The Biomechanical Observation

The eye sees
what the mind knows.

BY RICHARD L. BLAKE, DPM, MS

The purpose of this article is twofold. The first is simple and concerns motivating the reader to make more observations. This, of course, concerns every aspect of our life and profession. The second is more complex, but overwhelmingly the most important. It can be summarized by a saying accredited to DH Lawrence: "The eye sees what the mind knows." Everyone can be better observers. Yes, everyone. We have to have both the time and the desire to observe. You will never observe something you are not looking for, except perhaps "the elephant in the room".

Decades ago, at the California College of Podiatric Medicine, students were taught to measure everything, which was wonderful, but there was a common error in the process. Students would measure without observing, and this led to constant mistakes. Even though it is crucial to measure, observation will serve you best in your biomechanical practice. Imagine if you had to make treatment choices only based on observations. It is not too far-fetched, since most of the world practicing foot care does not measure much of anything. If you cannot measure, you must observe more. Let us strive to get better at observation.

When a patient presents at your office, you listen to their story, and then decide who needs biomechanical help. The ingrown toenail? Probably not today. The runner with plantar fasciitis and knee pain? For sure. An acute ankle injury? Any biomechanics will have to wait for the severity of the injury to be sorted out. The flat-footed child who cannot participate in sports? For sure. So, you select the patients for the day that need a biomechanical approach. Where do you start? Gait is the best place to start. Five to six times up and down your hallway can solidify Observation #1. What is Observation #1? It is simply the conclusion of stability. Are they stable or not? If we observe instability, what kind of instability is it? If we observe stability, let's move on today.

The focus of a biomechanical examination with gait and/or measurements is to discover instabilities that we can treat. You all probably know already that a patient can walk barefoot with great stability, but in another environment that same patient can be very unstable. So, over the course of your many office visits helping a patient with an injury, watch them walk barefoot, in different types of shoes, have a runner run, and a dancer/ice skater/ biker send videos so you can observe their sport-related gait. What are the standard instabilities we may find?:

- Poor shock absorption (probably not a true instability, but a serious cause of injuries that are very treatable)
- Pronatory (medial) instability
- Supinatory (lateral) instability
- Asymmetrical instability (due to functional and structural limb discrepancies)
- Instabilities caused by a variety of weak and tight muscles due to how they change the gait pattern.
- Instabilities caused by past and present problems (post- hip and knee surgeries, chronic lateral ankle sprains, etc.)
- More global instabilities (ligamentous laxity, recent debilitating illness, nerve damage)

Figure 1: Podiatry Students at California School of Podiatric Medicine learning to observe and measure.

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If You Don't Look, You Won't See

Let's simply show these 20-plus observations that are a standard part of biomechanical observational skills to get you started. As you make these observations, they will add value to help your patients stay or get health-

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ier. Remember, if you don't look, you will not see.

Before anything else, get a front view of your patient (Figure 2). We can observe major alignment issues like genu varum and valgum, tibial varum and valgum, asymmetrical pronation, bunions, and hammertoes. Here, the left greater than right tibial varum denotes asymmetry. Typically more varus should be put into the left orthotic Rx: medial Kirby skive, varus posting anterior and posterior, inverted technique, or balanced 2-3 more degrees varus.

For the same patient, the posterior view (Figure 3) can highlight the knee (genu) component of the examination with more genu valgum right and more tibial varum observed right. The two deformities cancel each other out. The straighter left knee has more left tibial varum leading us to the same conclusion as above. The left side is more classic rearfoot varus, needing more varus in the Rx. Here you can see the heel position well. Is it varus, valgus, or fairly vertical?

Figure 2: Front view of your patient

Figure 3: Posterior view of your patient

Figure 4: Evaluation of heel position.

If the patient has a possible shoulder drop, you have to check the tips of the fingers to see if they are also low.

Whether you mark the line to bisect the heel, or find that you can easily evaluate whether it is inverted, everted, or vertical, this observation of the back of the heel (Figure 4) helps our categorization of patients. The 7 categories of patients that have various orthotic modifications or corrections for are:

1) Heel Vertical
2) Heel Slightly Inverted
3) Heel Very Inverted
4) Heel Slightly Everted
5) Heel Moderately Everted
6) Heel Dramatically Everted (Figure 4)
7) Heel Serious Everted (PTTD or Adult Acquired Flat Foot)

Figure 5: Evaluation for limb-length discrepancy

Figure 6: Look for shoulder drop.

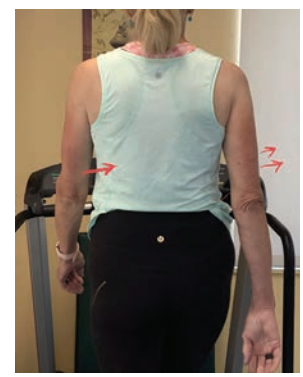

Figure 7: Asymmetrical arm swing in gait has many functions. Note that the right arm swings further away from the body.

Figure 8: Check for limb dominance.

Figure 9: Check for truncal instability.

Figure 10: Look for hip hike.

