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Submitted by

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

Date of Presentation:

July 19, 2005

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The Relationship Between Gait Parameters and Global Rating Scales for Individuals with Parkinson’s Disease

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ABSTRACT

Introduction. Parkinson’s Disease (PD) is a progressive CNS disorder caused by a decrease in dopamine, which commonly leads to motor disturbances. The purpose of this study was to determine the relationship among the gait characteristics of individuals with varying degrees of PD and the various global rating scales used to assess PD. Methods. Twenty subjects aged 49-85 years (X = 70.25 ± 10.03) with PD volunteered for this study. Subjects walked the length of the mat of the GAITRite® walking system at his/her normal walking pace. The data from 3 trials were then averaged. A physician then determined the degree of PD of each subject based on the motor section of the Unified Parkinson’s Disease Rating Scale (UPDRS) and the Hohen & Yahr (H&Y). Spearman rank correlation coefficients were used to determine the relationship between the various GAITRite® parameters and the UPDRS motor score, UPDRS gait sub-score, and H&Y score. Results. Significant negative correlations were found between some of the gait parameters and the H&Y score and the UPDRS motor score. Significant positive correlations were found between some of the parameters of gait and the UPDRS gait sub-score. Conclusion. Several gait parameters of individuals with PD are correlated with the global rating scales used to assess PD, indicating a relationship between objective and subjective measures of PD. These results can improve the efficiency and effectiveness by which physicians and clinicians evaluate and treat 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 tremor, rigidity, bradykinesia, and postural instability, leading to secondary manifestations such as musculoskeletal changes and gait disturbances.¹,²,⁴ Individuals with PD have typical gait characteristics that include decreased stride length, velocity, foot clearance, and trunk rotation as well as an increased cadence.⁵ As PD progresses the symptoms become more prominent and physical abilities decline.

A variety of assessment tools, rating scales, and subjective and objective tests are used by physicians to evaluate or classify an individual with PD and to determine the effectiveness of therapeutic interventions, such as medications. However, many of these tools are global measures that characterize the overall effects of the disease, or are specific measures that emphasize primary effects of PD, such as tremor and rigidity.¹ For example, the Hoehn-Yahr (H&Y) Classification of Disability Scale is used to estimate the stage and severity of PD with stage 0 indicating no symptoms, stage I: unilateral involvement, stage II: minimal bilateral or midline involvement, stage III: impaired righting reflexes, unsteadiness, and postural instability, stage IV: severe symptoms, and stage V: the person is confined to a bed or wheelchair.² As a patient’s severity of PD increases the Hoehn and Yahr score increases.
Another example of a tool used to assess PD is the Unified Parkinson’s Disease Rating Scale (UPDRS). The UPDRS is one of the most reliable and valid scales for patient with PD, and is composed of 6 different sections with 42 characteristics that globally assess the effects of PD.\textsuperscript{5, 6} Part I (mentation, behavior, and mood) has four characteristics related to a person’s mental status. Part II (Activities of Daily Living) has 13 characteristics that assess the person’s speech, swallowing, fine motor, and gross motor skills. Part III (motor examination) has fourteen characteristics which assess a person’s motor impairments including posture and gait. Part IV (complications of therapy) has eleven characteristics that assess motor and non-motor complications. Part V consists of a Modified Hoehn and Yahr Scale, and part VI is the Schwab and England Activities of Daily Living Scale. Parts I-III can be analyzed independently or simultaneously with parts IV-VI. Parts I-III are scored using a 5-point scale with zero representing no impairment and 4 representing marked impairment. The total UPDRS has a maximum score of 124, and as disability increases the score decreases. According to Goetz et al.\textsuperscript{7} the UPDRS is the most commonly used clinical scale for the assessment of motor impairments and disabilities in those with PD.

