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Review of the psychometric properties of lower limb motor coordination tests

Revisão das propriedades psicométricas de testes de coordenação motora de membros inferiores

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Abstract

Introduction: Adequate motor coordination (MC) of the lower limbs is essential for most of the motor tasks. Therefore, it is important to know the psychometric properties of the tests employed to assess lower limb MC, so that professionals could have a better basis to choose the most adequate assessment tools. **Objectives**: To investigate the psychometric properties and clinical utility of instruments used to assess lower limb MC, by means of a critical review of the literature. **Materials and methods**: A search was conducted in six databases looking for studies which evaluated reliability, validity, sensitivity to changes, or clinical utility of the tests employed to assess lower limb MC. The articles were assessed and the data of their psychometric properties were extracted by two researchers, independently. **Results**: The search returned 1361 studies, 1,325 were excluded after analyses. The hand search yielded four eligible articles, totaling nine included articles. The included studies evaluated the psychometric properties of eight tests, but only three were specific to assess lower limb MC and the others were sub-items of other scales, which assess other domains. None of the tests provided data for all of the basic psychometric properties. **Final remarks**:

According to the results of this review, none of the tests had their basic psychometric properties reported, which is necessary to be investigated in future studies. This review may facilitate the search and selection of lower limb MC tests by researchers and clinicians.

Keywords: Validity of tests. Reproducibility of results. Motor skills. Lower extremity.

Resumo

Introdução*: Adequada coordenação motora (CM) dos membros inferiores (MMII) é fundamental para a execução de diversas tarefas motoras e, portanto, a sua avaliação é amplamente empregada na prática clínica e pesquisa. Assim, é importante conhecer as propriedades psicométricas dos testes que avaliam a CM dos MMII, para que os profissionais possam escolher de forma embasada os testes mais adequados a serem utilizados.* ***Objetivos****: Investigar as propriedades psicométricas e utilidade clínica de testes que avaliam a CM dos MMII, por meio de uma revisão crítica da literatura.* ***Materiais e métodos****: Foi conduzida uma busca em seis bases de dados procurando por estudos metodológicos que avaliaram confiabilidade, validade, sensibilidade à mudanças ou utilidade clínica de testes que medem a CM dos MMII. Os artigos foram avaliados e os dados das propriedades psicométricas foram extraídos por dois autores, de forma independente.* ***Resultados****: A busca retornou 1.361 estudos e 1.356 foram excluídos após análise. Outros quatro artigos elegíveis foram encontrados pela busca manual, totalizando nove artigos incluídos. Os estudos incluídos avaliaram as propriedades psicométricas de oito testes, sendo que apenas três são instrumentos específicos para avaliar a CM dos MMII, sendo os demais subitens de escalas que avaliam outros domínios. Nenhum teste apresentou dados para todas as propriedades psicométricas.* ***Considerações finais****: Segundo os resultados desta revisão, nenhum dos testes encontrados teve todas as suas propriedades psicométricas básicas avaliadas, o que torna necessária a realização de futuros estudos. Esta revisão poderá facilitar a busca e seleção de testes que avaliam a CM dos MMII por parte dos pesquisadores e clínicos.*

Palavras-chave*: Validade dos testes. Reprodutibilidade dos testes. Destreza motora. Extremidade inferior.*

Introduction

Dexterity or motor coordination (MC) is defined as the ability to intentionally perform a motor task in an accurate, rapid, and controlled manner, in order to achieve a given environmental demand (1, 2). MC can be tested in situations that require temporal and spatial accuracy. It is suggested that the best way of evaluating MC is by assessing the performance of rapid and alternating movements and the considered criteria should be the speed and quality of the movements (3, 4). Within clinical settings, MC evaluation is a common part of the physical therapists' routines (5).

Lower limb motor coordination (LLMC) is essential for the performance of most daily motor activities, such as walking, running, ascending/descending stairs, standing from a chair, being the effective performance of these tasks critical for an independent life (4, 6). According to Ada and Canning (3), adequate LLMC significantly contributes to functionality of stroke individuals, being its loss the major contributor to disability in this population. For Capranica et al. (7), motor tasks performed within different contexts require between-limb coordination, which is essential for an independent and safe life in elderly individuals. Thus, therapeutic approaches aimed at restoring LLMC are of great interest for rehabilitation professionals who are involved in research and clinical settings (3).

