Original Article

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Reliability of the Mobility Scale and Ruler in Assessing Mobility of post-stroke patients during hospitalization

Confiabilidade da Escala e Régua de Mobilidade na avaliação da mobilidade do paciente pós acidente vascular cerebral em fase hospitalar

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ABSTRACT

Objective: The aim of this study was to determine the intra-rater repeatability and inter-rater reproducibility of the Mobility Scale and Ruler for post-stroke assessment during hospitalization. **Methods:** A consecutive sample of 58 patients was assessed by two independent and blinded physical therapists (A and B) on the same day (inter-rater reproducibility). For repeatability analysis, therapist A assessed the patients twice, with a five-minute interval between assessments. The Kappa statistic was used to analyze reliability. **Results:** The mean age of participants was 62.7 (±14.5) years, and 60.34% were male. Ischemic stroke was identified in 88% of the cases, with mild severity (median NIHSS of 3; IQR 4). Assessments were performed 12.5 (±11) days post-stroke. Regarding mobility level, 33 (57%) patients were able to ambulate independently, reaching level 12 on the Scale. Repeatability for both the Mobility Scale and Ruler yielded a Kappa of 1.00 (p<0.001). Inter-rater reproducibility showed Kappa values of 0.928 (p<0.001) and 0.957 (p<0.001), respectively. **Conclusion:** The Mobility Scale and Ruler demonstrate high reproducibility in assessing mobility in post-stroke patients during hospitalization and can be used both by the same professional to monitor patient progress and by different professionals at various points during the hospital stay.

Keywords: Stroke, Active Mobility, Mobility Limitation, Reproducibility of Results

RESUMO

Objetivo: Determinar a repetibilidade e a reprodutibilidade interavaliador da Escala e Régua de Mobilidade para avaliação pós acidente vascular cerebral (AVC) na fase hospitalar. **Método:** Uma amostra consecutiva composta por 58 pacientes foi avaliada por dois fisioterapeutas (A e B) independentes e cegados entre si, no mesmo dia (reprodutibilidade interavaliador). Para a repetibilidade, o fisioterapeuta A avaliou os pacientes duas vezes, com 5 minutos de intervalo entre as avaliações. A estatística Kappa foi utilizada para análise da confiabilidade. **Resultados:** A idade média dos pacientes foi 62,7 (±14,5) anos, sendo 60,34% homens. O AVC isquêmico foi identificado em 88% dos casos, com severidade discreta (mediana NIHSS de 3; IQR 4). A avaliação dos pacientes ocorreu 12,5 (±11) dias pós-AVC. Em relação ao nível de mobilidade, 33 (57%) pacientes foram capazes de deambular independente, atingindo o nível 12 da Escala. A repetibilidade de ambas, Escala e Régua de Mobilidade, obteve Kappa de 1,00 (p<0,001) e, a reprodutibilidade interavaliador, obteve Kappa de 0,928 (p<0,001) e 0,957 (p<0,001), respectivamente. **Conclusão:** A Escala e a Régua de Mobilidade são reprodutíveis na avaliação da mobilidade pós AVC na fase hospitalar, podendo ser utilizadas tanto por um mesmo profissional para acompanhar a evolução do paciente, quanto por diferentes profissionais que assistem os pacientes em diferentes momentos de internação hospitalar.

Palavras-chaves: Acidente Vascular Cerebral, Mobilidade Ativa, Limitação da Mobilidade, Reprodutibilidade dos Testes

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Nothing to declare

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INTRODUCTION

Limitations in mobility during walking and other activities (standing up, sitting down, climbing stairs, transferring, using a wheelchair, and walking at different speeds and distances) are often present post-stroke, becoming a central focus of rehabilitation.[1] Mobility is a process that evolves from an initial phase of dependence and bed rest until independent walking is achieved.[2] Mobility limitations are common in the acute phase of the disease, creating difficulties in performing daily activities and social participation,[3] and can be assessed using different scales, used alone or in combination to characterize the functional mobility of patients.

Among the most commonly used tools are the Katz Independence in Activities of Daily Living Scale (ADLS),[4] the Stroke Motor Assessment Scale,[5] the Rivermead Motor Assessment Scale,[6] the Trunk Control Scale,[7] the Trunk Impairment Scale,[8] the Timed Up and Go (TUG),[9] the Perme ICU Mobility Score,[10] and the ICU Mobility Scale.[11] These scales have limitations when it comes to specific mobility assessments. Some include aspects of functional capacity, while others fail to consider the level of assistance required for the patient to perform activities. Furthermore, many are limited to assessing only one or two mobility activities, such as rolling or sitting, without adequately addressing fundamental aspects such as standing and ambulation, which can compromise the accuracy of functional mobility assessments.