Clinicians, such as physical therapists (PT’s) and occupational therapists (OT’s) often use objective assessment tools for individuals with PD that provide performance-based measures of function such as gait, balance, transfers, and activities of daily living.\textsuperscript{1, 2} The Berg Balance Scale (BBS), Functional Reach Test (FRT), Tinetti Gait Assessment (TGA), and video analysis are ways that clinicians can assess functional impairments related to PD. The BBS and FRT are often used to assess balance and risk of falls. The BBS has been found to be effective (85% sensitivity) for predicting the risk of
falls in community dwelling adults. The BBS assesses one’s balance but has not been shown to be sensitive for detecting gait abnormalities. Moreover, the BBS does not include items related to gait such as gait adaptability and gait speed. The FRT is also often used by clinicians to assess balance. A study by Smithson et al. found that the FRT is a useful tool for assessing balance as well as predicting the chance of falls in individuals with PD. In contrast, Behrman et al. found that outcomes on the FRT are not sensitive enough to make clinical decisions, referrals for intervention, or make decisions regarding patient safety. In addition, Brusse et al. found that the forward FRT does not predict fall risk in individuals.

Gait is often assessed using the TGA or by video analysis. The TGA assesses gait by having the person perform various motor tasks such as sitting, standing, and ambulating. It is also used to estimate one’s fall risk based on the number of chronic disabilities an individual has. However, a study by Berhman et al. found that the TGA lacks sensitivity to detect meaningful changes in gait when used for evaluating individuals with PD. Vassallo et. Al also found that the Tinetti had only a 38.5% predictive accuracy, which was the lowest accuracy when compared with other fall risk assessment tools. In contrast, video analysis provides accurate, sensitive, and detailed data regarding one’s gait pattern; however, this method is complex and time consuming. Moreover, most video analysis systems are expensive and require advanced skills to achieve reliable and valid results. Thus, video gait analysis is not a practical means of assessing gait in the clinical setting. Until further research is done validating the use of expensive analysis tools to assess patient function, expensive video analysis systems will remain as research tools.
There is a need to determine the effectiveness of the various strategies used to evaluate PD so that health care professionals can determine the most effective and efficient means by which to manage individuals with PD. In addition, there is a need to assess several different variables when determining the effectiveness of various treatment strategies for individuals with PD. For example, a certain treatment intervention may not reduce tremors, but may improve postural control and gait to allow for greater independence with activities of daily living. It is important to evaluate a variety of variables that represent individuals with PD from a holistic perspective, especially gait, which is a basic functional skill that can be affected by all of the characteristics of PD including tremors, bradykinesia, and postural instability.

The GAITRite® system is a portable instrument composed of a 5m x 1m x 0.3 cm electronic walkway with sensors embedded within a mat in a grid-like pattern. The pressure sensors detect each footfall and send data to a computer for software analysis. The GAITRite® integrates temporal and spatial variables to give numerical representation of a person’s gait pattern. The computerized program records different parameters of gait such as cadence, mean normalized velocity, step length, step width, single support and double support percentage, and stance percentage of the gait cycle.\textsuperscript{13} The GAITRite® has been found to be valid and reliable for normal individuals when measuring these various gait parameters and can be used with confidence to evaluate the effects of various interventions on walking speed, cadence, and step length.\textsuperscript{13, 14} The GAITRite® has also been found to be a valid tool to assess the gait of an individual with PD.\textsuperscript{15} Nelson et al.\textsuperscript{15} studied the gait of twenty-two subjects (eleven with PD and eleven aged matched without PD) using the GAITRite® mat. The GAITRite® system was determined to be a valid
instrument to provide clinicians with a more thorough analysis of gait characteristics in patients with PD.\textsuperscript{16} In addition, the authors suggested that using the GAITRite® system would allow clinicians to both monitor and reassess treatment plans that were created to improve the gait of patients with PD.

Although there are a variety of assessment tools used by physicians and clinicians to assess primary effects of PD and the functional limitations that result, there is a need to determine if there is a relationship among the findings of the various assessment tools so that PD can be assessed most effectively, thoroughly, and efficiently. Therefore, the purpose of this study was to determine the relationship among the gait characteristics of individuals with varying degrees of PD and the various global rating scales. It was hypothesized that various gait parameters would significantly correlate with the global rating scales used to assess the severity of PD.

