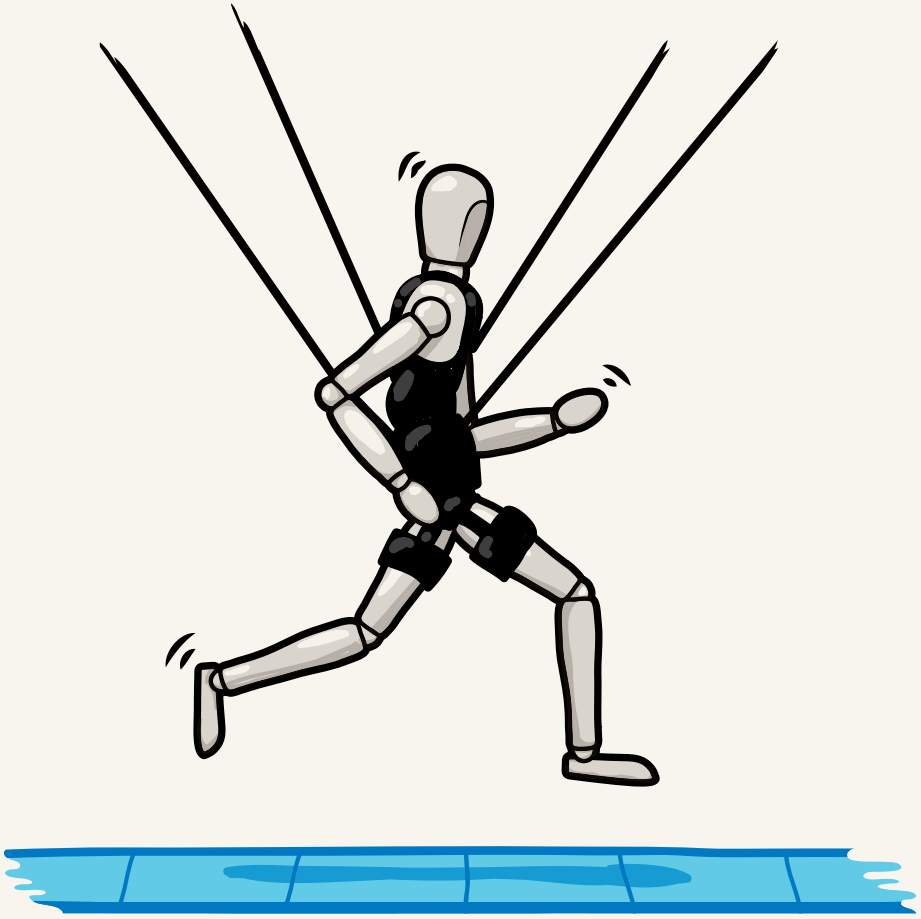


Fig 3.6 | *We had runners run under different loading conditions, and looked at how their bodies reacted.*

change is different for each one of us, based on our running experience, muscle strength, and ligament laxity. What is even more interesting is that when we looked at the individuals in this study, we found that some of them were actually able to maintain their motion patterns despite the added load, whereas others changed dramatically. We believe this discovery is the start of a new line of questioning that will help us truly decipher running comfort. Ultimately, it could give us the ability to match shoes to each runner's individual style, helping him or her to run better, more comfortably, and injury free.

These findings led us to conduct yet another study to understand how much deviation in our Natural Habitual Joint Motion occurs when unloaded (i.e., swinging freely in space) compared to a loaded state (i.e., running, which produces 2.5 times body weight at impact). Furthermore, we wanted to understand how, on an individual level, each person responds to these changes. For this study, we developed a cushioned sock to replicate the foam-mat runway we used in our previous experiment. We then asked our runners to perform different activities from freely swinging the leg, to squatting, to jumping, to walking and running, to understand how the joints move in each of these activities (Fig. 3.7). While performing these different activities, we had the participants run in different footwear conditions to see how their joint motion paths were altered. We hoped this would give additional insight into how we can harmonize our footwear to work with each runner's unique Natural Habitual Joint Motion corridor.