The Mobility Scale and the Mobility Ruler[12] were developed to jointly assess patient mobility during hospitalization, facilitating hospital care for these patients. The protocol for its use—the Mobility Scale and Ruler Usage Protocol (PERMo)—had its content validity confirmed with rates above 80%.[13] The Mobility Scale is a digital instrument available as a smartphone app, which provides a score from 1 to 12, classifying the degree of mobility, from bed rest to independent ambulation. The Mobility Ruler is a physical tool, made of PVC, that replicates the Mobility Scale header and should remain at the bedside, visible to all who interact with the patient. It was designed to provide, in a playful way, information about the patient's highest level of independent mobility, being useful both for the physical therapist and hospital staff, as well as for the patient and their family.[12]

Although the Mobility Scale and Ruler (RMS) are considered current instruments, developed to address limitations present in other instruments, with a validated usage protocol,[13] their use is still limited because their reliability has not been tested. Instrument reliability is a fundamental aspect in clinical practice and research,[14] and is often determined by the repeatability and reproducibility of measurements. Repeatability is the agreement of successive measurements performed by the same evaluator,[15] while reproducibility indicates the agreement between the findings of two or more evaluators (inter-evaluator) or between measurements performed by the same evaluator on different occasions (intra-evaluator).[14,16]

OBJECTIVE

The objective of this study was to evaluate the repeatability and inter-examiner reproducibility of the Mobility Scale and Ruler (ERMo), following the Protocol for the use of the Mobility Scale and Ruler (PERMo), in the assessment of mobility of post-stroke patients in the hospital phase.

METHOD

This study was approved by the CEP of the Hospital de Clínicas de Porto Alegre (HCPA), under number 42306321.1.3001.5327. All participants signed an Informed Consent Form.

The sample was consecutive, composed of post-stroke patients of both sexes, admitted to the HCPA Stroke Unit. The sample size was defined based on a two-tailed test, adopting a power of 80%, assuming a null hypothesis with a k value of 0.40 and a detectable Kappa of 0.80, with a proportion of positive classifications of 0.50, resulting in a minimum number of 41 patients.

The inclusion criteria were: being over 18 years old and scoring zero in the categories of level of consciousness (1a), coherence in response to questions (1b) and coherence in response to commands (1c) of the National Institutes of Health Stroke Scale (NIHSS), indicating that there was no cognitive deficit.[17] The exclusion criteria were: (1) hemodynamic instability; (2) deep vein thrombosis; (3) previous deformity or pathology that affected mobility; (4) more than one episode of stroke; or (5) other associated neurological pathology.

Assessment with the Mobility Scale and Ruler

The ERMo (Mobility Scale and Ruler) aims to assess an individual's performance in performing postural changes, that is, to determine whether or not they are capable of performing a given activity, using environmental factors to their advantage. In the hospital setting, elements such as the edge of the bed, canes, or walkers are considered environmental factors that can facilitate the performance of mobility activities. Therefore, patients are encouraged to perform the activity as they are able, without detailed instructions on how to perform it, receiving assistance from the evaluator only when necessary.

The assessment began with the activity of rolling in bed, as instructed in the PERMo.[13] The evaluator asked the patient to roll in bed, starting from the supine position to both lateral decubitus positions, observing the need for assistance to roll to one or both sides and providing this assistance when necessary. The patient was classified as level 1 (dependent), 2 (semi-independent), or 3 (independent). Only patients who reached level 3, indicating independence in rolling to either side, proceeded to the bed sitting assessment.

To assess sitting, the patient was asked to sit on the edge of the bed, as preferred or able, observing the need for assistance with the task and providing it if necessary. The patient was classified as level 4 (dependent), 5 (semi-independent), or 6 (independent). Only patients who reached level 6, indicating independence in sitting, were assessed for their ability to stand.

Orthostasis was assessed similarly: the patient was asked to rise from a sitting to a standing position, observing the need for assistance and providing it when necessary. The patient was classified as level 7 (dependent), 8 (semi-independent), or 9 (independent). Only patients who reached level 9, indicating independence in standing, were assessed for their ability to walk.

To assess ambulation, the patient was asked to walk three meters, walk around an object, and return to the starting position, starting from a standing position. The need for assistance was observed, and assistance was provided if necessary. The patient was then classified as level 10 (dependent), 11 (semi-independent), or 12 (independent). Level 12 indicates independence in ambulation, representing the highest level of mobility.

After the Mobility Scale assessment, the evaluator classified the patient on the Mobility Ruler according to their highest level of independent mobility achieved. Thus, the patient was classified as "able to roll" upon reaching level 3 on the scale; "able to sit" upon reaching level 6; "able to stand" upon reaching level 9; and "able to ambulate" upon reaching level 12 on the Scale. Chart 1 illustrates the correspondence between the Scale levels and the Ruler levels. To complete the assessment, the evaluator recorded the patient's mobility according to the ERMo on the assessment form.

