Reliability of the GAITRite(R) Walking System for the assessment of gait in individuals with Parkinson's disease

Amy M. Stover
Medical University of Ohio

Follow this and additional works at: http://utdr.utoledo.edu/graduate-projects
Reliability of the GAITRite® Walking System for the Assessment of Gait in Individuals with Parkinson’s Disease

Submitted by

Amy Stover

In partial fulfillment of the requirements for the degree of Master of Science in Biomedical Sciences

Date of Presentation:

Academic Advisory Committee

Major Advisor
Michelle Masterson, Ph.D., P.T.

Department Chairperson
Clayton Holmes, Ed.D., P.T.

Dean, College of Health Sciences
Christopher E. Bork, Ph.D., P.T.

Dean, College of Graduate Studies
Keith K. Schlender, Ph.D.
Reliability of the GAITRite® Walking System for the Assessment of Gait in Individuals with Parkinson’s Disease

Amy M. Stover, BS
Michelle M. Masterson, PT, PhD
ABSTRACT

**Background:** The need exists for reliable methods to evaluate spatial and temporal parameters of gait in individuals with Parkinson’s disease (PD). This is important in an attempt to track the disease progression and to determine the most effective and efficient treatment interventions. Multiple methods of gait analysis exist, but as of now, no clinically-useful, objective tool has been found to be reliable or sensitive to gait impairments in persons with PD. Although the GAITRite® walking system has been found to be valid and reliable for normal adult gait, the reliability of its use for individuals with PD has not been established. **Purpose:** To determine the test-retest reliability of the GAITRite® system for measurement of gait parameters in individuals with PD. **Methods:** 20 subjects age 49-85 years with a diagnosis of PD volunteered for the study. Subjects were asked to complete up to four trials of walking the length of the GAITRite® walking system at his/her normal walking pace with shoes on. Subjects were given a two minute rest period between the first three trials and a 10 minute rest between the 3rd and 4th trials. An Interclass Correlation Coefficient (ICC) was used to determine the test-retest reliability of each gait variable of the GAITRite® system for individuals with PD, \( p \leq 0.05 \). **Results:** The ICC’s for all gait parameters were 0.89 or higher. Specifically, the ICC’s for mean normalized velocity, step length, stride length, double support, and base of support (step width) demonstrated very good reliability (ICC = 0.93 – 0.99). The test-retest reliability for cadence and single limb support was good (ICC = 0.89). **Conclusion:** The GAITRite® system is a highly reliable assessment tool for evaluating the temporal and spatial parameters of gait typically affected in individuals with PD.
INTRODUCTION

Parkinson’s disease (PD) is a progressive central nervous system (CNS) disorder caused by degeneration of nigrostriatal dopaminergic neurons in the basal ganglia resulting in dopamine depletion.\(^1\) The basal ganglia, via the neurotransmitter dopamine, play a major role in motor and postural control.\(^2,3\) With the degeneration of the basal ganglia and the depletion of dopamine, the result is a variety of motor disturbances. The cardinal manifestations of PD include bradykinesia or slowness of movement, tremor, rigidity, and postural instability, all of which can lead to secondary manifestations such as musculoskeletal changes and gait disturbances.\(^1,2,4\) Individuals with PD have typical gait characteristics including decreased stride length, walking speed, trunk rotation, and arm swing, and increased cadence.\(^5\) Other gait deviations include inadequate heelstrike and toe clearance and insufficient hip, knee, and ankle flexion.\(^5,6\) An individual with PD may experience “freezing” episodes and may have difficulty performing more than one task at the same time, such as walking while carrying a tray with drinking glasses.\(^7\) These episodes typically increase in number as the disease progresses, as does the risk and occurrence of falls.\(^5\) The need for reliable methods to evaluate spatial and temporal parameters of gait is of critical importance in an attempt to track the disease progression and to determine the most effective and efficient treatment interventions.

There are various ways to assess and analyze gait. Methods include visual observation, use of a stopwatch and a measured pathway, chalked footprints on a dark mat, three dimensional (3-D) motion analysis, and the Tinetti Gait Assessment (TGA) of mobility. Visual gait observation, while common and simple to perform, has been shown to have poor inter-rater and retest reliability.\(^8\) A clinician can use a stopwatch and measured pathway to count the number of steps and the time taken to complete the path to calculate cadence and velocity. Although the
use of the stopwatch method has been shown to have moderate to high reliability, it typically requires the timer to estimate when the subject broke the plane of the start and finish lines, increasing the potential error in temporal measures. In addition, this method does not allow for determining the spatial variables of gait. Another method of gait analysis that includes the measurement of both spatial and temporal parameters entails marking the bottom of an individual’s feet with paint or chalk and having him or her walk along a dark mat. A certain point, such as the middle of the heel of each foot can be located and the clinician can use a measuring tape to determine such variables as base of support (also known as step width), step length, stride length, and degree of toe in/out. However, this method can be time consuming, cumbersome, and messy.

