Validity and Reliability of Four Clinical Gait Measures in Patients with Multiple Sclerosis

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Background: The gold standards for assessing ambulation are the Expanded Disability Status Scale (EDSS) and the Timed 25-Foot Walk (T25FW) test. In relation with these measures, we assessed the reliability and validity of four clinical gait measures: the Timed Up and Go (TUG) test, the Dynamic Gait Index (DGI), the 2-Minute Walk Test (2MWT), and the 6-Minute Walk Test (6MWT). Patient self-report of gait was also assessed using the 12-item Multiple Sclerosis Walking Scale (MSWS-12).

Methods: Individuals 20 years or older with a diagnosis of multiple sclerosis (MS) and an EDSS score of 2.0 to 6.5 completed the MSWS-12, T25FW test, TUG test, DGI, 2MWT, and 6MWT. All the tests were repeated 2 weeks later at the same time of day to establish their reliability and concurrent validity. Predictive validity was established using the EDSS.

Results: Forty-two patients with MS were included. All measures showed high test-retest reliability. The TUG test, 2MWT, and 6MWT were significantly correlated with the T25FW test (Spearman $\rho = -0.902$, $-0.919$, and $-0.905$, respectively). The EDSS was also significantly correlated with all the walking tests. The MSWS-12 demonstrated the highest correlation to the EDSS ($\rho = 0.788$).

Conclusions: The TUG test, the DGI, the 2MWT, and the 6MWT exhibited strong psychometric properties and were found to be significant predictors of the EDSS score. Use of these tests to prospectively monitor the effects of medical and rehabilitation treatment should be considered in the comprehensive care of patients with MS. Int J MS Care. 2017;19:247–252.

Multiple sclerosis (MS) presents in individual patients with a variety of clinical manifestations that can affect functional mobility, especially ambulation. The standardized assessment tools currently used for ambulation are the gait component of the Expanded Disability Status Scale (EDSS)$^1$ and the Timed 25-Foot Walk (T25FW) test, a component of the Multiple Sclerosis Functional Composite.$^2$ Limitations have been reported with both the EDSS gait component and the T25FW test.$^5,8$ The gait component of the EDSS is an ordinal scale with criteria for ambulation limited to the distance walked and use of a unilateral or bilateral assistive device. It does not measure fall risk or gait speed. The T25FW test is a ratio scale in which gait speed can be calculated; however, variations may exist in the command for walking (eg, walk as fast as you can or walk at your comfortable speed), which affects the reliability of the test.$^3$ Because the person with MS is asked only to walk in a straight line for a short distance of 25 feet, the examiner may not be able to observe gait deviations and cannot ascertain the ability of the patient to modify gait during turns, the impact of endurance on gait, or fall risk.$^8$ The limitations identified restrict the clinician’s ability to comprehensively evaluate the patient’s gait. As such, there is a need to establish whether a correlation exists with clinical measures of gait that...
Two trials were performed. Patients 

the participants. 

obtaining approval from the University at Buffalo inter 

turn around, and return to the chair (TUG test). After 

knee, and ankle), and inability to perform the follow 

fair (3/5 manual muscle test in all muscles of the hip, 

strength less than 

of mild disability, and a score of 6.5 indicates the 

and ending, rotational vestibulo-ocular 

reflex testing, and the Dynamic Visual Acuity Test. If 

the patient was unable to hold gaze during the repeti 

tive rotational vestibulo-ocular reflex testing or had a 

greater than two-line difference during the Dynamic 

Visual Acuity Test, a limitation in vestibular process 

was noted. These tests, which were not included in 

the statistical analysis, were performed to establish a 

comprehensive baseline for each patient. For example, 

limited proprioception in the lower extremities or 

vestibulo-ocular deficits may affect the patient’s ability 

to perform a sit-to-stand transfer or to turn 180° safely, 

which were components of this study. If a deficit was 

detected, patients were monitored and guarded more 

closely during completion of the walking tests. (4) Five 

walking tests: the T25FW test, the TUG test, the DGI, 

the 2MWT, and the 6MWT.

Walking Tests

The walking tests were performed in a tiled hallway 60 feet in length and free of obstructions. One examiner 

(S.E.B.) performed all the standardized gait measures 

during both visits. Mandatory rest breaks were estab 

lished between specific tests. The specific time for each 

rest break was established before data collection and 

was based on the difficulty and energy level required for 

each preceding test. For example, if the item required 

one task (such as the T25FW test) or three tasks (such 

as the TUG test), rest breaks were shorter than for an 

eight-item task (such as the DGI) or an endurance task. 