LLMC evaluation is extremely important for physical therapist practice, as it enables the understanding of the nature and level of impairments of the individual in a standardized way (8, 9). The information gathered from the LLMC assessment may help planning the interventions and monitoring the clinical status of the patients before, during, and after physical therapy interventions (10, 11). However, the use of any assessment tool is subjected to various types of errors, which may compromise the quality of the information

(12, 13). Therefore, assessment instruments should have adequate psychometric properties, to ensure the effectiveness of the measures (11-14).

LLMC assessment instruments are commonly used within research and clinical contexts and their constant improvements are necessary to allow the enhancement of treatment approaches and to speed up the clinical decision-making process of rehabilitation professionals (15, 16). It is believed that some errors in interpreting the clinical information could be more related to the failure of the instruments, than to the lack of efficiency of the investigator (17). Within research context, when interpreting study findings, the errors arising from the methodological flaws, such as the choice of inadequate instruments, could lead researchers to conclude as false a true hypothesis or accept the one that should be refuted (12), which may invalidate the results of the study. Professionals should, therefore, carefully select the instruments to be used, align the goals of the study or intervention to the choice of the instruments, and select instruments that show adequate psychometric properties. This selection represents a challenge for the professionals (18).

Ideally, instruments should accurately evaluate what they propose to measure. Additionally, in situations when they are used to measure changes over time, they should have the lowest possible rate of variability and also the ability to detect real changes (11, 19). Therefore, to be used within clinical or research contexts, an instrument must be scientifically reliable in terms of three basic psychometric properties: reliability, its ability to accurately measure through the consistency of the results; validity, its ability to accurately measure what the test aims to assess; and sensitivity, its ability to detect changes when they actually exist (8, 17, 20, 21). In addition, the clinical utility is another important property and according to Harris and Warren (22), it comprises several aspects, such as cost, time, levels of difficulty for application, scoring, and interpretation of the gathered data. Briefly, clinically useful tools should be short and easy to administer, understand, and score (22). To facilitate the evaluation of these aspects, Tyson and Connel (18) developed a tool to grade the clinical utility of instruments, using a scale with scores ranging from zero to 10. This scale considers the time spent to administer the instrument, the cost, the need for specialized equipment and training, and portability. According to the authors, the instrument must achieve a score ≥ 9 before it can be recommended for its use in clinical practice.

As LLMC is important for the performance of daily activities and several instruments are used to assess it within clinical settings, it is important to know the psychometric properties, clinical utility, and limitations of the instruments described in the literature to evaluate LLMC. Health professionals can use this information to base their decisions regarding the choice of the most suitable instrument to be used. Therefore, the aim of this study was to summarize the psychometric properties and clinical utility of LLMC instruments, by conducting a critical review of the literature.

Materials and methods

Studies selection

A search was conducted in the following databases: AMED (OVID - 1985 to April 2012), CINAHL (EBSCO - 1982 to April 2012), LILACS (BIREME - 1982 to April 2012), MEDLINE (OVID - 1948 to April 2012), SciELO (BIREME - 1982 to April 2012) and Web of Science (Web of Knowledge - 1970 to April 2012). Optimized and specific search strategies were used for all databases, using combination of keywords and subject headings, such as psychometric properties, clinical utility, motor coordination, dexterity, lower limb, and assessment tools. Hand search was also conducted in all articles included in this review. Studies that used other instruments that were not retrieved in the search, but that are well known and used within clinical practice and research were included. When the examiners identified some potentially useful article that the full text was not available, a copy was requested by e-mail to the main author. No restrictions were applied regarding language and year of publication.

Two authors independently evaluated the articles regarding eligibility and extracted the data. Disagreements in any of these steps were discussed until a consensus was achieved. The psychometric properties were evaluated based upon reference values previously described by Andresen et al. (23), to ensure the standardization and interpretation of the results (Table 1), as there is variability in the literature about how to evaluate them (15).

