The GAITRite Portable Walkway System... Footprints You Can See, Measurements You Can Trust!

GAITRite... Measuring Function One Step at a Time!
Why Measure Gait

“During walking, more than 1000 muscles are synchronized to move over 200 bones around 100 moveable joints. Gait adaptation as seen in the elderly population may be associated with the general decrease in muscle strength due to loss of motor neurons, muscle fibers and aerobic capacity... Even if walking is considered a very complex task, a healthy person walking at self selected velocity, performed this task at a minimal energy cost.”

Francois Prince, Hélène Corriveau, Réjean Hébert, David A. Winter “Review Article - Gait in the elderly” 
Gait and Posture, Pages 128-135, May 1997

“A decline in economy of mobility indicates that more physical work is required for a task (i.e. walking) and may suggest an abnormal gait pattern. A normal gait pattern is essential for maintaining independence in older adults.”

Michael J. Davies, MS; Gail P. Dalsky, Ph.D., “Economy of Mobility in Older Adults” 
JOSPT Volume 26, Number 2, August 1997
“Walking is one of the most common of all human movements... Falls are a major cause of morbidity in the elderly and in almost all incidences of falls, some aspects of locomotion have been implicated. With the increased life expectancy of the elderly and their more active lifestyle there is now an emphasis on determining any changes that occur in their gait patterns in order to reduce the frequency of falls, to identify diagnostic measures that are reliable predictors of fall-prone elderly and finally to develop programs for preventing such falls.”

Francois Prince, Hélène Corriveau, Réjean Hébert, David A. Winter “ Review Article - Gait in the elderly”
Gait and Posture, Pages 128-135, May 1997
Functional Measures Over Time (9 Tests)

Velocity

Consistent, Steady Gait

Step Length
Health Status Change Over Time

(9 Tests)

Velocity

Big Decrease in Gait Speed & Step Length

WHY?

What’s Going On?

Step Length

Left

Right
The Problem

“There is a defined need for objective measurement of gait because without it the quality of treatment decisions is reduced because of the subjective and often unreliable nature of the assessment. Objective measures must also be employed if one is to demonstrate the efficacy of a treatment protocol, a function that will become increasingly important as health care resources become more strained and health care providers are held more accountable...Gait assessment is an everyday responsibility for the practicing therapist. Visual assessment, which is almost universally used for this purpose, has been shown to be unreliable at best. Measurement of the temporal and distance factors of gait have been found to be clinically useful.”

James C. Wall, Ph.D., Denis Brunt, PT, Ed.D.; Chapter 17, Clinical Gait Analysis: Temporal and Distance Parameters. Assessment in Occupational Therapy and Physical Therapy edited by J.V. Van Deusen, 1996
The Solution

GAITRite effortlessly provides valid and reliable measurements in real-time, such as: cadence, step length, velocity and many other important gait parameters! Now you can objectively quantify functional ambulatory status and document treatment outcomes by incorporating GAITRite into your clinical evaluations.
What is the GAITRite System?

- The GAITRite system automates measuring temporal (timing) and spatial (distance) gait parameters via an electronic walkway connected to the USB port of a Windows® Laptop PC, while collecting video of the walk from up to 2 cameras.

- The 12’ GAITRite electronic walkway contains six sensor pads encapsulated in a roll up carpet to produce an active area 24 inches (61cm) wide and 144 inches (366cm) long. In this arrangement the active area is a grid, 48 sensors by 288 sensors placed on .5 inch (1.27 cm) centers, totaling 13824 sensors. The walkway is portable, can be laid over any flat surface, requires minimal setup and test time, and requires no placement of any devices on the patient.
Walkway connections
How does GAITRite work?

• As the patient ambulates across the walkway, the system captures the geometry and the relative arrangement of each footfall as a function of time. The application software controls the functionality of the walkway, processes the raw data into footfall patterns, and computes the temporal (timing) and spatial (distance) parameters. The software’s relational database stores tests individually under each patient, and supports a variety of reports and analyses.

• Testing patients with or without shoes, including those patients using assistive devices and ambulatory aids such as: crutches, walkers, or canes. In addition, testing patients pre- and post-treatment is quickly, and easily performed when utilizing this versatile and ingenious measurement tool.
The GAITRite in Action

Roll it up...take it with You!
Consistent and Reliable Data

In the above graphical mock-up, the footfall patterns are almost identical; they do however, start and end at different points on the walkway.
Footfalls - Close-up

Right Foot

Left Foot

Pressure Level  1 = lowest  2  3  4  5  6 = highest

Color  Dark Gray  Light Gray  Cyan  Yellow  Magenta  Red
One Completed Walk

See the next two slides for parameter definitions
Temporal (Timing) Parameters

1) **Step Time** is the time elapsed from the first contact of one foot to the first contact of the opposite foot.

