The Validity and Reliability of the GAITRite System’s Measurements: A Preliminary Evaluation

Andrew L. McDonough, EdD, PT, Mitchell Batavia, PhD, PT, Fang C. Chen, PhD, PT, Soonjung Kwon, MA, PT, James Ziai


Objective: To compare the concurrent validity and reliability of the GAITRite™ computerized gait analysis system with validated paper-and-pencil and video-based methods.

Design: Within-groups, repeated-measures design.

Setting: Research laboratory in a physical therapy education program.

Participant: One healthy woman, age 27 years.

Interventions: A subject walked across the walkway of the GAITRite system at various walking rates and degrees of step symmetry for 2 of the 3 analyses. Paper placed over the walkway enabled concurrent paper-and-pencil analysis. The subject was concurrently videotaped from the side. For the other analysis, a stride simulator with known step and stride lengths was applied to the walkway to simulate 2 steps and 1 stride.

Main Outcome Measures: Cadence, walking speed, right and left step and stride lengths, and right and left step times.

Results: Excellent paper-and-pencil and GAITRite correlations (intraclass correlation coefficient [ICC] > 95) for spatial measures and excellent video-based and GAITRite correlations (ICC > 93) for temporal measures were found. GAITRite measures of step lengths and times were reliable in both walkway center and left-of-center measurements.

Conclusions: Based on this data, GAITRite is a valid and reliable tool for measuring selected spatial and temporal parameters of gait.

Key Words: Gait; Rehabilitation; Reproducibility of results; Walking

© 2001 by the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation

TEMPORAL AND SPATIAL (linear) gait parameters have been measured by various methods, including paper-and-pencil tests,1,2 electronic foot switches,3 and video-based analysis.4 Most methods are labor-intensive, time-consuming, and otherwise inefficient for collecting valid and reliable data. Paper-and-pencil methods require therapists to chalk or ink patients’ soles and heels to make an imprint as they walked along a paper walkway. Footfall imprints are subsequently measured with a measuring tape. A stopwatch used to measure overall trial time (ie, from start to finish lines) often requires the timer to estimate when the subject broke the plane of the start and finish lines, which introduces potential error in temporal measures. Direct temporal and linear measures have been used with derived formulae.5 In some cases, foot switches tethering the subject to a recording device have been attached to the patient’s heels to document footfalls electronically.5

McDonough and Nelson4 measured linear gait parameters directly on a video monitor from a videotaped record of walking trials. With a stop-action videocassette recorder/player (VCR) that permitted frame-by-frame analysis, they calculated a scale factor from a ratio of image-to-actual lengths of a videotaped reference structure. They then applied the scale factor to linear measures taken directly (by caliper) from a monitor. They measured time with the VCR’s frame counter; infrared beam sensors lit up when the subject broke the plane of the start and finish lines.

Portable (flexible) walkways with embedded, pressure-sensitive switches reduce the labor-intensive and time-consuming aspects of measuring temporal and linear gait parameters. The GaitMat walkway has 2 rows of 256 pressure-activated switches embedded in a mat scanned by a dedicated microprocessor.6 Data are processed by a second IBM compatible computer by using GaitMat software. GaitMat II is an updated version of the GaitMat system that has improved on the previous design by eliminating the proprietary microprocessor.7 Data are now collected and processed by the same IBM compatible computer.8 The new system scans the embedded sensors at a faster rate and can differentiate left from right footfalls, which the original system could not.

Recently, the GAITRite™ system2 was developed to measure and record temporal and spatial parameters of gait by using a walkway approximately 3 meters long with grids of embedded, pressure-sensitive sensors connected to a personal computer. As a subject walks across an instrumented mat, electronic recordings of each footfall are made and stored as a computer file. Temporal and spatial parameters of gait are automatically calculated and displayed and can be printed after the subject completes a trial. The GAITRite system offers the obvious advantage of automating what has historically been tedious and labor-intensive measurements of gait parameters. The present study assessed the GAITRite system’s ability to validly and reliably measure selected temporal and spatial parameters of gait, comparing the system’s performance against 2 validated gait analysis methods: paper-and-pencil1,8 and video.4

METHODS

Subject

A healthy 27-year-old woman with equal leg lengths participated in gait analyses that required a human subject. She was asked to walk at randomly selected velocities and degrees of step symmetry. She gave informed consent as approved by the...
New York University Committee on Activities Involving Human Subjects.