Table 1 - Statistical evaluation criteria to examine the disability assessment instruments and outcomes within research context

Psychometric property	Level
Reliability	
α Cronbach or *split-half statistics*	
Excellent	≥ 0.80
Adequate	0.70-0.79
Poor	< 0.70
Test-retest or inter-rater reliability (intra-class correlation coefficients [ICC] or *kappa*)	
Excellent	≥ 0.75
Adequate	0.40-0.74
Poor	< 0.40
Validity	
Construct/convergent and concurrent	
Excellent	≥ 0.60
Adequate	0.31-0.59
Poor	≤ 0.30
ROC curve (*Receiver operating characteristic analysis*) – area under the curve	
Excellent	≥ 0.90
Adequate	0.70-0.89
Poor	< 0.70
Sensitivity to changes	
Effect size	
Small	< 0.5
Moderate	0.5-0.8
Great	≥ 0.8
Ceiling/Floor Effects	
Excellent	No ceiling/floor effects
Adequate	≤ 20% of patients reach the maximum or minimum score
Poor	≥ 20% of patients reach the maximum or minimum score

Inclusion criteria

Participants

Studies that evaluated adults and elderly of both sexes, with or without disability were included.

Instruments

All studies that investigated any test, specific or not, for the evaluation of LLMC were included.

Study design

Methodological studies evaluating at least one of the following properties were included: Validity, test-retest, inter- or intra-rater reliabilities, internal consistency reliability, sensitivity to changes, and ceiling and floor effects.

Exclusion criteria

Studies were excluded if they did not clearly report the aims or the methods of evaluation of the

psychometric property or if they did not explicitly stated that the instrument was being used to evaluate LLMC.

Data extraction

Data were extracted using an adapted standardized form, based upon the Cochrane Collaboration (24). The information extracted from the studies were: Characteristics of the included participants, such as gender, age; source, and sample size; objectives; evaluated scale/instrument; description of the scale/instrument; psychometric properties or clinical utility; methods used for the assessment of the psychometric properties; and statistical results. In addition, information whether the instrument was specific for the assessment of LLMC or if it was a sub-item of another scale was obtained. In case of non-specific instruments, only the data for the LLMC item were extracted. The clinical utility was assessed using the Tyson and Connel scale (16).

Results

The initial search strategy returned a total of 1,361 studies. Of these, 1,119 were excluded after reading the titles and 206 after analysing the abstracts. The final number of articles selected for full text reading was 36. After this step, only six articles were included in this review according to the established inclusion and exclusion criteria. One article was excluded because it was not possible to obtain the full text and therefore its eligibility could not be assessed (25). The hand search returned four articles and all were included. Therefore, the total number of articles included and described in this study was nine.

The main reasons for the exclusion of the studies were because they did not evaluate LLMC or not explicitly stated the aim of LLMC evaluation, did not evaluate the pre-established population of interest (e.g.: children/adolescents), evaluated MC of the upper limb, did not assess the psychometric properties, or articles that investigated non-specific instruments and did not report any specific LLMC data. The flowchart of inclusion and exclusion of studies is shown in Figure 1.

Of the included studies, eight reported some type of reliability, and validity was investigated only by two studies. The studied population included healthy individuals (26), elderly (4), patients with schizophrenia or other psychiatric disorders (27), patients who had suffered spinal cord injuries (28), ataxia (29, 30), stroke (4, 31, 32), and Parkinson disease (33). The psychometric properties of eight tests were investigated: Auditory-paced ankle dorsi- and plantar-flexion task, Fugl-Meyer Scale (FMS), Foot-tapping test (FTT), Lower-extremity motor coordination test (LEMOCOT), Multi-joint lower-limb tracking-trajectory test (tracking-trajectory test), Rapid alternating movement patterns test (RAMP test), Scale for the assessment and rating of ataxia (SARA), and Standardized neurological examination in schizophrenia (NSS). Only three instruments were specific for the assessment of LLMC and the other five were sub-items of other instruments.

Specific tests for the evaluation of LLMC

The values found for the psychometric properties of the three specific LLMC tests are summarized in Table 2.

Description of specific tests

Foot tapping test

The foot tapping test was designed to assess motor function of the lower limbs. Although it was not reported in the article that the test evaluated MC, it was included in this review because it has been used for this purpose in other studies (33). Two ways of performing the test were described: 1) Alternate foot tapping (foot tapping with two pedals), in which the individual is instructed to tap his foot as quickly as possible in two pedals (front and back) separated by 30 cm during 15 seconds; 2) Repetitive foot tapping (foot tapping with one pedal), in which the individual is instructed to tap his foot as quickly as possible on a pedal for 15 seconds. The score is calculated from the number of the pedal taps. The study was conducted with 50 patients with Parkinson's disease and excellent values for inter and intra-rater reliabilities were found (33).