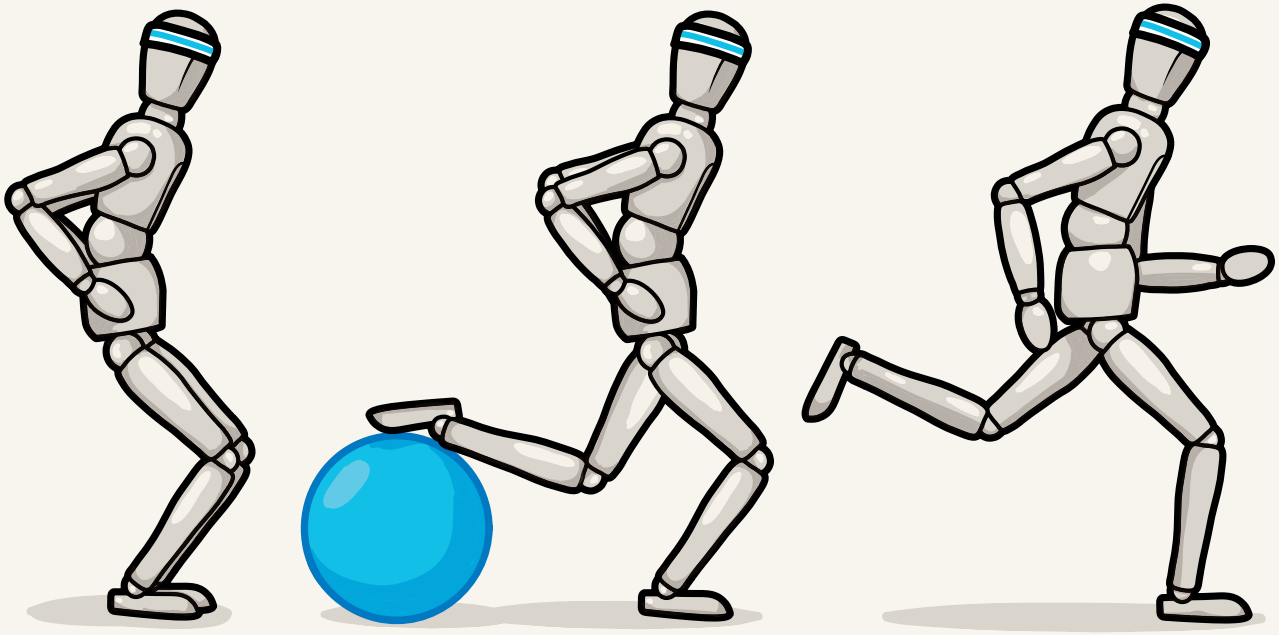


Fig 3.7 | *Runners wore a cushioned sock to replicate the foam-mat runway and did a variety of activities to see how their joint motion paths were altered.*

In creating this study, we wanted to identify the amount of deviation in runners. We expected that some individuals would not alter or leave their natural motion corridors, while others would deviate from them significantly (Fig 3.8). In the low-deviation group, you see that the motion of these runners was stable and within the corridor boundaries whether the joint was loaded or unloaded. For the high-deviation group you can see that as we perturbed the body by applying a greater load (i.e., running), the subjects increased the amount of motion at the joints. This increased motion left the unloaded natural motion corridor but is confined by the loaded motion corridor.

04 | GUIDERAILS

Returning to our Olympic theme, we can better explain the deviation from Natural Habitual Joint Motion corridors by moving from the running track to the bobsled track. You are now in Vancouver, British Columbia, seated at a corner of the bobsled run. As the sleighs rocket down the icy course you see some sliding high or low around the curve. Each crew tries to guide their sled down the "line" – the ideal path through the course. A sled's time down the course depends on how much it deviates high or low from that sweet zone around the corners. For the fastest times, you see the sleds glide effortlessly by you; for the slower times, you see the sleds careening high and changing course, costing precious seconds. Matching the shoe to the runner should help to give the smoothest ride and the fastest time through the course.

We are working diligently to understand how to design shoes that can provide Guiderails to keep runners' motion patterns within their unloaded corridors. For those runners who are stable and can easily maintain their Natural Habitual Joint Motion, we believe they can choose footwear based on comfort and experience. For certain types of deviators, we expect to see that different footwear conditions can provide solutions to help them maintain their Natural Habitual Joint Motion corridors. It should be emphasized that the goal is not to correct your body's motion, but to harmonize your shoes and your specific needs. We want to remove any hindrances that shoes create and match the shoe to the runner to maintain his or her unique Stride Signature. Our research shows there is a large proportion of runners who can self-select footwear because they maintain their natural movement patterns whether in an unloaded or loaded state. For those runners who did deviate from their natural corridors, we have identified three distinct patterns of deviation. For these runners, we can see how different shoe conditions can move them closer or farther away from their Natural Habitual Joint Motion. We continue to explore this concept to help us answer the question: "What is the right shoe for you?"