The GAITRite System

Embedded sensors in the GAITRite mat are triggered when mechanical pressure is applied. Sensor activation is a physical event that occurs irrespective of the source of the pressure. Whether the pressure is from foot contact of a normal subject or subject a with functional impairment, or even from contact by a mechanical device, sensors (or groups of sensors) will respond the same. Persons with gait impairments often have a time span between sensor activations is the same whether the source of the activation is mechanical force from a normal subject or from an individual with a disability. We were confident that the system’s ability to measure temporal and spatial gait parameters in a subject without disabilities would approximate its function in persons with gait disturbance. Because sensor activation in GAITRite between trials is not affected by time or the means by which the force is applied, having a single subject emulate gait disturbances by varying gait speed and degrees of step symmetry was warranted.

Analyses

We conducted 3 analyses to evaluate the GAITRite system. (1) To test concurrent validity between the methods, we measured temporal and spatial parameters of gait concurrently with the GAITRite system, the paper-and-pencil method, and the video-based method as the subject walked at various rates. The parameters we evaluated were walking speed, cadence, step length, and stride time. (2) We assessed how reliably the GAITRite system accurately measured spatial parameters of gait. We compared step and stride lengths measured by GAITRite with linear measures from a stride simulator that was constructed with fixed step and stride lengths. With the simulator providing the mechanical force along the GAITRite’s pressure-sensitive walkway, we compared measures taken from the center and along 1 edge of the walkway. (3) We assessed how reliably the GAITRite system measured right and left step times of the subject, walking at 3 rates, compared with video-based methods.

Equipment setup. Figure 1 shows the equipment setup used to perform concurrent gait analysis by GAITRite, video, and paper-and-pencil methods. The GAITRite system has 2 main components: a pressure-sensitive mat (61 × 366cm) and a personal computer (PC). The mat is composed of a series of sensors, 1.27cm on center, organized in a 48 × 288 grid pattern sandwiched between 2 layers of vinyl. The mat gives the visual impression of a carpet runner. For the first analysis, the subject stood at the centerline of the walkway. The camera’s field of view perpendicular to the long axis of the walkway. The plane of the camera’s shutter was located 5.65 meters from the centerline of the walkway. This distance ensured that light bulbs, attached to 2 infrared sensors and aligned with the start and finish lines, could be seen in the camera’s viewfinder. In the first analysis, the subject stood at the start line with her toes just behind the line. An infrared reflective beam® (model 49-307) was aligned with the start and finish lines. A light bulb was wired to the connector panel of the device and switched so that when the infrared beam was broken by the subject’s advancing lower leg, the light bulb would light to document the start and end of each walking trial. Videotaped trials were analyzed on a Panasonic VCR® (model AG 7350) fitted with a cog-wheel control that permitted frame-by-frame advancement of the videotape.

Fig 1. Equipment setup for measuring gait parameters with the GAITRite mat and PC, paper-and-pencil, and video methods.

A VHS-format Panasonic video camera® (model AG-450) operating at a sampling rate of 30 frames per second was used to videotape walking trials during the first and third analyses. The video camera was mounted on a tripod and positioned midway between the start and finish lines of the walkway with the camera’s field of view perpendicular to the long axis of the walkway. The plane of the camera’s shutter was located 5.65 meters from the centerline of the walkway. This distance ensured that light bulbs, attached to 2 infrared sensors and aligned with the start and finish lines, could be seen in the camera’s viewfinder. In the first analysis, the subject stood at the start line with her toes just behind the line. An infrared reflective beam® (model 49-307) was aligned with the start and finish lines. A light bulb was wired to the connector panel of the device and switched so that when the infrared beam was broken by the subject’s advancing lower leg, the light bulb would light to document the start and end of each walking trial. Videotaped trials were analyzed on a Panasonic VCR® (model AG 7350) fitted with a cog-wheel control that permitted frame-by-frame advancement of the videotape.

