Validation of a New Lower-Extremity Motor Coordination Test

Johanne Desrosiers, OT, PhD, Annie Rochette, OT, PhD, Hélène Corriveau, PT, PhD


Objective: To determine the test-retest reliability and construct validity of a new lower-extremity motor coordination test, the Lower Extremity MOtor COordination Test (LEMCOT).

Design: To test reliability, subjects with impairments in at least 1 lower extremity were evaluated twice by the same evaluator. To test construct validity, the LEMCOT scores obtained from subjects who had had a stroke were correlated with physical, functional, cognitive, and perceptual tests.

Setting: Geriatric day hospital and functional intensive rehabilitation unit.

Participants: In the reliability test, 29 people (mean age, 69.6y; range, 28–87y); in the construct validity, 144 people who recently had had a stroke.

Intervention: Not applicable.

Main Outcome Measures: In addition to the LEMCOT, the following measures were used for construct validity: the Fugl-Meyer Assessment (motor function), Berg Balance Scale, 5-m walking test, 2-minute walking test, Functional Autonomy Measurement System, Modified Mini-Mental State Examination, and Motor-Free Visual Perceptual Test.

Results: Intraclass correlation coefficients (ICCs) indicated that test-retest reliability is good (right-side ICC = .88; left-side ICC = .83). The construct validity of the LEMCOT was demonstrated by obtaining high correlations with physical and functional tests (r range, .62–.79; P < .001) and no correlations with cognitive (r = .11, P = .20) or visual perceptual tests (r = .15, P = .08) and by discriminating between subjects discharged to long-term care versus other living environments (P < .001).

Conclusions: The LEMCOT is a simple lower-extremity motor coordination test that showed good test-retest reliability and construct validity. It can be used in clinical and research settings, specifically with people who have had a stroke. Other studies should be carried out to confirm its psychometric properties.

Key Words: Lower extremity; Motor skills; Rehabilitation; Reliability and validity.

© 2005 by American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation

MOTOR COORDINATION CAN BE defined as the ability to produce a controlled, accurate, and rapid movement. Coordination results from the muscles working smoothly together in the execution of movements.2 Bourbonnais et al3 integrated these elements in their definition of motor coordination: “The ability of a given subject to activate the appropriate muscles for the execution of a purposeful movement in an accurate and effective manner.”3(pS58) Good coordination depends not only on muscle work but also on sensory information and body schema.4,5 Coordination is mainly under cerebellar control but can be affected by many other components of the central nervous system, such as the pyramidal and extrapyramidal systems.5

Usually, motor coordination is evaluated by observing patient performance during the execution of accurate, fast, and repeated movements. The 2 main criteria considered are the speed and quality of the movements. The Finger-Nose Test (FNT) is an example of such a test for the upper extremities.5,6 Although lower-extremity motor coordination is important in daily activities related to mobility, only a few tests are available to measure it. In the best known, the patient in the supine position is instructed to bring his/her heel to the knee cap of the opposite leg 5 times, as fast as possible, such as in the Fugl-Meyer Assessment (FMA).7 However, this position is not related to function and consequently is not often used in clinical settings and research.

The development of a new test, the Lower Extremity MOtor COordination Test (LEMCOT), was based on upper-extremity motor coordination tests, especially the FNT. The LEMCOT consists of moving the lower extremity as fast as possible from 1 target to another for 20 seconds. The number of on-target touches constitutes the score. In a prospective cohort study performed with subjects who had had a stroke, lower-extremity motor coordination, as measured with the LEMCOT, was among the best predictors of social participation 6 months after an intensive functional rehabilitation program.8 In addition, the LEMCOT appears to be able to detect changes during a stay in an intensive rehabilitation unit (standardized response mean, .57; 95% confidence interval [CI], .36–.75).9 Because this test appears to be useful in clinical and research settings, its psychometric properties should be verified.

One of these properties—reliability—shows that a measurement is performed in a reproducible manner. Test-retest reliability refers to the temporal stability of the measure, whereas interrater reliability refers to the similarity of results obtained by 2 or more evaluators.10 Validity is another important psychometric property to verify. The validity of an instrument refers to its ability to measure the general and specific characteristics for which it was designed.11 Different types of validity can be demonstrated, including face validity and content validity, which are established during the process of developing the instrument, often with the help of experts, and are not necessarily subjected to empirical analyses. Criterion and construct validity are 2 other main categories, which require empirical experimentation and statistical analyses. Criterion validity is verified by comparing the instrument to a benchmark...
measure (clinical judgment, diagnostic test, instrument recognized as a criterion standard). However, often there are no benchmark measures to validate an evaluation instrument. In such cases, construct validity is examined. This evaluates an instrument’s ability to confirm a hypothesis or theoretical construct related to the variable measured. Several types of construct validity can be studied, including convergent validity, divergent validity, and discriminant validity. Convergent construct validity refers to the relationship with another instrument, itself reliable and valid, that measures a similar concept. A divergent validity study verifies that there is no relationship between variables that are not expected to be related. Finally, discriminant validity evaluates an instrument’s ability to distinguish between groups of people who have different characteristics. Many construct validity studies must be performed before confirming the validity of a measurement instrument.