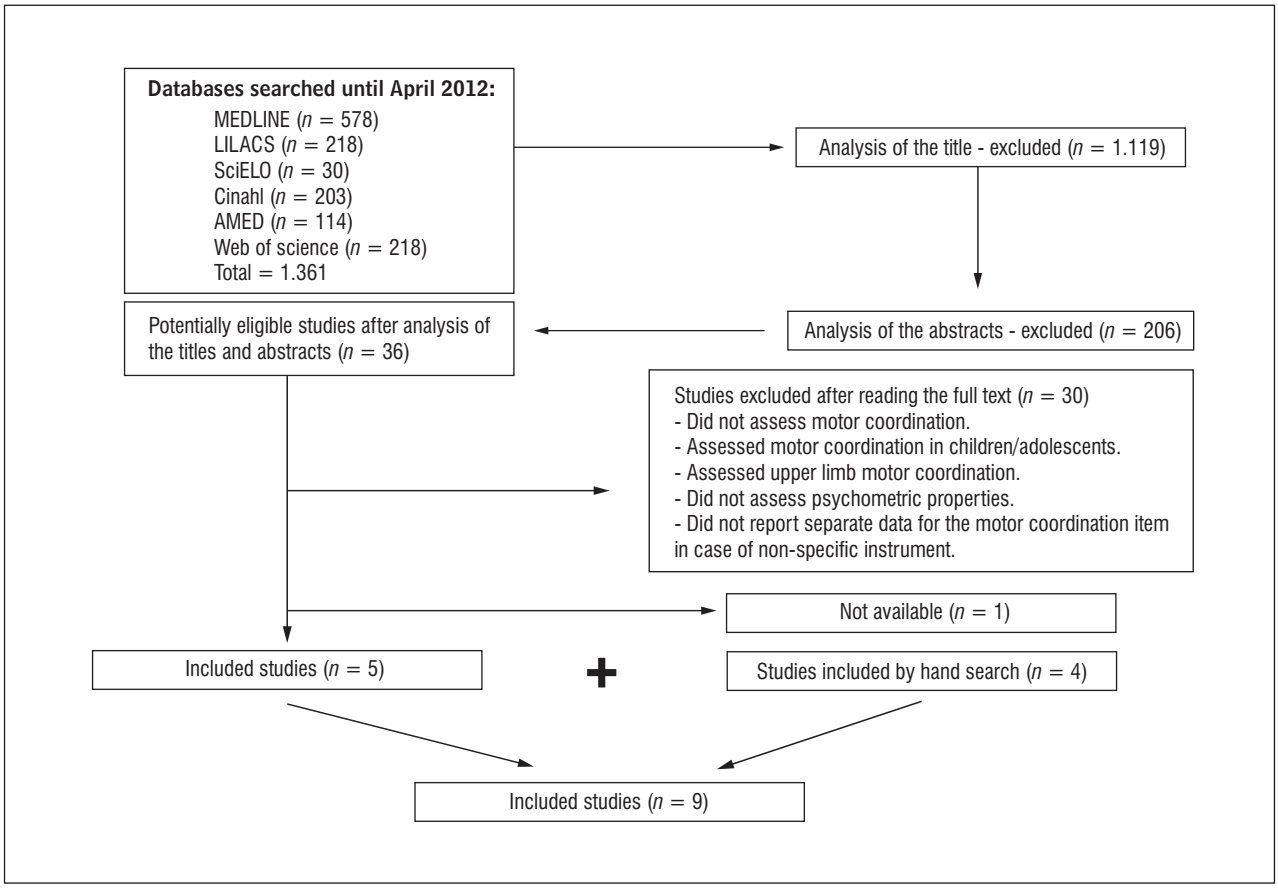

Figure 1 - Flowchart of inclusion and exclusion of studies

Table 2 - Values of the psychometric properties of the specific tests for the evaluation of lower limb motor coordination, reported by the studies included in the review

(To be continued)