2) **Gait Cycle** is the elapsed time between the first contact of two consecutive footfalls of the same foot.

3) **Ambulation Time** is the time elapsed between the first contacts of the first and the last footfalls.

4) **Velocity** is obtained after dividing the Distance by the Ambulation time.

5) **Mean Normalized Velocity** is obtained after dividing the Velocity by the Average Leg Length and it is expressed in leg length per second (LL/sec). The average Leg Length is computed (left leg length + right leg length)/2.

6) **Single Support** time is the time elapsed between the Last Contact of the current footfall to the First Contact of the next footfall of the same foot. This is equal to the Swing Time of the opposite foot.

7) **Double Support** is the time elapsed between First Contact of the current footfall and the Last Contact of the previous footfall, added to the time elapsed between the Last Contact of the current footfall and the First Contact of the next footfall.

8) **Stance Time** is the time elapsed between the First Contact and the Last Contact of two consecutive footfalls on the same foot. It is also presented as a percentage of the Gait Cycle of the same foot.

9) **Swing Time** is the time elapsed between the Last Contact of the current footfall to the First Contact of the next footfall on the same foot. It is also presented as a percentage of the Gait Cycle of the same foot. The Swing Time is equal to the Single Support time of the opposite foot.
Spatial (Distance) Parameters

1) **Step Length** is measured on the horizontal axis of the walkway from the heel point of the current footfall to the heel point of the previous footfall on the opposite foot. The step length can be a negative value if the patient fails to bring the landing foot heel point forward of the stationary foot heel point.

2) **Stride Length** is measured on the line of progression between the heel points of two consecutive footfalls of the same foot (left to left, right to right).

3) **Step/Extremity Ratio** is Step Length divided by the Leg Length of the same leg.

4) **Toe In / Toe Out** is the angle between the line of progression and the line connecting the heel point to the forward point of the footfall. This angle is reported positive for toe out and negative for toe in.

5) **H-H Base of Support** is the perpendicular distance from heel point of one footfall to the line of progression of the opposite foot.

6) **Distance** is measured on the horizontal axis from the heel point of the first footfall to the heel point of the last footfall.
All data fields can be exported in comma/tab delimited ASCII format or direct to Excel.
I use GAITRite because...

“The Functional Ambulation Performance score (FAP) that’s part of the GAITRite, gives me a single objective number that allows me to quickly and easily track my patients progress. The FAP is a valid and reliable clinical measure that identifies asymmetries and deviations from normal time and distance values. On many occasions, I have successfully petitioned HMO and compensation carriers for continued care based on the GAITRite data. My clinical practice includes both adult and pediatric orthopedic and neurological patients. By integrating objective gait measures into my evaluations and daily operations, I gain tremendous insight into understanding and treating the underlying cause of my patient’s dysfunction.”

Arthur J. Nelson, Ph.D., PT; FAPTA —
Staten Island, NY
GAITRite works for us because...

“Within our system we provide therapy services in acute care, long term care, home care and outpatient facilities. Our clinicians spend a significant amount of time restoring functional ambulation through gait training. We feel that GAITRite efficiently captures the objective data necessary to reliably document patient progression. We also like the portability and versatility of the GAITRite, considering that we provide care in a number of settings.”

John Ward, PT; Vice President, Rehabilitation Services — SSM Ambulatory Care / Northwest Covenant Medical Center
Compare Two Conditions

Without Orthotics

With Orthotics

High Pressure/Less Control

Lower Pressure/More Control

Left Foot

Right Foot

Heel → Toe

Heel → Toe

Heel → Toe

Heel → Toe
Normals..Reports..Narratives

• Each parameter is deemed within or outside of the normal range.
• The normal range has been extracted from documented peer-reviewed scientific literature, as well as from the GAITRite database.
• Numerous client-specific normal databases can be created and compared against.
• The coefficient of variation is checked to validate data consistency.
• The results of these comparisons can be viewed on the computer monitor or printed in conjunction with a narrative report.
• These parameters can be tracked over time to produce progress and status reports.
Quick Comparison Report