The aims of our study were (1) to study the test-retest reliability of the LEMOCOT; (2) to study convergent construct validity by correlating the LEMOCOT score with physical and functional variables that should require lower-extremity coordination: lower-extremity motor function, balance, walking speed, walking endurance, and functional autonomy; (3) to study divergent construct validity by correlating the LEMOCOT score with 2 variables (cognitive functions, visual perception) that should not be associated with it; and (4) to verify the discriminant validity of the LEMOCOT by testing its ability to obtain different scores for people living in different types of environments with different levels of functional independence.

METHODS

Participants

Two populations participated in the study. First, participants in the reliability study were recruited in the functional intensive rehabilitation and geriatric day hospital programs of the Sherbrooke Geriatric University Institute (SGUI), in Sherbrooke, QC, Canada. To be eligible for the reliability study, participants had to have impairments or disabilities in at least 1 lower extremity and be able to understand simple instructions. Several studies with people who have had a stroke partially performed, and 2 if it is fully performed. The maximum score of 34 indicates good lower-extremity motor performance. Several studies with people who have had a stroke have confirmed the validity of this test.

Balance: Berg Balance Scale. The Berg Balance Scale (BBS) consists of 14 tasks based on functional activities and quantified on a 5-category scale for an optimal score of 56 points. A study of the reliability of the total score conducted with stroke subjects produced very high interrater (intraclass correlation coefficient [ICC]=.98) and intrarater coefficients (ICC=.97). Good sensitivity to changes in the scale was shown with a stroke population, and the scale’s concomitant criterion validity has been studied with laboratory instruments.

Walking speed: 5-m walking test. Walking speed was evaluated by counting the number of centimeters walked per second over a distance of 5m from a standing start, where the speed included the acceleration phase. The subject must walk at his/her normal walking speed. A high score indicates fewer disabilities. This test is a very sensitive measure, even 3 months after a stroke. The 5-m walk test (SMWT) has been recommended as the best measure, among other walking tests, for detecting longitudinal changes in walking disability.

Walking endurance: 2-minute walking test. Walking endurance was estimated by a 2-minute walk on a continuous straight line without markers. The total distance covered was recorded in meters. A low score indicates greater disability.
Functional independence: Système de Mesure de l’Autonomie Fonctionnelle. The Système de Mesure de l’Autonomie Fonctionnelle (SMAF), or Functional Autonomy Measurement System, is a 29-item scale based on the World Health Organization’s Classification of Impairments, Disabilities and Handicaps. The SMAF measures functional ability in 5 areas: activities of daily living (7 items), mobility (6 items), communication (3 items), mental functions (5 items), and instrumental activities of daily living (8 items). Disability for each item is scored on a 5-point scale: 0 (independent), 0.5 (difficulty), 1 (needs supervision), 2 (needs help), and 3 (dependent). The total score (out of 87) and mobility section score (out of 18) were used in this study. A higher score indicates a higher level of dependence. Psychometric properties have been studied with older adults who presented a significant loss of independence and lived in different residential settings ranging from own home to long-term-care hospitals. An interrater reliability study of each item showed a mean Cohen’s weighted κ of .75. Another reliability study showed that the ICC for total SMAF scores was .95 (95% CI, .90–.97) for test-retest and .96 (95% CI, .93–.98) for interrater reliability.

Cognitive function: Modified Mini-Mental State Examination. The Modified Mini-Mental State Examination (3MS) comprises 15 items assessing orientation to time and place, attention, immediate and short-term recall, language, visuospatial abilities, long-term memory, verbal fluidity, and semantic associations for a maximum score of 100. A test-retest reliability study done with 249 patients obtained ICCs ranging from .91 to .93.

Visual perception: Motor-Free Visual Perceptual Test, vertical version. The Motor-Free Visual Perceptual Test, vertical version (MVPT-V), comprises 36 items presenting a choice of 4 alternatives under a target to be matched by the subject. The maximum possible score, indicating a perfect performance, is 36 points. A test-retest reliability study of the measure done with an elderly stroke population obtained an ICC of .95.