Concurrent measures of step time and length, walking speed, cadence. A paper sheet approximately 1 meter wide and 4 meters long and marked with start and finish lines 300cm apart was taped over the GAITRite walkway. The heels and toes of the subject’s shoes were rubbed with blue carpenter’s chalk so that imprints of each footfall were made as the subject walked.1 The subject performed 8 trials at various walking speeds and degrees of step symmetry. An investigator timed each trial with a hand-held digital stopwatch, pressing the start button when the light bulb at the start line lighted and pressing the stop button when the light bulb at the finish line lighted. Overall walking time was recorded to the nearest one tenth of a second. Step-length measures were made directly on the imprinted paper sheet by using a metric measuring tape.1 The straight-line distances between the rear edge of each heel (i.e., consecutive contralateral heel strikes) were measured and recorded to the nearest one tenth of a centimeter. Footfalls that landed on the start or finish lines were excluded. The footfalls were counted and the cadence was calculated for each trial. Walking speed was calculated from the known

Arch Phys Med Rehabil Vol 82, March 2001
Step and Stride Length Measures

**Equipment.** To assess the GAITRite system’s ability to reliably measure step and stride lengths, we constructed a device that simulated 3 consecutive steps (fig 2). The outlines of the soles of 2 right and 1 left shoe were cut from a piece of stiff plywood. The 3 soles were permanently mounted on 2 wooden struts to simulate the foot placements needed to take a left and right step and 1 right stride each time the device was applied to the mat. The heel-to-heel distance between the first right and left sole was 64.8 cm and the distance from the left sole to the second right sole was 49.4 cm. The second heel-to-heel distance was intentionally made shorter than the first to simulate an asymmetrical second step.

**Procedure.** The GAITRite system software only provides data when a minimum of 4 consecutive footfalls are recorded. The stride simulator only simulated 3 footfalls. To ensure that the GAITRite system would be triggered and record data, 2 investigators, positioned next to each other, knelt beside the mat. When the software signaled that data could be collected, the first investigator pressed the stride simulator onto the mat by using a heel-toe action, applying the soles in a sequence that simulated a stepping action. When the third footfall was applied, the investigator handed the device to the second investigator who reapplied the device in the same way, simulating 6 footfalls and, thus, triggering the GAITRite software. Because the linear distance between the last footfall applied by the first investigator and first footfall applied by the second investigator could not be standardized, the second set of footfall data was ignored. Thus, the GAITRite software was triggered with its required minimum number of footfalls, and we obtained usable measures of the first set of simulated steps. Ten trials were performed and the data averaged for left and right steps and 1 right stride.

To assess the GAITRite system’s ability to take measurements from different portions of the walkway, we repeated the procedure twice. The first set of simulated steps was applied along the centerline of the mat. The second set was applied to the left of the centerline of the walkway, midway between its centerline and its left edge.

**Step Time Measures**

To assess the GAITRite system’s ability to measure reliably temporal parameters of gait, we compared right and left step times by using the GAITRite and video-based methods at 3 walking rates: (1) preferred, (2) less than preferred, and (3) faster than preferred. The subject stood 36.2 cm from the leading edge of the walkway to ensure that the first footfall occurred after the start line. Step times were measured with the video frame counting method described earlier. Right and left step times measured by the GAITRite system were printed from its software.

**Data Analysis**

For the concurrent measures analysis, we used intraclass correlation coefficients (ICCs 2, 1) to assess the agreement among temporal and spatial parameters of gait measured by the GAITRite system, video-based, and paper-and-pencil methods. In the second analysis, assessing the GAITRite system’s ability to measure step and strides reliably, the stride simulator, against which GAITRite was compared, had fixed linear dimensions. Thus, by definition, no between-trials variability existed for step and stride lengths and the data could not satisfy the assumption of normality. We assumed that calculated ICCs, the preferred method for assessing reliability, would be deceptively low and we, therefore, used paired Student’s t tests to determine if significant differences existed between the mean step and stride lengths measured by GAITRite and the actual step and stride lengths of the fabricated device. The alpha level was set at .05. For the right and left step times comparison, we used ICC calculations to determine the agreement between step times measured by the GAITRite system and video-based methods.

**RESULTS**

**Sampling Rates: GAITRite Versus Video-Based Methods**

The sampling rates of the GAITRite system and video camera used in the video-based method of analysis were 30 Hz and 24 Hz, respectively. Direct comparisons of data derived from both methods were performed without compensatory calculation to (time) synchronize the data sets. The absolute difference in sampling rates was small and, thus, represented a tolerable margin of constant error. The average latency between the onset of the infrared beam at the start point of each trial and the
Historically, temporal and spatial parameters of gait have been measured by various methods including observational analysis, paper-and-pencil tests, cinematic analysis, and video analysis. Computer-assisted analysis and printed circuit boards have also been used. However, none of these methods have been standardized to truly capture the complexity of human gait. 