Limb-Length Discrepancy

The treatment of limb-length discrepancy (Figure 5) first comes from observing its devastating effects on the body and wanting to do something about it as a biomechanics expert.

If the patient has a possible shoulder drop (Figure 6), you have to check the tips of the fingers to see if they are also low. Remember your dominant side, right- or left-handed, may appear to have a shoulder drop on that side since the musculature can look more rounded. Generally, the head tilts to the short side and shoulders drop to the long side.

Asymmetrical Arm Swing

Asymmetrical arm swing in gait has many functions. In Figure 7, the right arm swings further away from the body. This could mean just that the

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left arm swings closer to the body. Asymmetrical arm swing can also mean the amount of swing is much greater on one side (or more reduced on the other side).

Limb Dominance

Check for limb dominance (Figure 8). It indicates that the patient is leaning to one side and therefore putting more pressure on one side. The side that they are dominant to typically has more hip and back pain. The body has to work extra hard to right the ship with every step. The dominance tends to be the long side, but this is not more than 70% true. The dominance can be related to spinal or pelvic issues

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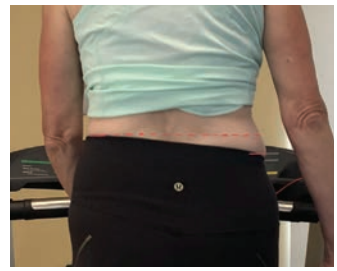

Figure 11: An uneven belt line is an unreliable determinant of a limb-length discrepancy.

Figure 12: Observe knee excursion.

Figure 13: Patients who are poor shock absorbers may show a jerk or calf shuttering.

Figure 14: Watching the heel position in gait, even though it is hidden by the shoe, can be very useful in categorizing our patients.

Figure 15: From this angle, the right arch looks a little more pronated and the orthotic Rx should reflect that finding.

Figure 16: Digital clawing can be one-sided or bilateral as is seen here.

Figure 17: Severely out-toed gait, if recent, can be a sign that the patient is seeking to be more stable.

Figure 18: Pigeon-toed gait.

Figure 19: One of the most important observations is heel position: vertical, everted, or inverted.

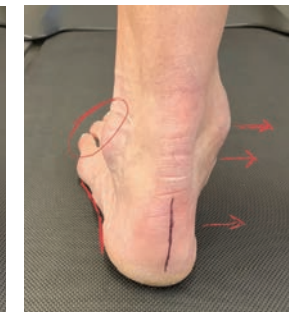

Figure 20: All the signs of over-pronation are seen: heel eversion and medial prominence of the ankle.

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unrelated to limb-length discrepancy. Some patients have postural instability where the limb dominance can change as they walk away from you and then towards you.

Observe the Trunk

When observing the trunk, it is good to have the shirt tucked into the pants (Figure 9). Most of your patients will be very solid in the back area, but some will show signs of truncal instability or sway. Their core needs a lot of work getting stronger.

When the foot strikes the ground, occasionally the hip area jerks upward (Figure 10). This is called hip hike and is pathological. It can indicate an arthritic hip or a very long leg. The difference between the right and left sides is dramatic.

Some patients have postural instability where the limb dominance can change as they walk away from you and then towards you.

Figure 21: A child with a pronated foot.

Figure 22: This is called lateral instability and is one of the worst instabilities that you will treat.

Probably the most unreliable of limb-length difference signs is an uneven belt line (Figure 11). Getting the pants exactly even on a patient with the shirt very evenly tucked in can be a challenge.

Knee Excursion

Hip motion in the transverse plane is largely seen by knee excursion (Figure 12). When there is excessive internal knee excursion, no knee motion, or excessive external knee excursion, problems can occur. This observation is especially true with knee problems, but for pronation an internally rotated knee can be a strong driver of excessive pronation moments.

As you watch the foot and back of the calf at heel contact, patients who are poor shock absorbers may show a jerk or calf shuttering (Figure 13). This indicates that there is excessive jarring at foot impact.

Watching the heel position in gait, even though it is hidden by the shoe, can be very useful in categorizing our patients (Figure 14). Are they stable? Do they have any signs of over-pronation or over-supination? Are they smooth as they walk? Of course, a well-lit hallway or treadmill is ideal.

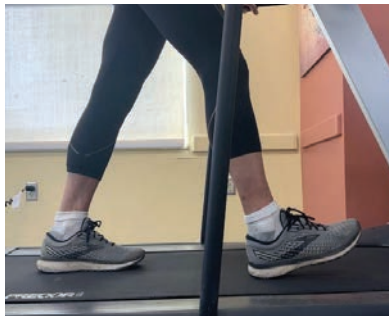

Figure 23: Observing someone walking from the side gives us the opportunity to time heel lift and heel contact of the opposite side.

Figure 24: Patients with tight Achilles tendons can compensate in many ways: foot pronation, out-toed gait, early heel off, or bouncy gait.

Figure 25: Besides seeing everted heels in a pronated child, you can see the flattening of the arch.

Asymmetry

Asymmetry is huge in biomechanics. Of course, this observation cannot be made on a moving treadmill. Looking at the ankle and arch alignment gives an idea of what is needed to even things out right to left, and also

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line up the foot to leg better. From this angle, the right arch looks a little more pronated (Figure 15) and the orthotic Rx should reflect that finding.