The tests were performed as described below and in this 

order:

T25FW Test. Two trials were performed. Patients 

started at a line on the floor and were instructed to “walk 
as quickly as possible but safely” beyond the second line 

25 feet away. Time was recorded in seconds beginning 

with the first heel strike beyond the start line and ending
Patients performed the eight walking tasks of the DGI in a hallway with tape markers on the floor every 5 feet for 20 feet total. The examiner used standardized cueing that has been validated in a previous study: normal walking cadence; change in gait speed (normal walk, fast as you can, slow as you can, which was cued by the examiner every 5 feet); walking normal pace for 5 feet, then head turn left for 5 feet, then head turn right 5 feet, then head in midline for 5 feet; walking at a normal pace for 5 feet, then with vertical (up) head turn 5 feet then vertical (down) head turn for 5 feet then head in midline for 5 feet; walking and turning 180° and stopping; walking and stepping over an object; walk around two objects in a figure-eight pattern; and ascend and descend four steps. The ordinal score is based on the physical therapist’s observation of any gait deviations or imbalance. A normal walk without challenge to balance is scored a 3, and inability to perform the task is 0 (maximum score = 24).

(There was a 5-minute rest period before proceeding.)

The 2MWT. Patients were instructed to “walk at your comfortable pace” back and forth along a 60-foot walkway for 2 minutes.15,16,22

(There was a 5-minute rest period before proceeding.)

The 6MWT. The same protocol as described for the 2MWT test was performed for 6 minutes.

Data Analysis

Based on previous literature and known variances of all the tests, a power analysis identified that 30 participants were needed for 90% statistical power with an expected large effect size ($r = 0.50$). For the T25FW and TUG tests, two trials of each test were performed on both of the two days separated by 2 weeks (days 1 and 2) to determine whether there were learning or fatigue effects. Two scores of the T25FW and TUG tests were compared using the paired $t$ test. For all the variables, test-retest reliability was examined using intraclass correlation coefficient with a two-way mixed model and consistency type. The distribution of all the variables was tested with a one-sample Kolmogorov-Smirnov test. All the variables were not normally distributed, except for day 1 of the MSWS-12 transformed scores. Therefore, Spearman rho correlation coefficients were used with a one-tailed test to assess concurrent and predictive validity. A statistical software program (IBM SPSS Statistics for Windows, version 22.0; IBM Corp, Armonk, NY) was used, and the significance level was set at $P < .05$.

Results

Fifty-four patients were referred from their neurologist or a local MS wellness program to participate in the study. Of the 54 patients, four were excused due to the presence of one or more exclusion criteria. A total of 50 patients completed the study; however, eight patients had incomplete data, and, therefore, 42 patients were used in the analysis. Three patients were lost to follow-up and did not complete day 2. Five patients were unable to complete the higher-level gait measures (DGI, 2MWT, and 6MWT) and, therefore, were excluded from the analysis. Baseline characteristics of all the participants are shown in Table 1.

There were no significant differences between trials 1 and 2 for the T25FW test or the TUG test or between days 1 and 2 for all the variables. Test-retest reliability, using intraclass correlation coefficient model 3 for single measures, was very high for all the variables (Table 2).

All the gait measures were strongly correlated ($P < .01$) with each other, establishing concurrent validity. Predictive validity was established given the high correlations between all the gait measures and the EDSS (Table 3). The highest correlation with the EDSS was the self-reported MSWS-12 ($\rho = 0.788$).

Table 1. Characteristics of the 50 study participants

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD (range), y</td>
<td>53.2 ± 9.23 (32–73)</td>
</tr>
<tr>
<td>Sex, No. (%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>20 (40)</td>
</tr>
<tr>
<td>Female</td>
<td>30 (60)</td>
</tr>
<tr>
<td>EDSS score, mean ± SD (range)</td>
<td>5.02 ± 1.67 (1.5–6.75)</td>
</tr>
<tr>
<td>Time since diagnosis, mean ± SD (range), y</td>
<td>13.29 ± 10.8 (1–49)</td>
</tr>
</tbody>
</table>

Abbreviation: EDSS, Expanded Disability Status Scale.
Table 2. Test-retest reliability

<table>
<thead>
<tr>
<th>Test</th>
<th>Day 1</th>
<th>Day 2</th>
<th>ICC, (P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T25FW test, s\textsuperscript{a}</td>
<td>9.94 ± 6.49</td>
<td>9.61 ± 4.80</td>
<td>0.864 (&lt;.001)</td>
</tr>
<tr>
<td>TUG test, s\textsuperscript{a}</td>
<td>15.37 ± 10.15</td>
<td>15.79 ± 9.80</td>
<td>0.973 (&lt;.001)</td>
</tr>
<tr>
<td>DGI</td>
<td>14.29 ± 5.58</td>
<td>14.19 ± 5.67</td>
<td>0.955 (&lt;.001)</td>
</tr>
<tr>
<td>2MWT, ft</td>
<td>286.27 ± 126.70</td>
<td>293.33 ± 127.82</td>
<td>0.957 (&lt;.001)</td>
</tr>
<tr>
<td>6MWT, ft</td>
<td>787.31 ± 410.4</td>
<td>792.71 ± 392.7</td>
<td>0.965 (&lt;.001)</td>
</tr>
<tr>
<td>MSWS-12 score (\text{(transformed)})</td>
<td>47.94 ± 9.39</td>
<td>45.60 ± 20.48</td>
<td>0.863 (&lt;.001)</td>
</tr>
</tbody>
</table>