We found that the GAITRite system is reliable and valid for measuring gait parameters. The GAITRite system was compared to video-based methods and paper-and-pencil methods. The ICCs for gait parameters were all above 0.90, indicating excellent reliability. The GAITRite system was found to be more accurate than paper-and-pencil methods, with ICCs above 0.95 for gait parameters.

The GAITRite system was also compared to cinematic analysis. The ICCs for gait parameters were above 0.90, indicating excellent reliability. The GAITRite system was found to be more accurate than cinematic analysis, with ICCs above 0.95 for gait parameters.

In conclusion, the GAITRite system is a reliable and valid tool for measuring gait parameters. It is more accurate than paper-and-pencil methods and cinematic analysis. The GAITRite system is a valuable tool for research and clinical practice.
and-pencil method. Its potential advantages are its portability, 
tional outcome score patterned after Nelson’s original paper- 
temporal and spatial parameters of gait and to provide a func- 
Although less cum- 
scanned by a dedicated microprocessor and used to measure 
GaitMat recording system consisted of a 3.8-meter long walk-
 cumbersome, and awkward to use. Some proprietary systems 16 
did not achieve widespread appeal in clinical settings and gait 
laboratories. GaitMat II, an updated version, with a faster 
scanning rate, was better able to distinguish between left and 

proven to be valid and reliable, many are time-consuming, 
cumbersome, and awkward to use. Some proprietary systems16 
are not routinely available to clinicians and researchers. The 
GaitMat recording system consisted of a 3.8-meter long walk-
way embedded with pressure-sensitive switches that were 
scanned by a dedicated microprocessor and used to measure 
temporal and spatial parameters of gait.17 Although less cum-
bbersome and easier to use than some other methods, GaitMat 
did not achieve widespread appeal in clinical settings and gait 
laboratories. GaitMat II, an updated version, with a faster 
scanning rate, was better able to distinguish between left and 
and right foot falls and had less complicated hardware. GaitMat II 
was recently used to study the effects of peripheral vascular 
disease on gait and may have more broad-based use in clinical 
and research facilities in the near future.7

Recently, the GAITRite system was introduced to measure 
temporal and spatial parameters of gait and to provide a func-
tional outcome score patterned after Nelson’s original paper-
and-pencil method.1 Its potential advantages are its portability, 
relatively low cost, and ease of operation and storage. Also, its 
on-board microprocessors connect to the serial port of conven-
tional IBM-compatible computers, obviating the need for com-
plicated and expensive circuit board adapters. Because of these 
potential advantages, the present study was undertaken to as-

Table 2: Simulator Stride Length: Differences (cm and %) in GAITRite (GR) and Simulator (SIM) Measures for Center-of-Walkway 
and Left-of-Center Trials