Instrument	Psychometric property reported
Foot tapping (33)	Inter-rater reliability: ICC = 0.87 (excellent)
	Intra-rater reliability: ICC = 0.84 (excellent)
Lower-extremity motor coordination test (4)	Convergent construct validity
	Fugl-Meyer assessment: $r = 0.79$ (excellent)
	Berg balance scale: $r = 0.67$ (excellent)
	5-minute walk test: $r = 0.67$ (excellent)
	Walking endurance: $r = 0.66$ (excellent)
	Functional autonomy measurement system (mobility): $r = 0.66$ (excellent)
	Functional autonomy measurement system (total score): $r = 0.62$ (excellent)
	Divergent Construct Validity
	Modified mini-mental state examination: $r = 0.11$ (poor)*
	Motor-free visual perceptual test: $r = 0.15$ (poor)*

Table 2 - Values of the psychometric properties of the specific tests for the evaluation of lower limb motor coordination, reported by the studies included in the review

(Conclusion)

Instrument	Psychometric property reported
	Test-retest reliability
	Right lower limb: ICC = 0.88 (0.76 to 0.94) – excellent
	Left lower limb: ICC = 0.83 (0.67 to 0.92) – excellent
Multi-joint lower-limb tracking-trajectory test (26)	Test-retest reliability
	Mean absolute error: ICC = 0.82 (excellent)
	Standard deviation: ICC = 0.80 (excellent)

Note: ICC = intraclass correlation coefficient. *Once the divergent construct validity was calculated, this value below 0.4 interpreted as "poor" represents a suitable value for this property psychometric.

Lower-extremity motor coordination test (LEMOCOT)

The LEMOCOT is a specific test for the evaluation of LLMC. The patients, in the sitting position, are instructed to alternately move their lower limb as quickly as possible and touch with their halluces two red targets with 6 cm in diameter (one proximal and one distal), separated by a distance of 30 cm for 20 seconds (4). During the test, the examiner counts the number of touched targets, and for the final score, the calculation of only the touched targets are considered. The test-retest reliability and construct validity of the LEMOCOT was established with 173 individuals (29 elderly and 144 post-stroke patients). For the assessment of convergent validity, the LEMOCOT was compared to the following instruments: Fugl-Meyer scale (FMS) scores, Berg balance scale scores, walking speeds (5-meter walking test), walking endurance (2-minute walking test), and functional autonomy measurement system. In this case, it is expected to find significant correlations between the selected instruments. For the assessment of divergent construct validity, the following instruments were used: Modified mini-mental state examination and motor-free visual perceptual test, and in this case, it is expected to find no or low correlations between the tests. The values found for the construct validity and test-retest reliability for the right and left lower limbs were considered excellent (4).

Tracking-trajectory test

The tracking-trajectory test is also a specific instrument for the assessment of LLMC. It is performed on the device, commercially known as Leg Press, which is connected to a computer and software that provides analysis of data in real time (26). The individuals are instructed to perform flexion and extension movements with their lower limbs, trying to follow a trajectory provided on a video monitor positioned on their eyes' vision. The test lasts 60 seconds and the individual is instructed to follow the path with the highest possible precision. Then, the software automatically calculates the mean absolute errors (in cm), i.e., the differences between the average actual path trajectory and the established trajectory and the standard deviation of the average errors. The test was administered to 22 healthy and physically active women, who were divided into two groups (according to the secondary objectives of the study), and the only assessed psychometric property was the test-retest reliability. The values of this property were considered excellent for both the mean absolute errors and the standard deviation of the average errors (26).

Non-specific tests for the evaluation of LLMC

The values found for the psychometric properties of the five non-specific tests for the evaluation of LLMC are summarized in Table 3.

Description of the non-specific LLMC tests

Auditory-paced and task dorsi-ankle plantar-flexion

This test aims to assess motor function of the lower limbs. To perform the test, the subject, in the

supine position, is instructed to alternately perform movements of dorsiflexion and plantar flexion (foot tapping) in pre-set frequencies by a computer with the greatest possible accuracy (28). These frequencies gradually increase (0.8 to 3.2 Hz at intervals of approximately 30 seconds), signalled by a beep sound. For each frequency, the individual should perform 20 repetitions of dorsiflexion and plantar flexion and change the direction of the movement when a beep is heard. The frequency performed by the participant was recorded and compared with the target frequency. The study was conducted with two groups (spinal cord injured patients and control group). The test-retest reliability values were provided for all frequencies, at which the test was performed. The ICC for the frequency of 0.8 to 1.2 Hz could not be calculated due to the low data variability. The ICC values were considered excellent for frequencies from 1.6 to 3.2 Hz, with the exception of the frequencies of 2.0 and 3.2 Hz, which had adequate reliability (28).