Chart **1.** Relationship between the levels of the Mobility Scale and Ruler (ERMo)

Mobility Level on the Scale	Mobility Level on the Ruler
Level 1 (dependent to roll over)	No marking on the ruler
Level 2 (semi-independent to roll over)	No marking on the ruler
Level 3 (independent to roll over)	Able to roll over
Level 4 (dependent to sit up)	Able to roll over
Level 5 (semi-independent to sit up)	Able to roll over
Level 6 (independent to sit up)	Able to sit up
Level 7 (dependent to stand upright)	Able to sit up
Level 8 (semi-independent to stand upright)	Able to sit up
Level 9 (independent to stand upright)	Able to stand upright
Level 10 (dependent to walk)	Able to stand upright
Level 11 (semi-independent to walk)	Able to stand upright
Level 12 (Independent walking)	Able to walk

Inter-examiner repeatability and reproducibility

Mobility level was assessed by physical therapists A and B following the instructions of the PERMo protocol.[13] Exceptionally for this study, to ensure blinding of the results between the evaluators, the Ruler result was recorded only on the evaluation form and never on the physical ruler located at the bedside.

For repeatability, physical therapist A assessed each patient twice consecutively in the morning, with a 5-minute interval between assessments. For inter-examiner reproducibility, the two physical therapists (A and B), independently and blinded to each other, assessed eligible patients on the same day.

Evaluator A assessed the patients in the morning, and Evaluator B in the afternoon (with a 2- to 3-hour interval between assessments). With this experimental design, each patient was assessed three times on the same day.

Statistical treatment

The data obtained by the two physical therapists were analyzed using the percentage of agreement (%C) and the kappa statistic (k). Because the ERMo is an ordinal scale, weighted and quadratic kappa were used, as it assigns different weights to minor and major disagreements, being more sensitive to serious errors, important in clinical contexts that require greater precision.[14]

The %C results were classified as %C < 0.30= poor; 0.31–0.50= weak; 0.51–0.70= moderate; 0.71–0.90= good; and 0.91–1.00= excellent. 18 The k values were classified as k < 0.20= poor; 0.21–0.40= mild; 0.41–0.60= moderate; 0.61–0.80= good; and 0.81–1.00= very good.[19] The significance level in all analyses was 0.05.

RESULTS

Regarding the mobility level of the sample (n= 58), 33 (57%) patients were able to walk independently, reaching level 12 on the Scale, while the others were distributed across other mobility levels (Table 1).

The reliability analysis found very good kappa values (>0.90), with excellent agreement percentages (100%) for repeatability and good (>80%) for inter-examiner reproducibility (Table 2).

Table 1. Demographic and clinical characteristics of post-stroke patients obtained in the first assessment

Sample characteristics (n= 58)	
Sex (M/F) (n %)	35(60.34%) / 23 (39.65%)
Age in years (SD average)	62,7 (±14.5)
Type of Stroke (ISC/ HEM)	51 (88%) / 7 (12%)
Thrombolysis	8 (15.7%)
Days post stroke* (SD average)	12.5 (±11)
NIHSS severity (IQR mean)	3 (4)
Sample characteristics (n= 58)	
1 (roll with a lot of help)	7 (12%)
2 (roll with little assistance)	2 (3.4%
4 (sitting with little assistance)	2 (3.4%)
5 (sitting with little assistance)	6 (10.3%)
8 (orthostasis with little assistance)	4 (6.9%)
11 (walk with little assistance)	4 (6.9%)
12 (walk independently)	33 (57%)

*Key: M: male; F: female; ISQ: ischemic; HEM: hemorrhagic; SD: standard deviation; Thrombolysis: number of patients who underwent thrombolysis, among those who had ischemic stroke; *Average in days after the stroke when the assessment was performed; NIHSS: National Institutes of Health Stroke Scale; **Mobility levels on the Mobility Scale recorded in the first assessment in the morning shift*

Table 2. Reliability analysis (repeatability and inter-rater reproducibility) of the Mobility Scale and Ruler (ERMo)

	Concordance (%)	Kappa	CI 95%	SE	Bias
Repeatability					
Scale	100	1	1.000-1.000	0	0
Ruler	100	1	1.000-1.000	0	0
Inter-rater Reproducibility					
Scale	82.8	0.928	0.865-0.991	0.032	0.17
Ruler	84.5	0.957	0.921-0.993	0.018	0.16

Key: Percentage of agreement (%); Squared weighted kappa (Kappa); 95% confidence interval (95% CI); Standard error (SE)