Three dimensional (3-D) motion analysis involves sophisticated equipment requiring placement of markers on bony landmarks on the subject. Typically, up to six cameras are used to follow the progression of the markers. Often, there is also a force platform involved in which the subject must make sure to strike the entire foot on the platform which can be difficult to time correctly and still keep steady-state walking. The information from the markers and the force platform is sent to a computer for processing of both kinematic and kinetic variables. However, this method is expensive, requires a large space, technical expertise, and can be problematic if the individual with PD requires assistance with walking as some of the markers may be blocked from view of the cameras. In addition, there may be error in placement of the markers on the bony landmarks.

A method of gait analysis that does not measure kinematic or kinetic variables, but provides a brief and simple assessment of position changes, response to perturbations, and gait movements during activity is the Tinetti Gait Assessment (TGA). Behrman et al. examined
whether the gait component of the TGA provided a useful and clinically accessible alternative to motion analysis assessment in detecting change in walking performance of individuals with PD. The authors found that the TGA was not sensitive to detecting meaningful change in gait impairments in individuals with moderate PD. Therefore, research must be conducted to find another tool that is reliable and sensitive to gait impairments in those individuals with PD.

The GAITRite® system is a portable, electronic walkway which has pressure sensors embedded within its length. Individuals are able to walk over the mat without being hindered by markers or wires, and the data can be obtained quickly and easily for each footfall within the length of the mat. Potential advantages of the GAITRite® include its portability, relatively low cost, and ease of storage and operation. Studies have shown the GAITRite® system to be valid and reliable for normal adult gait.8,11

In addition, a study by Gretz et al.12 examined the reliability of temporal and spatial gait measures for adults with Down syndrome using the GAITRite® system. Gait measures such as mean normalized velocity, step length/leg length ratio, step time, and base of support of adults with Down syndrome were compared to adults without developmental disability. The study concluded that the test-retest reliability results support the use of the above mentioned gait measures as indicators of performance in both the Down syndrome and adults without developmental disability groups.

Nelson et al.13 conducted a study to determine the validity of the GAITRite® system in detecting footfall patterns and selected gait characteristics such as cadence, mean normalized velocity, step length, and step time for individuals with PD. The results of the study indicated that the GAITRite® system can be useful in identifying footfall patterns and selected time and
distance measurements of individuals with early stage PD. However, the reliability of the GAITRite® system for PD was not determined.

While the GAITRite® walking system has been shown to be reliable for individuals with normal gait and for the gait of individuals with Down syndrome, the reliability of its use for individuals with PD has not been established. The gait of an individual with PD is slower, more variable, and often with shuffled steps, all of which may influence the test-retest reliability of the GAITRite® system. Therefore, the purpose of this study was to determine the test-retest reliability of the GAITRite® system for measurement of temporal and spatial parameters of gait in individuals with PD.

**METHODS**

**Subjects.** Twenty subjects age 49-85 years (mean= 70.25 ± 10.03 years) with a clinical diagnosis of PD volunteered for this study. The motor section scores of the Unified Parkinson’s Disease Rating Scale (UPDRS) ranged from 12-53. Subjects were required to stand and walk with or without a cane or walker for at least 20 feet for up to four trials with rest periods in between each trial. Exclusion criteria included any other neurological or musculoskeletal disorders that affected the subject’s ability to stand and walk.

**Instruments.** The GAITRite® walking system (CIR Systems Inc., Clifton, NJ) was used to determine spatial and temporal parameters of gait. The system included a special floor mat (dimensions = 5m x 1m x 0.3cm) with embedded sensors throughout the mat in a grid-like fashion. The sensors were triggered when mechanical pressure was applied from each footfall, and data were transmitted to a computer for gait analysis and storage.

**Procedures.** The research protocol was approved by the Medical University of Ohio Institutional Review Board. Upon arrival, the researcher reviewed the informed consent with the
subject, answered any questions the subject may have had, and obtained the written consent. The subject’s leg length from the greater trochanter to the floor was measured for both the left and right leg with shoes on. A chair was placed six to eight feet away from each end of the mat for the subject to rest in after each trial. The purpose of starting before the mat and continuing past its end assured that the subject would be walking at his or her preferred steady-state pace over the instrumented portion of the mat. Each subject was asked to walk with shoes on at his or her normal walking pace. Subjects wore a safety belt during all walking trials and a researcher walked alongside of the subjects, beside the electronic walkway to guard against any loss of balance. Subjects were asked to complete up to four trials of walking the length of the GAITRite® walking system, with a two minute rest period between the first three trials and a 10 minute rest between the 3rd and 4th trials.