| Progress/Outcome for: Jones, Bill B | | | | | | | |
|------------------------------------|-----------------|--| --|--| | | | | | | | |
| Step Time (sec) | L | 0.664 (3) | 0.600 (0) | -0.064 | | | | | | | | | | | |
| R | 0.695 (3) | 0.598 (3) | -0.109 | | | | | | | | | | | |
| Cycle Time (sec) | L | 1.359 (1) | 1.173 | -0.186 | | | | | | | | | | | |
| R | 1.339 (0) | 1.185 (2) | -0.154 | | | | | | | | | | | |
| Swing Time (sec) | L | 0.460 (3) / 33.8 | 0.447 / 38.1 | -0.013 | | | | | | | | | | | |
| / %GC | R | 0.500 (0) / 37.3 | 0.448 (0) / 37.6 | -0.052 | | | | | | | | | | | |
| Stance (sec) | L | 0.630 (0) / 66.1 | 0.725 / 61.9 | -0.172 | | | | | | | | | | | |
| / %GC | R | 0.638 (0) / 62.6 | 0.730 (3) / 62.3 | 0.1 | | | | | | | | | | | |

**Numerical Change**

- Step Time: 0.064 seconds
- Cycle Time: -0.186 seconds
- Swing Time: -0.013 seconds
- Stance Time: -0.172 seconds

**Symmetry Change vs Normal Range**

Create Numerous Report Templates

Produce Narrative & Outcome Reports

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Goals

- Improve by Increasing
- Improve by Decreasing
- Any Change
- Report

Goals Description Summary

Velocity improved from 73.4 to 125.7 cm/sec.
Step Time improved from 0.679 to 0.593 sec.
Step Time Differential improved from 0.031 to 0.014 sec.
Step Length improved from 49.916 to 74.472 cm.
Step Length Differential improved from 7.066 to 3.471 cm.
Double Support improved from 0.392 to 0.298 sec.
Toe In/Out Angle improved from 29 to 6 deg.
In the example above, a patient was tested on the GAITRite prior to right knee surgery. All values outside of the normal range are noted with a red arrow. The results are consistent with the patient not applying weight on his right leg due to the pain caused by a torn right meniscus (cartilage). Instead of moving straight across the walkway, he see-sawed up and down in an inefficient gait pattern.
Individual footfall values and coefficient of variation are presented in the above chart. The normal range for the variable is highlighted in teal, while the actual bilateral value for the variable is identified as a vertical line.
Example: Injured Right Knee

At the footfall level, the footfall transition line illustrates that the patient rocked backwards (due to pain) during his right step, as indicated by the “Z”-like pattern.
Averaged left heel contact time = 590ms, which is 49% of gait cycle

Averaged right heel contact time = 394ms, which is 33% of gait cycle

Clearly, the heel contact times/lines are much shorter for the right foot. The patient unloaded his right heel significantly quicker than his left heel. He wanted to get his injured right leg off the ground as fast as possible.
Example: Elderly Ambulator

56 year old male, 3 months post stroke, right side affected

Wide base of support (should be +/- 20 cm for him) and prolonged stance phase (norm = +/- 60%)

Very slow (norm = +/- 130 cm/s)
Total symmetry means that L/R vertical lines are on top of each other.

Colored boxes indicate normal range for each variable.
Individual Footstep Information (Continued)

Left foot is driving their gait; right side is along for the ride.

Pronounced Left Heel Strikes

Cross Test Comparisons

Center of Pressure Comparison
Falls

The frail elderly individual is prone to accidents and trauma of many types. The most costly injury to this group is the accidental fall. **Falls account for as much as 71 percent of the total costs of all injuries for the population over the age of 60.** One especially serious complication of accidental falls is hip fractures.

Characteristics Associated With Falls

As individuals age, they become prone to accidental falls and fall-related injuries. Factors that contribute to these falls are decreased vision, loss of flexibility and muscle tone, and environmental factors such as rugs and stairs. Almost one-third of community-dwelling elderly fall each year and over half of long term care residents fall. Around half of those who fall will fall again... This study was conducted in Finland to determine characteristics associated with falls in the Finnish population over the age of 50... Results indicated a 284 percent increase in fall-related injuries over a twenty-five year period. The authors suggest preventive measures are necessary to deal with this continuing increase in injury rate.

Kannus, Pekka, et al. Fall-Induced Injuries and Deaths Among Older Adults. 

_JAMA_ May 26, 1999; 281(20): 1895-1899
"Of all the gait measures, the single best predictor of falling was stride-to-stride variability in velocity. Using this predictor, fallers and non-fallers were classified at an accuracy of 71%, similar to the results achieved using the postural-sway measure that was identified as the best predictor in previous analyses...Combination of the sway and gait measures in a single logistic model led to a small but statistically significant improvement in predictive accuracy (73%). Variability in speed was also the single best predictor of falling while walking (65% accurate). For these falls, inclusion of a second gait measure - variability in stride width - in the logistic model significantly improved the predictions (75% accurate); however, inclusion of the postural-sway measure failed to provide any additional benefit.”