DISCUSSION

The International Classification of Functioning (ICF) defines mobility as: (1) changing and maintaining body position, (2) carrying, moving, and handling objects, (3) walking and moving, and (4) moving using transportation.[20] The ability to perform these activities determines the individual's independence in mobility.[21,22] The assessment of mobility activities allows the quantification of the functional impacts of post-stroke motor impairments, providing prognostic data and guiding interventions, which is essential for efficient and quality rehabilitation.[1]

The reliability of the MoER was assessed based on repeatability and inter-rater reproducibility. The interval between repeated assessments is a critical factor in measuring repeatability. Very short intervals can induce bias due to rater recall, while long intervals can allow changes in the assessed attribute. Defining this interval should consider the stability of the measured characteristic: stable attributes tolerate longer intervals, while unstable attributes require short intervals to ensure validity in the comparison between measurements.[14] It is noteworthy that the patients were between the acute (1 to 7 days) and subacute (up to 3 months) post-stroke phases (12.5 ± 11 days), periods marked by rapid functional changes due to intense neuroplasticity,[23] and were in a referral center for acute neurological care, where they received intensive physical therapy. Thus, the choice of a short 5-minute interval between assessments performed by the same evaluator (repeatability), and two shifts, for inter-examiner reproducibility, aimed to avoid fatigue while preserving the clinical stability of patients.

The kappa coefficient (λ) is widely used to assess reliability when data are ordinal, as it allows us to differentiate between true agreement and that which would occur by mere chance.[14,24] This was important in the case of ERMo, as it penalized more severely for wider disagreements between evaluators. This approach is particularly relevant in hospital settings, where differences in scores can have important practical implications. For example, if one evaluator classifies a patient as level 9—indicating independence in standing—and another as level 3—indicating independence only in rolling over in bed—this divergence can lead to misinterpretations of the patient's true mobility. In practice, this can result in inappropriate behavior and increase the risk of adverse events, such as falls.

Fall prevention is a global health priority and is one of the goals of the WHO and the National Patient Safety Program (PNSP).[25] Creating an institutional culture focused on fall prevention and coordinated multidisciplinary actions is essential to reducing fall incidence and promoting patient safety.[26] Therefore, the Ruler could be considered an educational intervention for patients and professionals to reduce falls in the hospital environment. Unlike other mobility scales, whose information is restricted to medical records, the ERMo stands out for facilitating interprofessional and family communication by making the patient's level of mobility visible at the bedside through the Ruler.

The ERMo demonstrated excellent repeatability (k= 1.00; p<0.001) with 100% agreement and good inter-rater reproducibility (Scale: k= 0.928; Ruler: k= 0.957) with agreement above 80%. Furthermore, the Bias, which refers to the systematic difference in the proportion of cases classified differently between evaluators, was less than 0.18, reinforcing the reliability of the ERMo (Table 3).

The Motor Assessment Scale for Stroke (MAS) showed inter-rater reliability with a mean correlation of r= 0.95, ranging from r= 0.89 to 0.99 between items.[5] The Rivermead Motor Assessment Scale (RMA) also demonstrated excellent inter-rater reliability in the acute phase, with an ICC of 0.92 for the total score.[27] The Trunk Control Scale (TCT) showed r= 0.76 (p < 0.001) in post-stroke patients,[7] and the Trunk Impairment Scale (TIS) demonstrated ICCs between 0.85 and 0.99 in patients in the subacute phase.[28] The Timed Up and Go (TUG) test also showed excellent test-retest reliability in post-stroke individuals, with an ICC= 0.96.[29] Although not specifically tested in stroke patients, instruments such as the Katz Scale showed ICCs of 0.999 in older adults,[30] and the Perme Mobility Score demonstrated a kappa between 0.78 and 0.99 and an ICC of 0.98 in cardiovascular patients admitted to the ICU.[31,32] Given these results, it can be seen that the reproducibility indices obtained by the MoRS are compatible with or superior to those of the main scales currently used in hospital settings for assessing post-stroke patients. This reinforces the robustness of the proposed instrument and its practical applicability in assessing the mobility of post-stroke patients during the hospital phase.

The main limitation of this study is the sample, which consisted of patients with mild neurological impairment and independent ambulation, corresponding to the highest level of the MoRS. This reduced data variability, compromising generalizability to populations with more severe stroke or greater motor restrictions. For future research, it is recommended to expand the sample diversity, including patients with different levels of functional impairment. Furthermore, assessing the concurrent validity of ERMo, comparing it with instruments considered the gold standard for mobility assessment, may strengthen the evidence of validity and expand its clinical applicability.

CONCLUSION

The Mobility Scale and Ruler (ERMo) presented reliable reliability indices and can be used both by the same professional, to monitor the evolution of the post-stroke patient over time, and by different team members at different moments during hospitalization, as long as the assessments follow the PERMo protocol.

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