Abbreviations: DGI, Dynamic Gait Index; ICC, intraclass correlation coefficient; MSWS-12, 12-item Multiple Sclerosis Walking Scale; TUG, Timed Up and Go; T25FW, Timed 25-Foot Walk; 2MWT, 2-Minute Walk Test; 6MWT, 6-Minute Walk Test.
Note: Data are given as mean ± SD.
\textsuperscript{a}The best time of the two trials for each day was selected for analysis.

Table 3. Spearman rho correlations between clinical tests

<table>
<thead>
<tr>
<th></th>
<th>EDSS</th>
<th>T25FW test</th>
<th>MSWS-12</th>
<th>TUG test</th>
<th>DGI</th>
<th>2MWT</th>
<th>6MWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDSS</td>
<td>1.00</td>
<td>0.691</td>
<td>0.788</td>
<td>0.763</td>
<td>-0.763</td>
<td>-0.749</td>
<td>-0.755</td>
</tr>
<tr>
<td>T25FW test</td>
<td>-</td>
<td>1.00</td>
<td>0.732</td>
<td>-0.902</td>
<td>-0.800</td>
<td>-0.919</td>
<td>-0.905</td>
</tr>
<tr>
<td>MSWS-12</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>0.806</td>
<td>-0.702</td>
<td>-0.757</td>
<td>-0.768</td>
</tr>
<tr>
<td>TUG test</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>-0.809</td>
<td>-0.904</td>
<td>-0.925</td>
</tr>
<tr>
<td>DGI</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>0.853</td>
<td>0.861</td>
</tr>
<tr>
<td>2MWT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>0.959</td>
</tr>
<tr>
<td>6MWT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Abbreviations: DGI, Dynamic Gait Index; EDSS, Expanded Disability Status Scale; MSWS-12, 12-item Multiple Sclerosis Walking Scale; TUG, Timed Up and Go; T25FW, Timed 25-Foot Walk; 2MWT, 2-Minute Walk Test; 6MWT, 6-Minute Walk Test.
Note: All the variables are significantly correlated with each other \((P < .01)\).
(mean score, 16.9) in MS. The DGI discriminated better than the Berg Balance Scale but not as well as the Activities-Specific Balance Confidence Scale or the Dizziness Handicap Index.11

In addition to gait measures for fall risk, examining the person’s ability to walk safely for a specific time could be an indication of his or her return to community participation. The 2MWT and the 6MWT have been incorporated into research examining patients with cardiac and pulmonary dysfunction, lower-limb amputees, and people with MS.14-16 The verbal instruction used for the 2MWT and the 6MWT followed the protocol of earlier research in respiratory disease.14-16 We chose not to use the verbal instructions cited by Goldman et al.,14 which instruct the patient to “walk as fast and as far as possible” for safety reasons. Goldman et al.14 identified three falls during the 6MWT using that script. During the present study, no falls occurred, and the correlations with the other gait measures were high despite using the previously established command “walk at your comfortable pace.”

Another noteworthy finding was that the MSWS-12 score was a strong predictor of the EDSS score. This finding enforces the value of using a self-report instrument as part of a comprehensive gait analysis. Limited ambulation is a primary consequence of disease progression in MS, and lower-limb function required for ambulation was rated as the most important function for persons with MS.29 Gait limitation is a complex multifactorial impairment and as such should be assessed with multiple valid and reliable outcome measures. This study supports use of the MSWS-12 by all health-care professionals to initiate discussion about the patient’s walking ability. Functional measures should then be assessed in a clinical setting to provide a detailed baseline of the patient’s gait impairment with the goal of detecting minor functional change earlier in the disease course that would lead to an expedited therapeutic intervention.

As with most study designs, limitations exist, including the fact that these patients were followed up at an MS clinic or in an MS rehabilitation program; therefore, the sample may not represent the general population of patients with MS. Also, owing to the longer disease duration and relatively high level of disability in the sample, the results may not represent patients at an earlier stage of the disease. Finally, the study did not assess sensitivity to change, which is an important quality to ascertain before choosing a measure for clinical monitoring.

Conclusion

With the advances in medical management and rehabilitation in MS, it is imperative that we establish outcome measures that quantify an individual’s level of function and gait. This study demonstrated that the TUG test, the DGI, the 2MWT, and the 6MWT exhibit strong psychometric properties. Use of these gait measures, which are easy to perform in any clinical setting, enables the health-care practitioner to monitor the effect and benefit of medical and rehabilitation treatment.

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References