Maki, Brian E., Ph.D., “Gait Changes in Older Adults: Predictors of Falls or Indicators of Fear?” J Am Geriatric Society 45:313-320, 1997
The present results have some important practical implications for clinicians. In terms of identifying high-risk individuals, measures of stride-to-stride variability show promise as a screening tool, at least for ambulatory patients, providing predictive accuracy similar to the postural-sway measure found to be the best predictor of falling in an earlier study. Although variability in velocity was the single best predictor of falling, variability in double-support time was also a strong predictor and has the advantage of requiring only temporal (e.g., footswitch) data; hence, it may be more feasible in some clinical settings. It seems clear from the present results that it is essential to have a measurement system that can record stride-to-stride changes; determination of an average speed of gait (or stride length) or visual assessment of performance is unlikely to be very successful in predicting falling in a moderately mobile older population.

Maki, Brian E., Ph.D., “Gait Changes in Older Adults: Predictors of Falls or Indicators of Fear?” J Am Geriatric Society 45:313-320, 1997
GAITRite Measures These Parameters
And Many Other Important Gait Characteristics

Double-support time
Stride velocity
Stride width
Velocity

<table>
<thead>
<tr>
<th>GAITRite Test Fields (summary)</th>
<th>Detail Fields (individual footfalls)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST FIELDS</td>
<td>Select</td>
</tr>
<tr>
<td>Test Record #</td>
<td></td>
</tr>
<tr>
<td>Pt Record #</td>
<td></td>
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<tr>
<td>Date / Time of Test</td>
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<tr>
<td>Distance</td>
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<td>Ambulation Time</td>
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<td>Velocity</td>
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<tr>
<td>Detail FootFalls</td>
<td>Select</td>
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<tr>
<td>Double Support Time</td>
<td></td>
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<tr>
<td>Stride Velocity</td>
<td></td>
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<tr>
<td>Real Foot Flag</td>
<td></td>
</tr>
<tr>
<td>Pass Number</td>
<td></td>
</tr>
<tr>
<td>Toe In / Out</td>
<td></td>
</tr>
<tr>
<td>Step Width</td>
<td></td>
</tr>
<tr>
<td>Stride Width</td>
<td></td>
</tr>
</tbody>
</table>
"Measurement of stride-to-stride variability may also be useful in evaluating or monitoring interventions aimed at improving balance and gait. Future studies should address whether the variability in gait, and the associated risk of falling, is amenable to change through specific interventions such as gait or balance training, changes in footwear, or use of assistive devices or sensory aids."

Maki, Brian E., Ph.D., “Gait Changes in Older Adults: Predictors of Falls or Indicators of Fear?” J Am Geriatric Society 45:313-320, 1997
Falls Predict Nursing Home Admission

According to a study by researchers at Yale University School of Medicine, falls and injuries caused by falls are strong predictors of long term placement in a nursing facility for community-living older persons. The study, published in this week's New England Journal of Medicine, found that even a single fall without injury offered almost five times greater risk of admission to a nursing facility. Researchers examined 1,103 people over 71 years old living in the New Haven, CT, community during a three-year period. A total of 133 study participants had long-term admissions to nursing facilities in the study period. The risk of admission for those who suffered one noninjurious fall was 4.9 times greater than those in the study sample with no falls. Those who experienced multiple noninjurious falls had an 8.5 times greater risk, while those who suffered at least one fall causing serious injury had a 19.9 times greater risk.

Falls - Psychoactive Medications

There are several risk factors contributing to the incidence of accidental falls in nursing facility residents. Dementia, arthritis, incontinence, stroke, use of some medications, and irregular gait and balance problems are good indicators of and contributors to falls in facilities. One suggestion to reduce the number of falls has been the creation of a fall risk assessment for residents. Incorporating psychoactive medications in this assessment is important...The study was conducted by a consultant pharmacist on 182 residents in one nursing facility. Initially, the rate of falls ranged between one fall and 19 falls per resident. Medications were implicated as a contributor in 257 falls in 83 residents. Alternative drug therapy recommendations were made in several cases. In the group for whom recommendations were accepted, the number of falls was reduced from 91 to 13 over the study period. Results indicate that falls were reduced when pharmacotherapy change recommendations were accepted during the one-year study period.