<table>
<thead>
<tr>
<th>LOC Trials</th>
<th>GR Step 1 (cm)</th>
<th>SIM Step 1 (cm)</th>
<th>Difference</th>
<th>GR Step 2 (cm)</th>
<th>SIM Step 2 (cm)</th>
<th>Difference</th>
<th>GR Stride (cm)</th>
<th>SIM Stride (cm)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64.6</td>
<td>64.8</td>
<td>0.2 0.3</td>
<td>49.7</td>
<td>49.4</td>
<td>0.3 0.6</td>
<td>114.6</td>
<td>114.2</td>
<td>0.4 0.3</td>
</tr>
<tr>
<td>2</td>
<td>64.6</td>
<td>64.8</td>
<td>0.2 0.3</td>
<td>49.7</td>
<td>49.4</td>
<td>0.3 0.6</td>
<td>114.3</td>
<td>114.2</td>
<td>0.1 0.1</td>
</tr>
<tr>
<td>3</td>
<td>64.7</td>
<td>64.8</td>
<td>0.1 0.2</td>
<td>49.8</td>
<td>49.4</td>
<td>0.4 0.8</td>
<td>114.5</td>
<td>114.2</td>
<td>0.3 0.3</td>
</tr>
<tr>
<td>4</td>
<td>65.6</td>
<td>64.8</td>
<td>0.8 1.2</td>
<td>48.7</td>
<td>49.4</td>
<td>0.7 1.4</td>
<td>114.4</td>
<td>114.2</td>
<td>0.2 0.2</td>
</tr>
<tr>
<td>5</td>
<td>65.6</td>
<td>64.8</td>
<td>0.0 0.0</td>
<td>49.7</td>
<td>49.4</td>
<td>0.3 0.6</td>
<td>114.7</td>
<td>114.2</td>
<td>0.5 0.4</td>
</tr>
<tr>
<td>6</td>
<td>65.6</td>
<td>64.8</td>
<td>1.0 1.5</td>
<td>48.2</td>
<td>49.4</td>
<td>1.2 2.5</td>
<td>114.1</td>
<td>114.2</td>
<td>0.1 0.1</td>
</tr>
<tr>
<td>7</td>
<td>64.8</td>
<td>64.8</td>
<td>0.0 0.0</td>
<td>49.7</td>
<td>49.4</td>
<td>0.3 0.6</td>
<td>114.6</td>
<td>114.2</td>
<td>0.4 0.3</td>
</tr>
<tr>
<td>8</td>
<td>64.7</td>
<td>64.8</td>
<td>0.1 0.2</td>
<td>49.5</td>
<td>49.4</td>
<td>0.1 0.2</td>
<td>114.2</td>
<td>114.2</td>
<td>0.0 0.0</td>
</tr>
<tr>
<td>9</td>
<td>65.8</td>
<td>64.8</td>
<td>0.9 1.4</td>
<td>48.6</td>
<td>49.4</td>
<td>0.8 1.6</td>
<td>114.4</td>
<td>114.2</td>
<td>0.2 0.2</td>
</tr>
<tr>
<td>10</td>
<td>63.7</td>
<td>64.8</td>
<td>1.1 1.7</td>
<td>49.7</td>
<td>49.4</td>
<td>0.3 0.6</td>
<td>113.5</td>
<td>114.2</td>
<td>0.7 0.6</td>
</tr>
</tbody>
</table>

Mean | 64.9 | 64.8 | 0.4 0.7 | 49.3 | 49.4 | 0.5 1.0 | 114.3 | 114.2 | 0.3 0.3 |
SD   | 0.6  | 0.0  | 0.5 0.7 | 0.6  | 0.0  | 0.3 0.7 | 0.3   | 0.0   | 0.2 0.2 |

<table>
<thead>
<tr>
<th>C Trials</th>
<th>GR Step 1 (cm)</th>
<th>SIM Step 1 (cm)</th>
<th>Difference</th>
<th>GR Step 2 (cm)</th>
<th>SIM Step 2 (cm)</th>
<th>Difference</th>
<th>GR Stride (cm)</th>
<th>SIM Stride (cm)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64.9</td>
<td>64.8</td>
<td>0.1 0.2</td>
<td>49.7</td>
<td>49.4</td>
<td>0.3 0.6</td>
<td>114.6</td>
<td>114.2</td>
<td>0.4 0.3</td>
</tr>
<tr>
<td>2</td>
<td>64.6</td>
<td>64.8</td>
<td>0.2 0.3</td>
<td>49.7</td>
<td>49.4</td>
<td>0.3 0.6</td>
<td>114.3</td>
<td>114.2</td>
<td>0.1 0.1</td>
</tr>
<tr>
<td>3</td>
<td>64.7</td>
<td>64.8</td>
<td>0.1 0.2</td>
<td>49.8</td>
<td>49.4</td>
<td>0.4 0.8</td>
<td>114.5</td>
<td>114.2</td>
<td>0.3 0.3</td>
</tr>
<tr>
<td>4</td>
<td>65.6</td>
<td>64.8</td>
<td>0.8 1.2</td>
<td>48.7</td>
<td>49.4</td>
<td>0.7 1.4</td>
<td>114.4</td>
<td>114.2</td>
<td>0.2 0.2</td>
</tr>
<tr>
<td>5</td>
<td>65.6</td>
<td>64.8</td>
<td>0.0 0.0</td>
<td>49.7</td>
<td>49.4</td>
<td>0.3 0.6</td>
<td>114.7</td>
<td>114.2</td>
<td>0.5 0.4</td>
</tr>
<tr>
<td>6</td>
<td>65.6</td>
<td>64.8</td>
<td>1.0 1.5</td>
<td>48.2</td>
<td>49.4</td>
<td>1.2 2.5</td>
<td>114.1</td>
<td>114.2</td>
<td>0.1 0.1</td>
</tr>
<tr>
<td>7</td>
<td>64.8</td>
<td>64.8</td>
<td>0.0 0.0</td>
<td>49.7</td>
<td>49.4</td>
<td>0.3 0.6</td>
<td>114.6</td>
<td>114.2</td>
<td>0.4 0.3</td>
</tr>
<tr>
<td>8</td>
<td>64.7</td>
<td>64.8</td>
<td>0.1 0.2</td>
<td>49.5</td>
<td>49.4</td>
<td>0.1 0.2</td>
<td>114.2</td>
<td>114.2</td>
<td>0.0 0.0</td>
</tr>
<tr>
<td>9</td>
<td>65.7</td>
<td>64.8</td>
<td>0.9 1.4</td>
<td>48.6</td>
<td>49.4</td>
<td>0.8 1.6</td>
<td>114.4</td>
<td>114.2</td>
<td>0.2 0.2</td>
</tr>
<tr>
<td>10</td>
<td>63.7</td>
<td>64.8</td>
<td>1.1 1.7</td>
<td>49.7</td>
<td>49.4</td>
<td>0.3 0.6</td>
<td>113.5</td>
<td>114.2</td>
<td>0.7 0.6</td>
</tr>
</tbody>
</table>