Statistical Analyses
Characteristics of the samples and the data were described by the mean and standard deviation (SD) for continuous variables and by the frequency and percentage for categorical variables. Test-retest reliability of the LEMOCOT was estimated using ICCs (1-way random effect model) that compared within-subject variability with between-subject variability. This estimate is obtained using results from an analysis of variance (ANOVA). For each ICC, the 95% CI was calculated to take sampling variation into account. Paired t tests on the mean difference between the scores obtained on the 2 measurements were used to test for the presence of a systematic bias (P<.05). In addition, the standard error (SE) of measurement, which corresponds to the absolute reliability, was also calculated. The SE of measurement expresses the measurement error in the same units as the original measurement. It is defined in terms of the total variance and the reliability coefficient. The interpretation of 2 SEs of measurement is that 95% (the equivalent of 2 SDs) of the time the true value will be within ±2 SEs of the measured value. According to Donner and Eliasziw, a sample size of 30 is sufficient to allow the estimation of ICCs more than .80 with a type I error of .05.

For the convergent and divergent construct validity analyses, the Pearson correlation coefficient was used to calculate correlations between the LEMOCOT score and the other tests. Finally, an ANOVA between the LEMOCOT scores for the 5 living environments at discharge was used to verify discriminant validity. Pairwise comparison tests were then done to locate the differences. To take into account multiple comparisons and to prevent a type I error, the Bonferroni adjustment was used (P=.05/10=.005). Based on a 5% α error and a statistical power of 85%, a sample size of 140 participants was sufficient to detect a correlation of .25 or more as statistically significant (bilateral test). All statistical analyses were done with SPSS, version 11.0, for Windows.

RESULTS
Twenty-nine people aged 28 to 87 years (mean ± SD, 69.6±13.8y), with lower-extremity impairments, participated in the reliability study. The majority (20/29) had had a stroke, and the others had different diagnoses, such as multiple sclerosis, fractures, and loss of autonomy resulting from many factors. Table 1 presents characteristics of these participants.

One hundred forty-four people (mean age, 70.7±13.1y; 50.7% women) who had had a stroke participated in the validity study. For most of the subjects (71.9%), admission to rehabilitation was for the first stroke. There were more right hemisphere strokes (53.6%) than left hemisphere strokes. The mean time since the stroke was 33.0±20.9 days.

Reliability
The results of the test-retest reliability study indicate that the ICCs were very good with acceptable 95% CIs (table 2). However, the scores on the second evaluation were systematically higher than on the first, as indicated by significant P values for both sides on the paired t test on the mean differences. The SE of measurement indicated that 95% of the time, the true value of the LEMOCOT would be within 3.1 (1.96×1.55) of the measured value for the right side and 7.6 (1.96×3.87) for the left.

Construct Validity
Correlations between the LEMOCOT and other measurement instruments, including raw scores, are in table 3. As expected, physical and functional tests correlated moderately to highly with the LEMOCOT (convergent validity), whereas cognitive and perceptual tests did not (divergent validity). It must be noted that the participants presented no or only mild to
moderate cognitive problems, because they had to understand their involvement in the study and the tasks to be performed.

The ANOVA between the LEMOCOT scores for the 5 living environments (table 4) confirmed the test’s discriminant validity (P<.001). Pairwise comparison tests indicated that people discharged to the long-term care unit had lower scores than those discharged to home alone (P<.001), home with others (P<.001), or to a seniors’ private residence (P=.001).

**DISCUSSION**

The main purpose of our study was to validate a new lower-extremity motor coordination test (the LEMOCOT) and, more specifically, to verify its test-retest reliability and construct validity. Results showed that the ICCs were high, with an acceptable 95% CI. According to Landis and Koch guidelines, our ICCs were “almost perfect” (.79 –.80). However, lower CIs were “substantial” (.60 –.70). The relatively large range of CIs may be the consequence of the sample size. A measurement bias was found for both lower extremities, with the second score being systematically higher than the first. Is this the result of a practice or learning effect and/or natural recovery of the participants who were in an active rehabilitation program? In our study, natural recovery related to the time between the 2 measures may, at least partially, be responsible for this bias. Consequently, reducing the time between the measurements could improve the reliability of the test. However, a learning effect should also not be excluded. Clinicians must therefore be cautious when interpreting a better score on a second evaluation. A practice effect may influence the results without reflecting a real improvement in their clients. The magnitude of the differences in scores between the 2 measures was rather small (2 points). This statistically significant difference may not be clinically significant.

Better ICCs and SE of measurement were obtained for the right lower extremity than for the left. It is known that a larger intersubject variability produces better ICCs, which was the case for the right lower extremity. For the SE calculation, another major component taken into account, in addition to the ICC value, is the total variance (between variance and within or error variance). The within or error variance cannot be controlled for and is due to the patient characteristics, whereas the between variance is related to the measurement time (t1, t2). In our study, total variance was 4 times larger for the left side than for the right, which led to higher SEs for the left. This difference could have been related to the dominance of the participants, which we did not evaluate; however, most older adults were right-handed. Consequently, the task could be done with less skill on the left side, which could increase the variance and produce a higher SE.