METHODS

Subjects. Twenty subjects, 12 males and 8 females, aged 49-85 years (70.25 ± 10.03 years) with a clinical diagnosis of PD volunteered for this study. The subjects were required to be able to stand and walk with or without an assistive device for at least 20 feet. Exclusion criteria included any other neurological or musculoskeletal disorders that affected their ability to stand and walk.

Instruments. The GAITRite® walking system previously described (CIR Systems Inc., Clifton, NJ) was used to determine spatial and temporal parameters of gait including velocity, cadence, percentage of the gait cycle spent in single support and double support, stride length, and base of support (step width).


**Procedures.** Upon arrival, the researcher reviewed the informed consent form with the subject, answered any questions the subject may have had, and written consent was obtained. 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 GAITRite® mat for the subject to rest in after walking. Subjects were asked to walk with shoes on at their normal walking pace. Subjects wore a safety belt during all walking trials and a researcher walked alongside the subjects without stepping on the GAITRite® mat to guard against any loss of balance. Subjects completed up to three trials of walking the length of the mat with at least a two-minute rest period between each trial. A physician then rated the degree of PD for each subject using the Hoehn-Yahr Classification of Disability Scale and the motor portion (part III) of the UPDRS.

**Data Analysis.** The data from the completed trials of each subject were averaged for mean normalized velocity, cadence, percentage of the gait cycle spent in single and double support, step length, stride length, and base of support. Since asymmetry is not a typical characteristic of PD; only the right footfalls were analyzed for convenience.

**Statistical Analysis.** Spearman rank correlation coefficients were used to determine the relationship between the UPDRS motor (part III) score, and the various GAITRite® temporal and spatial parameters. Spearman rank correlation coefficients were also used to determine the relationship between the UPDRS gait score and the various GAITRite® temporal and spatial parameters. The UPDRS gait score (item number 29 in part III) assesses overall gait on a scale of 0-4 with 0 being a normal gait pattern and 4 indicating the patient is non-ambulatory. Finally, Spearman rank
correlation coefficients were used to determine the relationship between the H&Y and the various GAITRite® parameters. All Spearman rank correlations were performed using statistical software (SPSS 11.5 for Windows®, Chicago, IL) with $p \leq 0.05$.

**RESULTS**

The results from this study indicated that there was a significant negative correlation between the H&Y score and several of the parameters of gait. Specifically, normalized velocity, stride length, and step length decreased as the H&Y score increased (Table 1 and Figures 1-3). No other gait parameters were significantly correlated with H&Y Score. Only step length was significantly correlated (negatively) with the UPDRS score such that as the UPDRS increased, right step length decreased (Table 1 and Figure 4). All other variables of gait were not significantly correlated with UPDRS scores.

The UPDRS Gait subscore significantly correlated (negatively) with several parameters of gait, specifically normalized velocity, stride length, and step length. In addition, the percentage of the gait cycle spent in double support, and the base of support were all found to have a significant positive correlation with the UPDRS gait subscore (Table 1 and Figures 5-9).

**DISCUSSION**

The primary purpose of this study was to determine the relationship among the gait characteristics of individuals with varying degrees of PD and the various global rating scales. It was hypothesized that as the severity of PD increased based on the H&Y, UPDRS, and UPDRS Gait sub-score ratings, there would be a significant worsening of the various parameters of gait.
The typical gait characteristics of PD include increased base of support and cadence as well as a decreased stride length, velocity, foot clearance, and trunk rotation. Therefore, it would be expected that all of those variables would significantly correlate with the scores used to determine the severity of PD. However, the results of this study indicated that, despite the UPDRS being one of the most commonly used scales, it was the least likely to correlate with gait variables as it only significantly correlated with step length. The H&Y only correlated with step length, stride length, and velocity. The UPDRS gait sub-score significantly correlated with all the gait variables except cadence and percent of gait spend in single support.

