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ORIGINAL ARTICLE

Reference Values and Psychometric Properties of the Lower Extremity Motor Coordination Test

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Abstract

Objectives: (1) To create predictive nomograms for the dominant and nondominant limbs on the Lower Extremity Motor Coordination Test (LEMOCOT) using reference values, and (2) to determine the inter- and intrarater reliability for the LEMOCOT; the best scoring method (first vs mean of the first 2 vs mean of the last 2 vs mean of 3 vs the highest of 3 trials); the best testing method (direct vs video observation); and the ability to detect real change (smallest real difference [SRD] and standard error of the measurement [SEM]).

Design: Normative and methodological study.

Setting: Metropolitan area.

Participants: Healthy individuals (N=320, 50% women) in 7 age groups: 20 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69, 70 to 79, and ≥80 years. Each group had 50 participants, except for ≥80 years (n=20).

Interventions: Not applicable.

Main Outcome Measure: LEMOCOT.

Results: Age and sex explained 48% of the variance in the LEMOCOT scores for the dominant limb and 44% for the nondominant limb ($125<F<148$; $P<.001$). No significant differences were found regarding the different scoring methods ($.12<F<1.02$; $.10<P<.92$), and all of them demonstrated good reliability (intraclass correlation coefficients between .90 and .99; $P<.001$). There was agreement between scores from direct and video observation (limits of agreement −1.99 to 1.85; −1.55 to 1.62). Appropriate SEM (2.27−1.85) and SRD (6.27−5.11) values were found.

Conclusions: Reference values were determined for the LEMOCOT, and predictive nomograms were created based on age and sex. The LEMOCOT is reliable, needing only 1 trial (after familiarization) to generate reliable scores; can be scored from either direct or video observation; and has the ability to detect real change over time.

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Adequate coordination of the lower limbs is necessary to perform activities of daily living[1] and to live independently.[2] Loss of coordination is associated with physical disability after stroke,[3-5] in the elderly,[6] in individuals with developmental coordination disorders,[7] and in individuals with mental retardation.[8] Since therapeutic intervention is often aimed at improving coordination,[9,10] it is necessary to use adequate instruments to accurately measure this impairment.

The Lower Extremity Motor Coordination Test (LEMOCOT) was developed to measure lower limb coordination.[1] It has good construct validity in stroke, both convergent validity (ie, the correlation between LEMOCOT scores and motor tests) and divergent validity (ie, the correlation between LEMOCOT scores and cognitive tests).[1] The LEMOCOT also has adequate clinical utility,[11] has the ability to detect changes in coordination after stroke[12] and low back pain,[13] and is a good predictor of social participation after stroke rehabilitation.[12,14]

In clinical settings, reference values are necessary for assessing the level of deficit and establishing realistic goals.[15,16] The usefulness of a measurement of coordination in a health condition depends on the ability to compare it with reference values—that is, a measurement of

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coordination using the same instrument in healthy controls.[15] However, reference values for the LEMOCOT have not yet been established. Determining useful reference values requires that the accuracy, precision, and stability of the instrument are adequate, since poor instrument performance could introduce bias.[17-19]

The scoring method of the original study[1] describing the LEMOCOT used the mean of 2 trials to obtain the final score. Most subsequent studies either did not report the number of trials[9,20-22] or used the best[13] or the mean of the last 2 out of 3 trials.[23] Therefore, it would be helpful to determine the least number of trials necessary to obtain reliable and consistent results[24] in order to optimize use of the LEMOCOT within clinical settings. Furthermore, the investigation of other testing methods, such as via video, could increase its applicability by being useful in situations that require blinded assessors or measurement across multiple sites. In addition, instruments are used to measure change over time. To detect real clinical change, the difference between scores generated by 2 independent assessments should be greater than the error.[15,25] Although the LEMOCOT test-retest reliability has been previously investigated,[1] its inter- and intrarater reliability, the best scoring method, the best testing method, and its ability to detect real change have not yet been determined.

Since the LEMOCOT has already proved to be useful within clinical and research contexts, the main purpose of this study was to create predictive nomograms from reference values of the dominant and nondominant lower limbs in healthy individuals, to enable the reference value appropriate for a given individual to be easily determined. The current study also aimed to determine inter- and intrarater reliability for the LEMOCOT; the best scoring method (first vs mean of the first 2 vs mean of the last 2 vs mean of 3 vs the highest of 3 trials); the best testing method (direct vs video observation); and the ability to detect real change (smallest real difference [SRD] and standard error of the measurement [SEM]).