Fugl-Meyer Scale (FMS)

The FMS is a sensorimotor measurement scale of patients who have suffered stroke (31). It assesses six domains: range of motion, pain, sensation, motor function of upper and lower extremity and balance. The sub-item that evaluates the LLMC is the heel to shin test, which is performed with the patients in the supine position, where they take their heels to the opposite leg five times, as quickly as possible. For the test scoring, three criteria are considered: the time taken to complete the task with the affected limb, when compared to the non-affected limb dysmetria, and tremor. Each item is scored by a three-point ordinal scale (0-2). The study was conducted with 50 stroke patients and provided specific results of inter- and intra-rater reliabilities for the LLMC sub-item. The values found for both reliabilities were considered excellent (31).

Table 3 - Values of the psychometric properties of the non-specific tests for the evaluation of lower limb motor coordination, reported by the studies included in the review

Instrument	Psychometric property reported
Auditory-paced ankle dorsi- and plantar-flexion task (28)	Test-retest reliability: Frequency of 1.6 to 3.2 Hz: ICC = 0.55 to 0.88 (adequate to excellent)
Fugl-Meyer scale (31)	Inter-rater reliability: ICC = 0.94 to 0.97 (excellent) Intra-rater reliability: ICC = 0.88 to 0.93 (excellent)
Standardized neurological examination (27)	Inter-rater reliability: *kappa* = 0.40 to 0.75 (adequate)
Rapid alternating movement patterns test (32)	Convergent construct validity: Strength: Non-paretic limb – r = -0.35 (adequate) Paretic limb – r = -0.61 (excellent) Predictive validity: Function (transference, gait, stairs climbing): Non-paretic limb – r = -0.14 (poor) Paretic limb – r = -0.51 (adequate) Length of stay in hospital: Non-paretic limb – r = 0.22 (poor) Paretic limb – r = 0.23 (poor)
Scale of the assessment and rating of ataxia (SARA) (29, 30)	Reliability – internal consistency: α = 0.41 to 0.66 (adequate) (29) Reliability – internal consistency: α = 0.93 (excellent) (30) Inter-rater reliability: Right lower limb: ICC = 0.81 (excellent) (30) Left lower limb: ICC = 0.74 (adequate) (30)

Note: ICC = intraclass correlation coefficient.

Standardized Neurological Examination (NSS)

This scale is designed to evaluate gait, MC, integrative sensory tasks, and lateral preference of patients with schizophrenia (27). It consists of 30 items, the item #22 evaluates LLMC by observing two simple tasks: 1) Foot tapping: tapping your foot as if you are expecting something impatiently, keeping your heel on the floor and moving only the forefoot 15 times; 2) heel/toe tapping: a foot swinging back and forth, heel and toes for 15 times. The scores range from zero to three, according to the speed of execution. The study was conducted with three groups (schizophrenia, mood disorder patients, and controls). For the evaluated psychometric properties, only the inter-rater reliability was calculated separately for the item 22, which showed to be appropriate (27).

Rapid alternating movement patterns test (RAMP test)

The RAMP test evaluates MC of the upper and lower limbs in large amplitudes (32). The sub-item that tests the LLMC is performed in the supine position with the knees fully extended. The individuals are instructed to flex their knee to be tested to the point where the heel is levelled with the contralateral knee, and then return their leg to the starting position with the knee fully extended. The score is given by the time, in seconds, required to perform 10 repetitions. The time is converted to an ordinal score, following pre-established values. The higher the score on the test, the worse is the MC. The study was conducted with 32 stroke individuals. For the assessment of convergent validity, the RAMP test was compared with strength measures of the lower limbs. For predictive validity, the test was compared with the function measures (transferring, walking, and climbing stairs) and length of hospital stay. The values for the convergent validity were considered adequate (non-paretic limb) to excellent (paretic limb). The predictive validity was poor to adequate. The internal consistency was excellent (0.81 to 0.85), but this finding was not reported separately for the lower limbs (32).