...Eighty-three residents had 257 falls in which medications were a contributing factor. In 57 residents, 195 falls were attributed to psychotropics. There were 97 fall-related injuries with this group. In 62 falls, 27 injuries were attributed to psychoactives that were non-psychotropic in nature. The costs of all falls averaged $754 per fall. Those falls associated with psychotropics averaged $858 and those associated with psychoactives averaged $427 per fall. Falls were reduced from 91 to 13 when recommendations of alternative pharmacotherapy were accepted. This lead to a possible cost savings to the facility of $58,812 for the year (using a figure for a reduction of 78 falls at a cost of $754 per fall).
“One of the most powerful features of the GAITRite is its ability to simultaneously measure both step time and step length. Muscle weakness, pain or limb shortening, may lead to reduction in stance time on the affected side. To compensate, patients either reduce their step time which in turn reduces their step length, or they increase their joint angular velocity without reducing their step length. In essence, the patient moves faster in a shorter period of time. Visual inspection of these compensation patterns just isn’t accurate. With my GAITRite, I can objectively measure if there is compensation for a gait abnormality.”

Anil Bhave, PT — Maryland Center For Limb Lengthening & Reconstruction
Example: Left Spastic Equinovarus Deformity

**Without AFO**
- Significant step length asymmetry
- Low velocity
- Poor heel contact
- Excessive stress on knee, hip and lower back

**With AFO**
- Reduced asymmetry
- Increased velocity by 12%
- Good heel contact
- Reduced stress on knee, hip and lower back
Left Spastic Equinovarus Deformity (Continued)

Without AFO  With AFO

L

Poor Heel Contact

Good Heel Contact

R
Example: Right Transtibial Amputee

- Increased stance time and single support time (as a % of the gait cycle) on the sound side
- Decreased swing time on the prosthetic side
- Narrow base of support
- Overall symmetry for many other parameters
- Efficient footfall transitions for both feet
Example: Right Transfemoral Amputee

The subject was asked to walk at a fast pace. Several asymmetries are evident, most notably there was a 9 cm step length differential.

In the footfalls to the right, notice the differences in heel strike, transition center and toe off transition on the right.
**Example: Right Transfemoral Amputee**

<table>
<thead>
<tr>
<th>Length</th>
<th><strong>Comparison: Step Length</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left (Sound)</td>
</tr>
<tr>
<td></td>
<td>Right</td>
</tr>
<tr>
<td>Self-Selected Pace</td>
<td>Slow Pace</td>
</tr>
</tbody>
</table>

In the graph above, step length for self-selected and slow pace trials were very symmetrical. At the fast pace, there is a 10% difference between the left and the right step lengths; the subject indicated that his prosthesis could not keep up.

In the graph below, the swing time on the prosthetic side was slower than that of the sound side. The average of 6 walks are compared in this example.
Walkway Specifications (12-Foot)

Overall Dimensions: 180 x 35.5 x .25 inches (L x W x H) in 12-foot model

Active Area: 144 x 24 inches (L x W) in 12-foot model (lengths up to 26 feet are available)

Weight: 40 pounds for 12-foot model (55 pounds with wheeled carrying case)

Sampling Rate: 80 Hz

Communications: RS-232, 57.6Kbps or 19.2Kbps

Power Requirements: 12Vdc

Number of Sensors: 13,824 sensors are placed on .5 inch centers arranged in a 48 x 288 grid

Sensor: .4 inches square, dual control

Walkway Indicators: Green light = Power Indicator, Yellow light = Program Status Indicator

Top cover: Vinyl with square thread reinforcement, waterproof and chemical resistant

Bottom cover: Open cell foam rubber

Price: Call For Details

Warranty: 2 year walkway and 2 year software maintenance included

Delivery: 30-45 days after receipt of purchase order

Computer Requirements: IBM® compatible personal computer with:
Windows® I3 Pentium Processor with 17” display
In Summary

• Peer-reviewed scientific literature cites gait function as an important outcome measure. Numerous injuries, illnesses and drug interactions may contribute to gait deviations and falls.

• Measuring and tracking walking function can help keep people independent longer, while significantly reducing medical costs.

• GAITRite can become an indispensable part of your day to day operations because it will aid you in:
  • Documenting gait patterns prior to any intervention
  • Measuring functional ambulation immediately after treatment/intervention
  • Documenting that intervention did or did not have a carry-over effect
  • Matching objective gait parameters with subjective findings
  • Refining proper alignment and fit of prosthetics & orthotics
  • Selecting the appropriate assistive device
  • Justifying reimbursement for services rendered and/or for continuance of care
  • So many other ways, that they all can’t be mentioned here!
What’s Next?

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