Pronation and Supination

Digital clawing can be one-sided or bilateral as in Figure 16. We claw to gain stability, probably more as we walk downhill. Most people with pes cavus tend to develop clawing due to the plantigrade declination of their metatarsals, but most are quite unstable anyway. A gradual loss of vision can cause clawing as with most cases of instability.

What does our angle of gait teach us? Severely out-toed gait, if recent, can be a sign that the patient is seeking to be more stable (Figure 17). The hip is the most comfortable at 30 degrees external, so there may be a hip problem developing. It can be a compensation for a tight Achilles tendon, and also can lead to over pronation as the weight does not go correctly through the foot. Out-toed patients are some of the worst supinators, as they land laterally and can break down the lateral side of their shoes too early to buy another pair, keeping them supinated. Very overweight patients can externally rotate their hips with abduction to clear their knees as they walk.

One of the most important observations is heel position: vertical, everted, or inverted.

Figure 26: the focus is on a patient with "squinting patella" with severe internal femoral rotation.

Pigeon-toed gait (Figure 18) is much more cosmetically unsightly for the parents, and it is our job to discover why children are intoed. In-toed gait is naturally laterally unstable as weight stays too lateral, so pronation can be an easy compensation.

One of the most important observations is heel position: vertical (Figure 19), everted, or inverted. This can have a direct effect on orthotic Rx writing. In Figure 20, all the signs of over-pronation are seen: heel eversion and medial prominence of the ankle.

Figure 21 shows a child with a pronated foot. Measure their relaxed calcaneal stance position (RCSP) without and with their new orthotic devices to show the parents what we are achieving. Watching the child walk should also show the parents that you are making improvements.

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However, the simple observation of this child, after looking at a dozen or so, can help you understand those children (and adults) who are out of the norm and need help.

In Figure 22, the opposite of pronation—foot supination—is occurring. The heel inverts or is inverted and the lateral ankle and distal leg move laterally at contact. This is called lateral instability and is one of the worst instabilities that you will treat.

Figure 29: The subtle tendency to supinate the right side (called "sickling" in ballet) that can lead to classic supinatory problems.

Observing someone walking from the side (Figure 23) gives us the opportunity to time heel lift and heel contact of the opposite side. The mantra that you need to remember is that heel lift occurs just prior to heel contact. Here, heel lift is delayed for some reason. This is a great time to see the effects of a weak Achilles tendon in action.

Patients with tight Achilles tendons can compensate in many ways with foot pronation, out-toed gait, early heel-off, or bouncy gait (Figure 24), where the heels do not touch the ground at all as in this case.

Figure 27: A good observer can see that one foot is pronated from heel vertical and one foot is supinated from heel vertical.

Figure 28: An important observation is how the heel is sitting on your current orthotic device. Here the left side is severely pronated on the left orthotic device.

An important observation is how the heel is sitting on the current orthotic device.

Besides seeing everted heels in a pronated child, you can see the flattening of the arch (Figure 25). You can ask the patient to go up onto the ball of their feet to check if the arch has some flexibility (or is it a rigid flatfoot).

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In Figure 26, the focus is on a patient with "squinting patella" with severe internal femoral rotation. You can see why if that was the natural position of this young adult that she would pronate her feet as far as possible to gain some external positioning.

Figure 30: Single heel raises.

A good observer can see that one foot is pronated from the heel vertically and one foot is supinated from heel vertically (Figure 27). Students need the lines drawn initially. Correlation to symptoms is huge in biomechanics. Does this windswept patient exhibit pronatory symptoms on the left and supinatory symptoms on the right?

An important observation is how the heel is sitting on the current orthotic device. Here the left side is severely pronated on the left orthotic device (Figure 28). Typically, when a patient does not respond to the correction of custom orthotics, on one or both sides, further correction is needed. The patient has a say in this based on symptom relief from the current orthotic device.

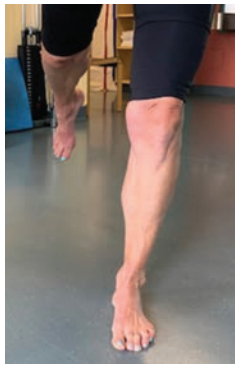

Figure 31: Single leg balancing.

Part of a biomechanical practice is to know what is good and bad technique in various sports you treat. Figure 29 shows the subtle tendency to supinate the right side (called "sickling" in ballet) that can lead to classic supinatory problems. The world of ballet has been dealing with pronation and supination problems for many years.

One of the most important observations that you can make with your patients concerns their ability to do single heel raises (Figure 30). This tests the overall strength of the all-important Achilles tendon complex.

Single leg balancing (Figure 31) is one of the most important biomechanical observations we can make of our patients at any age. It is an exercise that is part of ankle rehabilitation, knee rehabilitation, hip and low back rehabilitation, and every fall program.

Hopefully, this visual article helped you desire to observe more. All of these can be observed with a few instructions to the patients. You will learn a tremendous amount from your patients, and your patients will learn as you talk about what these observations mean. **PM**

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