> "THE GOAL IS NOT TO CORRECT YOUR BODY'S MOTION, BUT TO HARMONIZE YOUR SHOES AND YOUR SPECIFIC NEEDS"

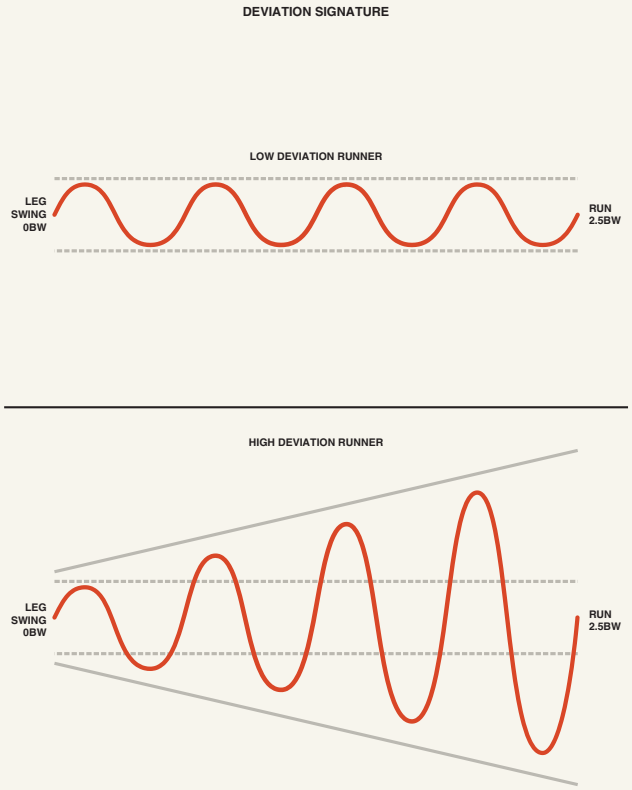


Fig 3.8 | *In creating the body adaptation study, we expected some individuals would not alter or leave their natural motion corridors, while others would deviate from them significantly.*

05 | CONCLUSION

The concept of Stride Signature starts with the runner, not the shoe. By taking a small step back and re-examining the foundation of our biomechanical assumptions, we are able to take a massive leap forward in our ability to better match runners to the right shoes. The idea that your joint geometry and motion patterns are completely unique is the basis for the need to start with the individual's natural form. Think of a golf swing. The next time you turn on a golf tournament, watch closely how each golfer's swing is unique. They are all at the top of the game not because they have perfected a singular perfect swing, but because they have embraced the natural characteristics of their own swing and found a way to make it consistent and highly repeatable. Consistent and highly repeatable is exactly what we are going for with Stride Signature. We want to understand the runner's natural pathway, and then build shoes to assist the body's desire to stay in that motion pattern for as long as possible.

We want to decode comfort in a running shoe. Why are there so many different shoes out there that work perfectly for one runner, but fall completely flat for the next? Why do some runners prefer a soft ride, while others prefer something firm? Why do some seek support while others go for flexibility? This is the beauty and challenge fitting running shoes. Up until now, finding your perfect shoe could take years of trial and error. And when you finally find that one perfect shoe, it changes – a frustrating process for runners. What if we told you that by better understanding you as a runner – your Natural Habitual Joint Motion patterns, and the dozens of parameters that make up your unique stride – that we could start to take the guess work out of it? That is exactly what we are looking to do with the concept of Stride Signature. It will involve a massive paradigm shift in how we evaluate runners. No longer will overpronation be the final diagnosis. It will merely serve as one of many parameters that help us to better understand how to optimize you and your habitual motion path.

We are excited to dedicate our brand to fully embracing this concept. We are just getting started at understanding all of the complexities that make this such a breakthrough idea. We don't have all of the answers, but we do know that we are at a revolutionary point in the running shoe industry that will impact footwear design and functionality for many years to come. Brooks is focused on leading the efforts to reduce injuries, enhance comfort, and improve performance for all runners. Stride Signature is the sea change needed to flip the current paradigm on end and forge a new runner-centric path to help everyone Run Happy!