TOG's GaitScan™: For Powerful, Reproducible and Practical Computerized Gait Analysis

By Dr. Jay Segel

For nearly 25 years, I have been a podiatrist on Martha's Vineyard. For this foot doctor, the visual combination of summer activities, take-out food, shorts and sandals automatically triggers the occupational hazard of a working lunch. Here I am with my wife, sitting on the boardwalk at the Oak Bluffs harbor, my face at knee height, watching the parade of tourists and neighbors pronating or supinating by with their adductory twists and early heel-offs. Observing short limb syndrome, ataxia and antalgic gait patterns day after day has left me with an acute sense of the need for public and patient education in biomechanics.

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I call it the *Quality of Life* lecture, which is based on the premise that if people knew the health cost of the way they walk, they would want to fix it. What's needed is for the patient to understand both what is going on and the fact that gait is fixable to a large extent. To be a "Quality of Life" podiatrist, perform a gait analysis and a physical exam and then create a treatment plan to deal with the etiology of the gait problem and the pathology in its wake. The facts are that the foot pronates and supinates to varying degrees during a gait cycle and correcting abnormal biomechanics is the challenge. No machine or computer can tell you exactly how much to correct a patient, but technology can guide you where to correct gait.

We have considerable control over the kinetic chain and musculoskeletal system through the feet. With shoes, wedges, plates and lifts we can aid foot function, improve proper timing, ease shock and improving balance. To do this we need two sets of data, establish norms and patient values. GaitScan gives you both. Touchstones like "arthritis" are useful to explain complex concepts like repetitive microtrauma and its relation to knee, hip and back pain; following up with diagnostic ultrasound images or asking the patient to feel joint wear are also effective communication tools, but, to me, nothing says it like the **TOG GaitScan**, with it's color pictures, charts, numbers and graphs.

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I liken the job of podiatrist specializing in biomechanics to that of an architect, with the additional complications/challenges of purposeful motion. Building requires creating a structure on a foundation under the influence of forces, loads, resilience, malleability, shear, and decay. Making an orthotic requires all of the above on an imperfect platform while dealing with triplane motions, ground force reaction and moment arms. The more pertinent information I can get about the loaded musculoskeletal structure, static and dynamic, the more success I'll have in weight redistribution, controlling motion and establishing appropriate event timing with the master plan of diminishing micro trauma and pathology. So, in other words, we have to build a skyscraper on an unsteady footing that moves, and diagnostic tools like the GaitScan help tremendously by adding quantitfication to your qualitative gait analysis and provide information not otherwise "seeable".

I have always been a fan of gait technology such that shortly after graduation I purchased Langer's Electrodynagram, which I used during my junior year for research and development of a strapping technique. Bringing this technology to the office and patient care was awkward in many ways and eventually fell by the wayside. It was many years before I found a computerized gait analysis system that was powerful, reproducible and practical! In short, I can see it makes me a better doc and the patients "get it."

What Is This Thing?

GaitScan is the product of Canada's **The Orthotic Group.**

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They report over 1,500 in use by healthcare practitioners. Specifically, the unit is an integrated hardware/software pressure and timing system that works with the computer for comparative and quantitative gait analysis. Released on June 17th 2008, the latest GaitScan software is update 2.3. It consists mainly of updated product information and Microsoft Windows Vista compatibility. The hardware is a plate whose dimensions are 40 inches by 15 inches and houses 4096 sensors. In dynamic mode it reports data at 300 frames per second, providing over one million data points for analysis. The polymer plate interfaces with the computer through a standard USB2 port.