Scale for the assessment and rating of ataxia (SARA)

The SARA was developed to assess and classify the severity of ataxia and consists of eight items that assess upper and lower limb function (29, 30). The sub-item that evaluates the LLMC is the #8, the heel to shin test. Unlike the execution procedure shown for the FMS, for the SARA, the heel to shin is also performed in the supine position, but the individual should take the heel to the opposite knee and slide the foot to the heel. This manoeuvre is performed three times and the score is given by an ordinal scale that ranges from zero to four, which considers the execution time and the quality of the movements. Two articles that studied this test were included in this review and both investigated the internal consistency of the LLMC item (Q8), which was considered adequate (29) to excellent (30). Only in one study the inter-rater reliability of this sub-item was reported, and the value found for the right leg was considered excellent, while the one found for the left was considered adequate.

Clinical utility

According to the initial purpose of this review, the clinical utility would be assessed by the scale of Tyson and Connell (18). However, this scale requires information, which was not reported in all studies. Therefore, to avoid subjectivity in the judgment by the examiners, the clinical utility was evaluated using the information reported by the authors, and the Tyson and Connell scale was only used as a guide. The tests that reported clinical utility data were FMS, LEMOCOT, NSS, and SARA. According to the authors, the FMS is easily administered, has relatively straightforward and simple instructions, and requires no special equipment (31). The LEMOCOT is simple, inexpensive and quick to apply (4). The NSS was also considered easily administered at the bedside or in the office (27). Finally, the SARA is easy to administer and requires less than 15 minutes per application (29).

Discussion

This review aimed to identify the studies that examined the psychometric properties of LLMC assessment tests. The nine articles that were included in this review evaluated the psychometric properties of eight tests. Overall, reliability was the most commonly assessed property and all tests had values considered adequate to excellent.

It is important to note that despite adequate reliability, the indices reported by these studies do not allow to draw rational conclusions, since high levels of reliability do not ensure the validity of the measurements (15). Validity refers to the extent to which a test or instrument measures what it is intended to measure and implies that a measure is relatively free of error. Therefore, a valid test must necessarily be reliable (11, 15). Although reliability is a pre-requisite for the validity, this relationship is unidirectional. A low reliability index is an automatic evidence of low validity, whereas a high level of reliability does not automatically suggest strong validity of a test or measure. In this review, only the predictive and construct validities were investigated and reported only for LEMOCOT and RAMP tests. Therefore, it is extremely necessary to investigate other types of validity for all the tests described in this review.

Only three tests included in this review were specific for the evaluation of LLMC, namely the tracking-trajectory test, the LEMOCOT, and foot tapping. Only test-retest reliability was reported for the tracking-trajectory, only construct validity and test-retest reliability were reported for the LEMOCOT, and only inter- and intra-rater reliabilities were analysed for the foot tapping. Despite showing some adequate psychometric properties, these tests still need to be further investigated.

It is important to note that Gunzler et al. (33) did not consider the foot tapping test as a specific test for assessing LLMC, but for the evaluation of lower limb function. However, this study was included because the foot tapping is an item of the NSS and has been used is in other studies (34, 35) with the aim of evaluating the LLMC.

Five tests described in this review were not specific for the evaluation of LLMC. For the NSS, only inter-rater reliability was assessed. For the SARA, only the internal consistency and inter-rater reliabilities were assessed, while for the FMS, only values of intra- and inter-rater reliabilities were reported. Despite the auditory-paced ankle dorsi- and plantar-flexion task be a specific test for the evaluation of the lower limbs, only test-retest reliability data were reported for MC. The study that investigated the RAMP test evaluated several psychometric properties, however, only the convergent and predictive construct validities were reported separately for the item that assesses LLMC. Thus, the use of these tests for the assessment of LLMC is limited, since they did not show adequate values for the three necessary basic psychometric properties (reliability, validity, and sensitivity to changes).

The lack of standardization of the execution procedures of the tests is another factor that limits the use of the instruments which were investigated in this review. For instance, the heel to shin and foot tapping tests have distinct scoring methods, applications, and score interpretations in different studies. Moreover, the method of application of foot tapping was not very clearly stated in the studies. Gunzler et al. (33) did not explain whether the subjects should hit their whole foot or just their forefoot on the pedals. Krebs et al. (27) did not report the criteria for grading the speed for hitting the target, since the scores are based upon four distinct situations: 0 - normal speed; 1 - mild retardation; 2 - reduced speed; and 4 - task accomplished with great difficulty, slowly, or require higher concentration. These factors lead to subjectivity during the scoring of the test, limit the comparison of the results, and make their use difficult. In addition, the heel to shin test is performed in the supine position, which is not a functional position to evaluate MC, since the majority of the daily activities that require LLMC is not performed in this position.