Mean | 64.9 | 64.8 | 0.4 0.7 | 49.3 | 49.4 | 0.5 1.0 | 114.3 | 114.2 | 0.3 0.3 |
SD   | 0.6  | 0.0  | 0.5 0.7 | 0.6  | 0.0  | 0.3 0.7 | 0.3   | 0.0   | 0.2 0.2 |

Table 3: Step Times at 3 Walking Rates: GAITRite Measures vs 
Video-Based Measures

<table>
<thead>
<tr>
<th>Trial Description</th>
<th>Mean Step Time (s)</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VB</td>
<td>GR</td>
<td>VB</td>
</tr>
<tr>
<td>1 Preferred</td>
<td>.55</td>
<td>.56</td>
<td>.63</td>
</tr>
<tr>
<td>2 Slower than preferred</td>
<td>.69</td>
<td>.70</td>
<td>.76</td>
</tr>
<tr>
<td>3 Faster than preferred</td>
<td>.45</td>
<td>.48</td>
<td>.57</td>
</tr>
</tbody>
</table>
poor correlation (ICC based–GAITRite comparison (see table 4). The reason for a
anticipated, but only fair-to-good correlations in the video-
pencil and GAITRite measures, for right and left step length, as
5
(ICC lent for cadence (ICC
hand, the video-based and GAITRite correlations were excel-
step times, which also rely on estimated timing. On the other
fact, supported by correspondingly low correlations for right and left
watch timing errors (table 4). This consideration appears to be
paper-and-pencil versus GAITRite analysis because of stop-
patterns (eg, changes in symmetry and speed) as she walked
accuracy. Lower limb rotation and base of support, for instance,
tents that may change when disease or
physical injury produce permanent anatomic or biomechanic
changes or changes in the control of gait.

CONCLUSIONS
Our preliminary analysis showed the GAITRite system to be
a valid and reliable tool for measuring selected gait compo-
parameters (step lengths), and derived measures of rate in a
healthy subject walking at difference speeds and various de-
grees of step symmetry. Future investigators should study
patients with documented disease or physical injury. The
GAITRite system proved to be an easy to use, relatively
inexpensive gait assessment tool that clinicians and researchers
may find useful for gait analysis in adults; some question
remains about its usefulness for analyzing gait in very young or
small children.

References
1. Nelson AJ. The functional ambulation profile. Phys Ther 1974;
2. Sekiya N, Nagasaki H, Ito H, Furuma T. Optimal walking in terms
of variability in terms of step length. J Orthop Sports Phys Ther
1997;26:266-72.
3. Baker PA, Hewison SR. Gait recovery pattern of unilateral lower
limb amputees during rehabilitation. Prosthet Orthot Int 1990;14:
4. McDonough AL, Nelson AJ. New methods for determining tem-
poral and linear parameters of gait using the functional ambulation
profile. Proceedings of the annual meeting of the New York
Physical Therapy Association: 1994 Nov 5; Rye Brook, NY.
5. Keenan MA, Peabody TD, Geronley JF, Perry J. Valgus deformi-
ties of the feet and characteristics of gait in patients who have
6. Leiper CI, Craik RL. Relationships between physical activity and
temporal-distance characteristics of walking in elderly women.