Information generated by GaitScan includes:

- Static plantar pressures
- Asymmetry with quantitative left/right proximal/distal, medial/lateral
- Dynamic segmental loading with norms
- Onset, peak, off-loading and duration on 14 plantar surfaces
- Phases of gait measurements with comparisons to established norms
- Overall impulse in percentage with comparisons to norms
- Multicolored gait and pressure graphics 2D/3D (Figure 1)
- Shock absorption/ground force reaction at the heel
- Pronatory charts, rearfoot/whole foot, right/left
- Foot abduction/adduction compared to plum line
- Quantitative gait speeds left/right
- Balance, posture, hypermobility and biomechanical anomalies
- Areas at risk for ulceration

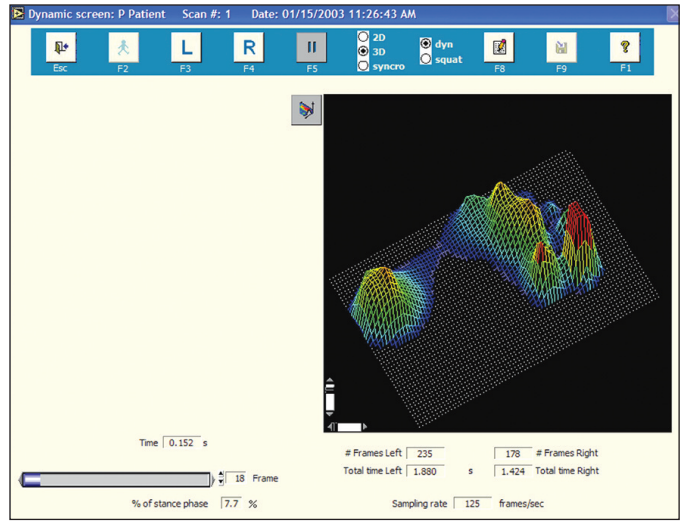

Figure 1.

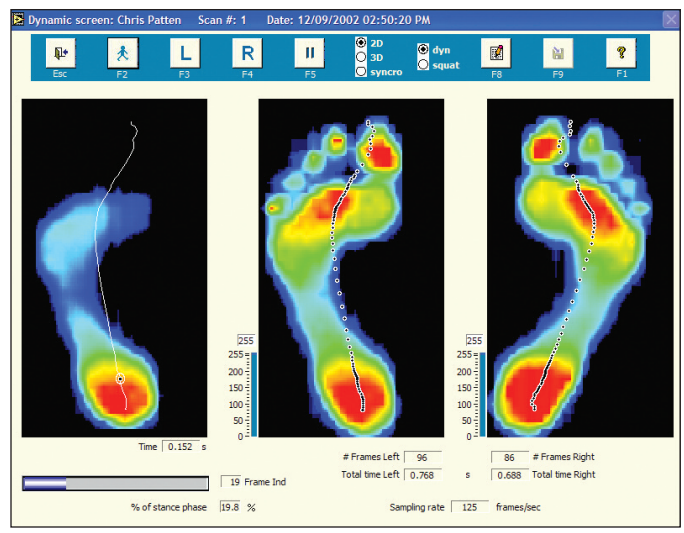

Figure 2.

How Do I Use This Thing?

Begin GaitScan diagnostics with the "Static Test." With the patient in bare feet, ask them to stand directly onto the center of the plate (after data entry) and settle into their "normal" stance. The feet are displayed in colors ranging from black, representing an absence of pressure, to blue, yellow, green, and red, highlighting increased pressure respectively. This is a great test for diabetics with histories of ulcers or calluses as it pinpoints areas to be offloaded with devices like orthotics. After saving the data,the feet are displayed in the aforementioned colors with quadrant pressures represented as percentages of 100%, i.e., 28% left rear foot to midfoot, 32% left midfoot to toes, 19% right rear foot to midfoot, and 21% right midfoot to toes. When you press the print button and select the static option, a similar display will appear superimposed against a plumb line, giving you overall left/right pressures as the aforementioned left foot bears 60% while the right bears 40%.