None of the studies evaluated sensitivity to changes or ceiling and floor effects. Ceiling and floor effects are measured by the percentage of the subjects who achieved the minimum and maximum possible scores in a certain test and are considered present when more than 20% of individuals reach the highest or lowest possible total scores (11, 15). The presence of floor and ceiling effects may affect the sensitivity of the test, since the ability of the test to detect real changes may be diminished (11, 13). The tests described in this study may, therefore, not be able to detect clinically significant changes, especially when used in patients with mild or severe disabilities, which may limit theirs use (18).

Only the FMS, LEMOCOT, SARA, and tracking-trajectory tests considered both the speed and the quality of movement as scoring criteria. In other tests, the score calculation takes into consideration only the time that the individuals take to perform the task. This may represent a limitation of these tests, since MC is related to the individual's ability to meet these two apparently opposing demands (3, 4) and the separation of these criteria for scoring the test may not reliably represent the construct being rated.

Regarding clinical utility, studies reported that the foot tapping, LEMOCOT, FMS, NSS, RAMP test, and SARA are easy to understand and to apply, have low cost, and are easy to transport. These characteristics explain why these tests are clinically useful (18).

The FMS, NSS, and SARA assess MC through the foot tapping and heel to shin items, whose psychometric properties have been little investigated. The same was observed for the RAMP test, since the studies did not report separate data regarding the reliability and responsiveness of the LLMC items. Although the foot tapping seems to be clinically useful and has adequate reliability indices, it has not been validated for the assessment of MC, instead it was validated for the evaluation of motor function of the lower limbs. Finally, the tracking-trajectory test and the auditory-paced ankle dorsi- and plantar-flexion task are more complex tests that require specialized equipment, probably of higher costs, and therefore do not have good clinical utility.

The LEMOCOT, among all evaluated tests, appeared to be the most suitable for the evaluation of LLMC, since it showed appropriate values of reliability and construct validity, as well as good clinical utility. Furthermore, other studies reported that the LEMOCOT scores were good predictors of social participation of stroke individuals after six months of rehabilitation (36, 37). However, among the many studies that used the LEMOCOT (38-43), no standardization procedures regarding the number of repetitions and scoring method were reported. Thus, the establishment of standardized procedures is necessary, as well the investigation of other types of validity.

It is noteworthy that health professionals from different areas applied the tests included in this review. It is necessary that the examiner be trained in order to know the tests and to acquire skills for the application procedures for not compromising the results.

Among the studies that were included by hand search, three used the FMS and SARA sub-items for the assessment of LLMC. One study did not report that the aim of the test (foot tapping) was to assess LLMC. This shows the effectiveness of the search strategy, since other specific tests were not found beyond those returned from database searches. However, a limitation of this study was to include only studies (except the foot tapping) that explicitly reported the aim of analysing the psychometric properties of tests for assessing LLMC. Such criteria may have excluded some important studies. It was not possible to get the full text of an article and, therefore, a potential eligible study may have been missed. Furthermore, it was not possible to apply the scale to assess the clinical utility. However, these decisions were made to avoid subjective decisions by the examiners and to ensure the quality of the review.

Final considerations

According to the findings of this review, the psychometric properties of the eight LLMC tests showed adequate values for some types of reliability, but insufficient data for validity and sensitivity to changes. The LEMOCOT proved to be the most suitable for evaluating LLMC, despite its limitations, such as lack of standardization in the application procedure, and lack of investigation of some psychometric properties, e.g., other types of validity and sensitivity to changes. These findings demonstrated the paucity of studies that evaluated the psychometric properties of LLMC, which may limit the interpretation and use of these tests. Therefore, this study may facilitate the search and selection of LLMC tests by researchers and clinicians, who can quickly and efficiently consult the general characteristics of the tests that are described in this review. However, it is important to note the need for further studies to investigate other basic psychometric properties and clinical utility of these tests.

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