Methods

Participants

Healthy individuals were recruited from the general community of the city of Belo Horizonte, Brazil, by means of advertisements in universities, local clubs, and associations. Volunteers were included if they (1) were aged ≥20 years; (2) had no neuromusculoskeletal/cardiovascular disorders; (3) had no pain in the lower limbs; (4) had lower limb range of motion necessary to perform the test; (5) had no uncorrected visual deficits; and (6) had no cognitive impairments as determined by the cutoff scores on the Mini-Mental State Examination.[26,27] They were collected in 7 age groups: 20 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69, 70 to 79, and ≥80 years. The study was approved by the University Ethics Committee, and participants provided consent before data collection.

Participants' demographic and anthropometric data, including sex, age, body mass, height (to calculate body mass index [BMI]), and lower limb dominance, which was defined as the leg that they would use to kick a ball and climb a step,[28] were collected. Level of physical activity was determined using a questionnaire derived from the Behavioral Risk Factor Surveillance System Survey, which has acceptable psychometric properties.[29-31] Physical activity was classified as vigorous, moderate, insufficient, or inactive, according to the frequency, duration, and intensity of the 2 physical activities that participants most often engaged in. The intensity was classified based on the metabolic expenditure of the activity in relation to the participant's maximal cardiorespiratory capacity.[32]

List of abbreviations:

BMI	**body mass index**
CI	**confidence interval**
ICC	**intraclass correlation coefficient**
LEMOCOT	**Lower Extremity Motor Coordination Test**
SEM	**standard error of measurement**
SRD	**smallest real difference**

Measurement of reference values

A sample size of 108 subjects would be required to include 4 independent variables (age, sex, BMI, physical activity level) in the regression analyses.[19] Since samples for studies to determine reference values should be broad and representative of the population heterogeneity,[15] the target sample was expanded to 50 for each age group (ie, 350) to increase the external validity of the study.

All participants performed the LEMOCOT, with first their dominant and then their nondominant limb, following previously described procedures.[1] They sat on a chair with the seat height adjusted to 100% of their shank length, without shoes, with their feet resting flat on a thin rigid foam, heels on the proximal target, and with knees at 90° of flexion. Then, after a familiarization trial, they were instructed to alternately touch the proximal and distal targets placed 30cm apart with their big toe, for 20 seconds. They were instructed not to sacrifice the accuracy of the touches or the quality of the movement to increase speed, and the number of touched targets was counted.

Measurement of inter- and intrarater reliability, best scoring method, best testing method, and ability to detect real change

Thirty participants (mean age ± SD, 42±15y; 17 men) performed 3 LEMOCOT trials with both limbs and were recorded using a video camera (Sony DCR-DVD408[a]). To determine interrater reliability, 2 examiners (M.B.P., L.F.T.-S.) who had previous experience with the LEMOCOT independently scored the test at the same time, using direct observation. To determine intrarater reliability, the videos were randomly analyzed at normal speed by 1 examiner (M.B.P.) on 2 occasions, 30 days apart. To determine the best scoring method, the scores from the first trial, the mean of the first 2 and last 2 trials, the mean of 3 trials, and the highest value of 3 trials were compared. To determine the best testing method, scores obtained from direct versus video observations were compared by 1 examiner (M.B.P.). To determine SEM and SRD, 30 participants (mean age ± SD, 46±17y; 9 men) performed 1 trial on 2 occasions at the same time of the day, 5 to 7 days apart.[15] The intraclass correlation coefficients (ICCs) were used to calculate the SEM and SRD.[33,34]

Statistical analyses

Descriptive statistics were calculated for all outcomes. Tests for normality and for equality of variances for the LEMOCOT scores were carried out with SPSS for Windows (release 15.0).[b] The paired Student *t* test was used to compare the LEMOCOT scores between the dominant and nondominant limbs. Stepwise multiple linear regression analyses were performed to produce predictive equations for both limbs, based on 4 input variables, as well as their interactions. The 4 selected variables included the commonly considered characteristics of age, sex, and BMI.[17] The level of physical activity was also included because it has been shown to influence coordination.[35] For efficiency of clinical use, nomograms were created based on the prediction equations.