There are 2 different types of dynamic exams, walking and squatting. The squat test is most useful in observing knee deviation on single stance loading or for proximal to distal loading for dancers and folks with forefoot pathology, but the money shot for most podiatric situations is the walking test. (Figure 2) To get the most representative walking test, it has been suggested that the patient needs to take three steps before plate strike and three after. Ask the patient if that felt like a normal walk to them. Also observe the foot

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strike—often I'll suggest to the patient that "it seemed like you short stepped", or "you looked like you were crossing over." It's easy to redo the test and I'll often do just that even with a perceived "good test" to verify the results. I have always been impressed with the relatively consistent results of the TOG GaitScan. It's important to point out GaitScan may misrepresent the left foot as right in "automatic" mode in patients with severe deformities. For these people you must toggle on the "manual" mode and assign left or right values for the scanned foot.

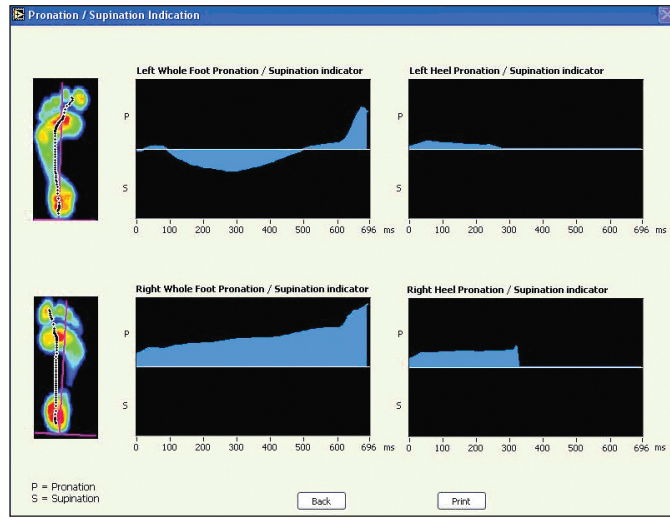

Figure 3.

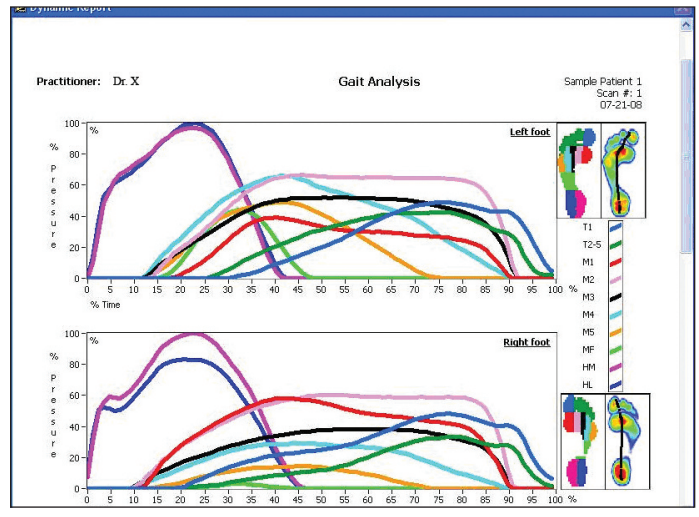

Figure 4.

What Do We Get Out of This Thing?

Once I've obtained and saved "good scans", I generate patient reports. While still in the walking mode, select the pronation/supination button to display both feet in linear format, showing rear foot and whole foot contact position, and motion (supination/pronation) through a gait cycle. (Figure 3) This is a condensed view of foot function, shock absorption, biomechanical deformity, timing and asymmetry. Now use the comparison button to display the patient's dynamic composite foot graph on the left side of the computer and "optimal" scan adjacent. This is a very useful educational tool for communicating with patients about how their feet stack up against the model and what it means to their health, both now and later. This is a good time to begin or continue an ongoing discussion about proper footwear and orthoses if appropriate. Under the print function you will find two other important reports, the aforementioned static report, and the dynamic report.