Three types of construct validity were studied. As expected, tests that should require lower motor coordination were moderately related to the LEMOCOT score, confirming convergent construct validity. The highest correlation with the LEMOCOT was with the FMA (r=.79), which is among the most common motor function tests used in clinical and research rehabilitation settings. In another study, however, the LEMOCOT appeared to identify people with slight lower-extremity impairment better than the FMA motor function, because some participants may obtain similar high scores but with functional levels that differ significantly (ceiling effect). Balance, walking speed, and walking endurance, as well as functional independence, were similarly related to lower-extremity coordination, which suggests its importance in activities.

Cognitive functions and visual perception were not related to lower-extremity coordination, which suggests good divergent construct validity of the LEMOCOT. People with cognitive deficits or visuo perceptual problems did not obtain lower scores than the other participants. Obviously, we did not expect to find a relation between these variables, because they measure different concepts. Having cognitive or visual perception problems did not interfere with performance on the new test. This suggests that the LEMOCOT may be administered to such people. It should be noted, however, that the generalizability of the LEMOCOT may be limited to patients with quite mild cognitive deficits.

Finally, this study showed that the LEMOCOT is able to discriminate among people living in different types of environ-

### Table 2: Test-Retest Reliability of the LEMOCOT (N=29)

<table>
<thead>
<tr>
<th>Construct Validity</th>
<th>Test Scores*</th>
<th>ICC (95% CI)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convergent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMA (LE motor function) (/34)</td>
<td>23.3±8.6</td>
<td>.79</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>BBS (/56)</td>
<td>23.5±18.7</td>
<td>.67</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>5MTW (cm/s)</td>
<td>21.2±26.7</td>
<td>.67</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2-minute walk test (m)</td>
<td>24.8±32.4</td>
<td>.66</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>SMAF (mobility section) (/18)</td>
<td>10.6±4.3</td>
<td>.66</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>SMAF (total score) (/87)</td>
<td>44.4±12.4</td>
<td>.62</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Discriment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3MS (/100)</td>
<td>85.1±9.8</td>
<td>.11</td>
<td>.20</td>
</tr>
<tr>
<td>MVPT-V (/36)</td>
<td>27.3±5.3</td>
<td>.15</td>
<td>.08</td>
</tr>
</tbody>
</table>

**NOTE.** Values are mean ± SD unless otherwise noted.

### Table 4: LEMOCOT Scores by Living Environment After Discharge From Rehabilitation

<table>
<thead>
<tr>
<th>Living Environment</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home, alone (n=17)</td>
<td>12.6±7.4</td>
</tr>
<tr>
<td>Home, with others (n=62)</td>
<td>10.2±9.4</td>
</tr>
<tr>
<td>Senior private residence (n=17)</td>
<td>9.7±7.9</td>
</tr>
<tr>
<td>Nursing home (n=6)</td>
<td>5.9±6.6</td>
</tr>
<tr>
<td>Long-term care (n=24)</td>
<td>2.3±8.6</td>
</tr>
</tbody>
</table>

**NOTE.** ANOVA, P<.001.
ment. Participants discharged to their homes or to seniors’ residences obtained significantly higher scores than those discharged to long-term care. Thus, the LEMOCOT score seems to be associated with the level of assistance available in different living environments.

**Strengths and Limitations of the LEMOCOT**

The LEMOCOT can be done by patients with severe lower-extremity disabilities and by those unable to stand or to walk and so is a simple and easy test to use to monitor changes in very disabled people. It can also discriminate performance in patients presenting with slight lower-extremity disabilities, and does not show the ceiling effects that may be found in the FMA. However, in the reliability study, a bias was found between the 2 measurements, with the second evaluation obtaining slightly higher scores. If the LEMOCOT is used in research as an outcome tool to detect changes, researchers should be cautious when interpreting their results. A small change in scores might be statistically significant without necessarily being clinically significant. In addition, our study was conducted mainly with people who had had a stroke; the utility of the LEMOCOT with other populations has not been shown.

**CONCLUSIONS**

Our study aimed to verify some psychometric properties of a new lower-extremity motor coordination test. The LEMOCOT is a simple, easy-to-use test that showed good test-retest reliability and construct validity. It can be used in clinical and research settings, specifically with patients who had had a stroke. In addition, these results emphasize the importance of evaluating lower-extremity motor coordination in a stroke population, because it is related to functional measurements. Other studies should be performed with other populations.

**APPENDIX 1: LEMOCOT MATERIAL**

A piece of rigid foam (Plastazote) measuring 50×55×0.4cm. Targets are circles 6cm in diameter. Target 1 is the proximal, starting target; target 2 the distal. The distance between the centers of the 2 targets is 30cm.

![Diagram of LEMOCOT targets](image)

**References**


Supplier
a. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.