One may ask, “Why didn’t all the parameters of gait significantly correlate with each respective rating scale?” Perhaps this is due to the inability of the H&Y and UPDRS to be specific enough to detect changes in gait as the severity of PD increases. If the H&Y and UPDRS had more explicit criteria for grading the stages of PD, perhaps there would have been more significant correlations with the gait variables. Moreover, the H&Y and UPDRS are subjective rating scales, and the measurements obtained from the GAITRite® are objective in nature which may have also affected the results. There were greater correlations with the UDPRS gait sub-score, which is to be expected because it is very specific to gait and can better capture changes in gait than the H&Y and the overall UPDRS score.

There are also limitations of this study that may have affected the results. Only 20 subjects were tested which is a relatively small sample size to determine significant relationships among scores. In addition, a larger sample size would allow for a broader range of severities of PD and would allow for the grouping of subjects based on rating
scores to determine if there are significant differences in gait relative to the severity of PD. Another limitation of this study includes not recording the time the subject had taken his or her medication because the medication cycle for a person with PD has peaks and valleys, which can greatly affect gait performance.

The clinical implication that can be obtained from this study is that varying degrees in the severity of PD are correlated with some parameters of gait. However, because other parameters did not correlate with these scales, their usefulness for assessing the gait of patients with PD is limited. Therefore, it is important to use the GAITRite® in conjunction with various PD rating scales to allow for more specific monitoring of one’s impairments. Specific gait deviations are commonly observed in those with varying degrees of PD, and because some of them significantly correlated with H&Y and UPDRS scores, one may expect to see a specific gait deviation for a given H&Y or UPDRS score. However, using the GAITRite® during the initial examination and in subsequent visits would allow for more discrete monitoring of gait. While not all variables of gait significantly correlated with the severity of PD, the changes that do occur may also alter a PT plan of care. Using the GAITRite® for individuals with PD allows the clinician to monitor specific parameters of gait so that the plan of care can be changed accordingly.

CONCLUSION

The results of this study indicate that the severity of PD, based on global rating scales, is significantly correlated with some parameters of gait. However, more research needs to be done to determine the reasons for the lack of correlation between all variables of gait. The results from this study provide the first opportunity to explore the relationships
between subjective ratings of PD and objective measurements of gait. Future research regarding these relationships will allow both clinicians and physicians to better understand how gait is affected by severity of PD, which assessment tools are most efficient to use for evaluating changes in gait for an individual with PD, and which treatment interventions are most effective for the clinical management of an individual with PD.
REFERENCES


Table 1: Spearman Rank Correlation Coefficients

<table>
<thead>
<tr>
<th>Variable</th>
<th>H&amp;Y</th>
<th>UPDRS</th>
<th>UPDRS Gait Sub-score</th>
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</thead>
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<tr>
<td>Range</td>
<td>2-4</td>
<td>12-53</td>
<td>.5-3</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>2.65 ± .75</td>
<td>26.4 ± 9.62</td>
<td>1.03 ± 1.01</td>
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<tr>
<td>Normalized Velocity</td>
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<td>-.31</td>
<td>-.61*</td>
</tr>
<tr>
<td>Cadence</td>
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<td>-.06</td>
<td>-.11</td>
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<td>Single Support %</td>
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<td>Double Support %</td>
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<td>Base of Support</td>
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<td>.11</td>
<td>.43*</td>
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<tr>
<td>Stride Length</td>
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<td>-.33</td>
<td>-.66*</td>
</tr>
<tr>
<td>Step Length</td>
<td>-.62*</td>
<td>-.39*</td>
<td>-.69*</td>
</tr>
</tbody>
</table>

*p ≤ .05
Figure 1: Normalized velocity and H&Y scatter plot
Figure 2: Stride length and H&Y scatter plot
Figure 3: Step length and H&Y scatter plot
Figure 4: Step length and UPDRS scatter plot
Figure 5: Normalized Velocity and UPDRS gait sub-score scatter plot
Figure 6: Stride length and UPDRS gait sub-score scatter plot
Figure 7: Step length and UPDRS gait sub-score scatter plot
Figure 8: Percentage of gait in double support and UPDRS gait sub-score scatter plot
Figure 9: Base of support and UPDRS gait sub-score scatter plot