The dynamic report is an expression of the walking test and consists of three parts. The first part is the numbers expressed as percentages of gait cycle; start times, end times, peak pressures and impulse for 14 plantar surface points, lateral heel, medial heel and submetatarsal heads one through five for both feet. This report also demonstrates sequential loading and phases of gait where a doctor might see values suggesting biomechanical, functional and/or acquired deformities such as forefoot valgus, rocker bottom foot or equinus. Aberrant readings are highlighted as follows; green is "normal", red indicates values relatively too high, too long, or too late, and blue values are relatively too low, too brief or too early. Remember, values generated from running, squatting, lifting or otherwise nonstandard walking, list no established norms so values don't necessarily mean anything. The data finds its value in comparison right to left and other advanced analysis available in continuing medical education programs offered by The Orthotic Group (TOG). They also offer a "no fee" consulting service. I routinely call the biomechanics department to discuss patient data and its practical applications in making better orthotics.

The second part is a multicolored wave display of the various segments of each foot expressed as force, vertically, and time, horizontally. (Figure 4). This is another wonderful graph for patient education. For instance, we can explain that heel-off should occur at about

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55% of gait cycle. One can clearly observe the graph and note when heel pressure is gone. Just as late peaking pressures at the ball of the foot may indicate pronation, by watching areas off-load we might find evidence of deformities like functional hallux limitus in a late peaking and sharply declining hallux line. To the right of the waves are small composite displays of the walking test which serve as a key to this color coded linear model and a check of the data. By a "check of the data" I'm referring to a phenomenon that can occur by the combination of segments diplayed as one colored line. I've observed this when the "blue" hallux region erroneously includes the adjacent metatarsal making that particular data line suspect. Rerunning the dynamic scan usually fixes this anomaly.

The third part of the walking report is a large multicolored pictogram of the aforementioned composite wave graph key but the colors herein represent pressure grades rather than plantar surfaces. It uses the same colors as the static exam but if you look carefully, you'll note black dots strung together indicating gait progression and pattern. Each dot represents one frame of data obtained at 300 frames per second, beginning at heel strike and continuing through toe-off. This is great for showing ground force reaction, Medial Longitudinal Arch collapse, and hitches in gait due to instability or pain. The above gait characteristics can be spotted by observing the gait line which should begin with a lateral heel strike followed by a small curl demonstrating ground force absorption, then an immediate heel eversion, resupination (laterally moving gait line), then as the foot approaches midstance, the gently arcing line heads medially till heel-off. Then, moving into the terminal phase of gait, the line continues medial, shifting the foot from its accommodative "loose bag of bones" state to that of a rigid lever for effective propulsion. In part, this is the same graphic as in the comparison view but here, a foot can be isolated (right or left) and played back in a larger cineloop for your commentary on the subject's gait in real time. This graphic can be viewed in both 2D and 3D modes. The 2D mode is great for overall linear function and whereas the 3D mode demonstrates loading and pressure data in a more accessible and dramatic format. For a visual of a GaitScan cineloop, hit my website at segelpodiatry.com. After testing, I often give copies of the static exam, dynamic report, pronation/supination graph, and comparison views with both subjects feet and "optimal" scans to share with friends, family and healthcare professionals.

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When Do I Use This Thing?

GaitScan is a biomechanical diagnostic tool. I use it for patients presenting with complaints related to the following:

- Walking, running, athletics, working, standing and balance
- Neurological disorders and/or ataxia, Parkinson's Disease
- Asymmetry, Short Limb Syndrome and contractures
- Musculoskeletal pathologies, Plantar Fasciitis, Heel Spur Syndrome, Scoliosis
- Biomechanical deformities; congenital Coxa Vara, acquired Hallux Valgus
- Macrotrauma, fractures, joint replacements and chronic ankle sprainers
- Microtrauma, overuse, Hallux Limitus, arthritis
- Pressure issues, Diabetes Mellitus
- Orthoses and brace wearers

With its easy portability, I have brought it to health fairs and schools for public education. Using this technology to raise awareness in young people to the dangers of abnormal gait and the ability to predict and prevent problems is perhaps the most important aspect of GaitScan. Maybe the next time I find myself eating at the Oak Bluffs waterfront, eyes besieged by the impending doom to barefoot beachgoers, I'll bring my GaitScan and make it a true working lunch.

For more information call 800-551-3008, visit www.GaitScan.com, or *circle #191 on the reader service card.*