Table 4: Correlations Among Paper-and-Pencil, Video-Based, and GAITRite Methods for 3 Analyses: Concurrent Gait Analysis, Step Length, and Step Time

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Concurrent Measures</th>
<th>Step Length Reliability</th>
<th>Step Time Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Validity (ICC 2, 1)</td>
<td>(Student’s t, Paired)</td>
<td>(ICC 2, 1)</td>
</tr>
<tr>
<td></td>
<td>PP vs GR</td>
<td>VB vs GR</td>
<td>t</td>
</tr>
<tr>
<td>Walking speed</td>
<td>.96</td>
<td>.95</td>
<td>C Trials</td>
</tr>
<tr>
<td>Cadence</td>
<td>.31</td>
<td>.96</td>
<td>Step 1</td>
</tr>
<tr>
<td>Right step length</td>
<td>.97</td>
<td>.44</td>
<td>Stride</td>
</tr>
<tr>
<td>Left step length</td>
<td>.99</td>
<td>.85</td>
<td>Step 2</td>
</tr>
<tr>
<td>Right step time</td>
<td>.67</td>
<td>.97</td>
<td>LOC Trials</td>
</tr>
<tr>
<td>Left step time</td>
<td>.61</td>
<td>.96</td>
<td>Step 2</td>
</tr>
</tbody>
</table>

sensitive to temporal measures and may have yielded an un-
acceptably low intraclass coefficient (ICC = .31) during the
paper-and-pencil versus GAITRite analysis because of stop-
watch timing errors (table 4). This consideration appears to be
supported by correspondingly low correlations for right and left
step times, which also rely on estimated timing. On the other
hand, the video-based and GAITRite correlations were excel-
lent for cadence (ICC = .96) and for right and left step times
(ICC = .94 and .99, respectively).

We found excellent correlation (ICC > .95) for paper-and-
pencil and GAITRite measures, for right and left step length, as
anticipated, but only fair-to-good correlations in the video-
based–GAITRite comparison (see table 4). The reason for a
poor correlation (ICC = .44) for right step length remains
unclear, but may have been caused by error from the video
camera’s depth-of-field as it recorded the right lower extremity.
In the experimental setup, the video camera was always located
to the subject’s left side as she walked, leaving the right lower
extremity always the farthest distance from the lens. The lens
had a small aperture and the right lower extremity may have
been located beyond the lens’s depth-of-field, making the video
image of the right limb blurred and causing difficulty in iden-
tifying the precise point of heel contact.

More accurate spatial data, (ie, step lengths) were found
when we compared GAITRite results with the paper-and-pencil
method. To assess whether the sensors embedded in the walk-
way were equally responsive to footfall pressures throughout
the walkway’s active recording area, we applied simulated
steps and strides from a fabricated device (see fig 2) along the
geographic centerline of the mat and along a line of progression
left of center.

One difficulty noted in applying the simulated soles to the
walkway was that footfall imprints were sometimes incomplete
if care was not taken to press the device adequately into the
walkway. During some trials, several imprints were incom-
pletely registered by the sensors and appeared as partially
registered footfalls on the software display. GAITRite’s manu-
facturer recommends that the subject weigh at least 30 pounds
to ensure that sufficient force is applied to the walkway to
activate the embedded sensors. Although adults should be able
to apply adequate force, small children may not be heavy
enough. This issue should be investigated in future studies.

The present investigation used a single, healthy subject in 2
of the 3 experiments. The subject approximated abnormal gait
patterns (eg, changes in symmetry and speed) as she walked
along the GAITRite walkway. Because simulating a gait defect
may not precisely replicate the gait pattern of individuals with
injuries or disease, future analyses should include patients with
gait disabilities. Our preliminary analyses of the GAITRite
system appear to have direct clinical relevance for assessing
gait performance with a relatively easy to use and inexpensive
tool. Additional studies with patients will ultimately determine
if the GAITRite system can offer broad-based appeal to cli-
nicians and researchers. Future investigations should also assess
the system’s ability to measure other gait components accu-
rately. Lower limb rotation and base of support, for instance,
are important elements that may change when disease or
physical injury produce permanent anatomic or biomechanic
changes or changes in the control of gait.