**Data Analysis.** Footsteps which did not fall in their entirety on the GAITRite® mat were deleted. Only complete footfalls were analyzed using computer software (CIR Systems, Inc., Clifton, NJ), and because PD gait is typically not asymmetric, only the right footfalls were analyzed for convenience. The gait variables analyzed included mean normalized velocity, cadence, base of support (step width), step length, stride length, and percentage of gait cycle spent in single support and double support. The averages of each gait variable for each subject were calculated for the 2nd to last trial and for the last trial only.

**Statistical Analysis.** An Interclass Correlation Coefficient (ICC) (p ≤ 0.05) (SPSS Version 11.5 for Windows® statistical software, SPSS Inc., Chicago, IL) was used to determine the test-retest reliability for each gait variable of the GAITRite® for individuals with PD using the averages of each footfall within the second to last and last trials (2,k), except for normalized
velocity and cadence, for which only one value was calculated for each of the two trials (2,1). A 95% confidence interval was established.

RESULTS

The ICC’s for all gait variables were 0.80 or higher (Table 1). Values above 0.75 indicate good reliability, values from 0.50 to 0.75 indicate moderate reliability, and values below 0.50 suggest poor reliability. The ICC’s for mean normalized velocity, step length, stride length, double support, and base of support (step width) demonstrated very good reliability (ICC = 0.93–0.99). The test-retest reliability for cadence and single limb support were good (ICC = 0.89).

DISCUSSION

Test-retest reliability is an essential requirement for any gait analysis system to make certain any observed differences in gait performance during different testing sessions reflect a change in gait and motor function, as opposed to random or systematic error in the technique used for measurement. Furthermore, the reliability of measurement tools that are used for decision making or diagnosis of individuals should be higher than 0.75 (ICC), and it has also been suggested that clinical measurement tools have reliability of at least 0.90 (ICC) or higher to ensure valid interpretation of results. The results of this study demonstrate that the GAITRite® system provides highly reliable measurements of spatial and temporal gait parameters typically affected in individuals with PD, including step and stride length, base of support, mean normalized velocity, single and double limb support time, and cadence.

The high test-retest reliability for the spatial and temporal variables measured by the GAITRite® system is consistent with previous research on the repeatability of gait parameters in normal adult gait. In addition, the results of this study are consistent with Morris et al. who...
used the Clinical Stride Analyzer® to determine the stability of PD gait variables under various conditions. The Clinical Stride Analyzer® system involves the use of footswitches worn inside the shoes and its reliability is well-established. The authors found a high degree of consistency on tests of cadence, walking speed, stride length, and double limb support duration when subjects with PD and control subjects were retested both within a session and from one day to the next day.

Limitations to this study include not recording the time the subject had taken medication. The medication cycle for a person with PD can cause peaks and valleys in its effectiveness, which can affect gait performance and thus the reliability of gait assessment tools. However, few changes in gait between the test and re-test trials were expected secondary to the relatively small rest period (10 minutes) between the trials. Fatigue may also be a factor that may have affected gait as the subjects had already performed three trials prior to the last (re-test) trial. However, if fatigue was a factor, greater variability would be expected in the gait parameters resulting in lower ICC’s.

CONCLUSION

The purpose of this study was to determine the test-retest reliability of the GAITRite® system for measurement of temporal and spatial parameters of gait in individuals with PD. The GAITRite® system was found to be highly reliable for assessing temporal and spatial parameters of gait in individuals with PD. In addition, the GAITRite® system provides a very detailed analysis of the individual components of gait. It is easy to use, requires minimal set up or data analysis time, and is relatively inexpensive. Clinical research in the area of PD, as well as in health care in general, often focuses on functional outcomes, which requires reliable, objective assessment tools. Gait is a common outcome measure of clinical research and the GAITRite®
system is a comprehensive, reliable measurement tool that should be used more frequently to objectively assess gait for individuals with PD.
REFERENCES


Table 1. Test-retest reliability (ICC) of the GAITRite® variables.

<table>
<thead>
<tr>
<th>Gait Variable</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean normalized velocity</td>
<td>0.97</td>
</tr>
<tr>
<td>Cadence</td>
<td>0.89</td>
</tr>
<tr>
<td>Step length</td>
<td>0.99</td>
</tr>
<tr>
<td>Stride length</td>
<td>0.99</td>
</tr>
<tr>
<td>Single limb support</td>
<td>0.89</td>
</tr>
<tr>
<td>Double limb support</td>
<td>0.98</td>
</tr>
<tr>
<td>Base of support (step width)</td>
<td>0.93</td>
</tr>
</tbody>
</table>