In the experimental setup, the video camera was always located
to the subject’s left side as she walked, leaving the right lower
extremity always the farthest distance from the lens. The lens
had a small aperture and the right lower extremity may have
been located beyond the lens’s depth-of-field, making the video
image of the right limb blurred and causing difficulty in iden-
tifying the precise point of heel contact.

More accurate spatial data, (ie, step lengths) were found
when we compared GAITRite results with the paper-and-pencil
method. To assess whether the sensors embedded in the walk-
way were equally responsive to footfall pressures throughout
the walkway’s active recording area, we applied simulated
steps and strides from a fabricated device (see fig 2) along the
geographic centerline of the mat and along a line of progression
left of center.

One difficulty noted in applying the simulated soles to the
walkway was that footfall imprints were sometimes incomplete
if care was not taken to press the device adequately into the
walkway. During some trials, several imprints were incom-
pletely registered by the sensors and appeared as partially
formed footfalls on the software display. GAITRite’s manu-
facturer recommends that the subject weigh at least 30 pounds
to ensure that sufficient force is applied to the walkway to
activate the embedded sensors. Although adults should be able
to apply adequate force, small children may not be heavy
enough. This issue should be investigated in future studies.

The present investigation used a single, healthy subject in 2
of the 3 experiments. The subject approximated abnormal gait
patterns (eg, changes in symmetry and speed) as she walked
along the GAITRite walkway. Because simulating a gait defect
may not precisely replicate the gait pattern of individuals with
injuries or disease, future analyses should include patients with
gait disabilities. Our preliminary analyses of the GAITRite
system appear to have direct clinical relevance for assessing
gait performance with a relatively easy to use and inexpensive
tool. Additional studies with patients will ultimately determine
if the GAITRite system can offer broad-based appeal to cli-
nicians and researchers. Future investigations should also assess
the system’s ability to measure other gait components accu-
rately. Lower limb rotation and base of support, for instance,
are important elements that may change when disease or
physical injury produce permanent anatomic or biomechanic
changes or changes in the control of gait.

CONCLUSIONS
Our preliminary analysis showed the GAITRite system to be
a valid and reliable tool for measuring selected gait compo-
parameters (step lengths), temporal parameters (step lengths), and derived measures of rate in a
healthy subject walking at difference speeds and various de-
grees of step symmetry. Future investigators should study
patients with documented disease or physical injury. The
GAITRite system proved to be an easy to use, relatively
inexpensive gait assessment tool that clinicians and researchers
may find useful for gait analysis in adults; some question
remains about its usefulness for analyzing gait in very young or
small children.

References
1. Nelson AJ. The functional ambulation profile. Phys Ther 1974;
2. Sekiya N, Nagasaki H, Ito H, Furuma T. Optimal walking in terms
of variability in terms of step length. J Orthop Sports Phys Ther
1997;26:266-72.
3. Baker PA, Hewison SR. Gait recovery pattern of unilateral lower
limb amputees during rehabilitation. Prosthet Orthot Int 1990;14:
80-4.
4. McDonough AL, Nelson AJ. New methods for determining tem-
poral and linear parameters of gait using the functional ambulation
profile. Proceedings of the annual meeting of the New York
Physical Therapy Association: 1994 Nov 5; Rye Brook, NY.
5. Keenan MA, Peabody TD, Geronley JF, Perry J. Valgus deformi-
ties of the feet and characteristics of gait in patients who have
6. Leiper CI, Craik RL. Relationships between physical activity and
temporal-distance characteristics of walking in elderly women.

Suppliers
a. E.Q. Inc, PO Box 16, Chalfont, PA 18914.
b. IBM Corp, New Orchard Rd, Armonk, NY 10504.
c. CIR Systems, Inc, PO Box 4402, Clifton, NJ 07012.
d. Microsoft Corp, One Microsoft Way, Redmond, WA 98052.
e. Panasonic Corp, One Panasonic Way, Secaucus, NJ 07094.
f. RadioShack Corp, 180 Throckmorton St, Fort Worth, TX 76102.