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Measurement of lower-limb muscle spasticity: Intrarater reliability of Modified Modified Ashworth Scale

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Abstract—The Modified Modified Ashworth Scale (MMAS) is a clinical instrument for measuring spasticity. Few studies have been performed on the reliability of the MMAS. The aim of the present study was to investigate the intrarater reliability of the MMAS for the assessment of spasticity in the lower limb. We conducted a test-retest study on spasticity in the hip adductors, knee extensors, and ankle plantar flexors. Each patient was measured by a hospital-based clinical physiotherapist. Twenty-three patients with stroke or multiple sclerosis (fourteen women, nine men) and a mean +/– standard deviation age of 37.3 +/– 14.1 years participated. The weighted kappa was moderate for the hip adductors (weighted kappa = 0.45, standard error [SE] = 0.16, $p = 0.007$), good for the knee extensors (weighted kappa = 0.62, SE = 0.12, $p < 0.001$), and very good for the ankle plantar flexors (weighted kappa = 0.85, SE = 0.05, $p < 0.001$). The kappa value for overall agreement was very good (weighted kappa = 0.87, SE = 0.03, $p < 0.001$). The reliability for the ankle plantar flexors was significantly higher than that for the hip adductors. The intrarater reliability of the MMAS in patients with lower-limb muscle spasticity was very good, and it can be used as a measure of spasticity over time.

Key words: ankle plantar flexors, hip adductors, intrarater, knee extensors, lower limb, MMAS, Modified Modified Ashworth Scale, muscle spasticity, rehabilitation, reliability.

INTRODUCTION

Upper motor neuron (UMN) syndrome occurs in multiple sclerosis (MS), stroke, spinal cord injuries, and cerebral palsy and can cause spasticity, which is common, complex, and disabling in many patients with these conditions. Spasticity affects at least 38 percent of people 12 months poststroke [1], and approximately 90 percent of people with MS experience spasticity at some point [2]. The definition provided by Lance describes spasticity as a velocity-dependent disorder of the stretch reflex that results in increased muscle tone as one component of UMN syndrome [3]. Measuring spasticity using reliable and valid tools is important for the evaluation of treatment efficacy. The Ashworth scale [4], Bohannon-Smith modified Ashworth scale [5], and Tardieu scales [6–9] are currently used to measure spasticity.

Currently, the Ashworth scales [4–5] are the most commonly used measures of spasticity in clinical practice and research. However, the reliability and validity of these scales has been recently challenged [10–16]. In an attempt to improve the quality of the Ashworth scales, Ansari et al. modified the Bohannon-Smith modified Ashworth scale,

Abbreviations: MMAS = Modified Modified Ashworth Scale, MS = multiple sclerosis, SD = standard deviation, SE = standard error, UMN = upper motor neuron.

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titling the new scale the Modified Modified Ashworth Scale (MMAS) [10]. In this modified version of the Ashworth scale, the grade “1+” is omitted and the grade “2” is redefined. In the MMAS, spasticity is scored on an ordinal scale from 0 to 4 as follows: 0 = No increase in muscle tone; 1 = Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part(s) is moved in flexion or extension; 2 = Marked increase in muscle tone, manifested by a catch in the middle range and resistance throughout the remainder of the range of motion, but affected part(s) easily moved; 3 = Considerable increase in muscle tone, passive movement difficult; and 4 = Affected part(s) rigid in flexion or extension.

The few studies performed on the reliability and validity of the MMAS have been encouraging. For the measurement of knee extensor spasticity in 15 patients after stroke, the MMAS demonstrated reliable inter- and intrarater reliability measurements. The kappa values were good between raters ($\kappa = 0.72$, standard error [SE] = 0.14, $p < 0.001$) and very good within one rater ($\kappa = 0.82$, SE = 0.12, $p < 0.001$) [17]. The interrater reliability for the MMAS was very good when evaluating wrist flexor spasticity in 30 patients with hemiplegia (weighted kappa [κ_w] = 0.92, SE = 0.03, $p < 0.001$) [18]. In a study to investigate the interrater reliability of the MMAS in the assessment of elbow flexor spasticity, inexperienced raters tested 21 adult patients with stroke. The κ_w was 0.81 (SE = 0.097, $p = 0.0002$), thus interrater reliability for two inexperienced raters was very good [19].

In a cross-sectional study to assess the interrater reliability of the MMAS in the upper limb of adult patients with hemiplegia, two physiotherapists rated two common spastic muscle groups (elbow flexors and wrist flexors) of 15 patients. The κ_w was 0.61 for elbow flexors and 0.78 for wrist flexors. The interrater reliability of the MMAS was good [20].

To assess the interrater reliability of the MMAS in lower-limb muscle spasticity, Ghotbi et al. tested 22 adults with stroke or MS. Hip adductors, knee extensors, and ankle plantar flexors were assessed. Interrater reliability was very good for the hip adductors and the knee extensors $\kappa_w = 0.82$, $p < 0.001$) and good for the ankle plantar flexors ($\kappa_w = 0.74$, $p < 0.001$) [21].

One further study explored the validity of the MMAS in 27 patients with stroke. The relationship between the MMAS scores obtained from the wrist flexor muscle group and the H_{Slope}/M_{Slope} and H_{Max}/M_{Max} ratios was statistically significant ($r = 0.39$, $p = 0.04$) [22].

Few studies have investigated the reliability of the MMAS. Only one study to date has evaluated intrarater reliability. Therefore, the goal of the present study was to evaluate the intrarater reliability of the MMAS when several lower-limb muscle groups were assessed in patients with spasticity.

METHODS

Study Design

This study employed a test-retest design to evaluate the intrarater reliability of the MMAS in patients with lower limb spasticity.

Population

Patients with MS or stroke with spasticity were recruited from inpatient wards of Sina University Hospital, Tehran, Iran. To be included in the study, patients had to have no previous pathology of the affected lower limb and had to be able to understand simple commands. The exclusion criteria were muscle contracture and severe joint pain.

Rater

The rater was a physiotherapist with more than 16 years experience in managing patients with muscle spasticity. She was familiar with the MMAS but was not experienced using it. The descriptions of the rating criteria were included on the recording form.

Scale and Testing Position

The MMAS was the scale used. Three muscle groups in the affected lower limb of each patient were assessed: hip adductors, knee extensors, and ankle plantar flexors. The standardized test positions and movements are described in **Table 1** and have been described and used in other studies [12,21].

Procedure

The procedure used in previous investigations was followed [12,21]. Demographic data including age, sex, etiology, affected side, and disease duration were recorded. The subjects were tested while in the hospital. The assessment order of limbs in cases of bilateral involvement in patients with MS was randomized; in all

Table 1.
Standardized positions and movements for rating with Modified Modified Ashworth Scale.

Muscle Group	Patient	Rater
Hip Adductors	Supine, head in midline, and lower limbs in extended position.	On side being tested, rater placed one hand underneath limb close to knee and other hand supported limb close to ankle. Limb was moved into full abduction (without rotation).
Knee Extensors	Side-lying, with hips and knees in extension. Head and trunk aligned in straight line. Pillow can be used behind hips, if necessary, to stabilize patient.	Behind patient, rater placed one hand just proximal to knee, on lateral surface of thigh, to stabilize femur and other hand just proximal to ankle. Knee was moved from maximum extension to maximum flexion.
Ankle Plantar Flexors	Supine, with head in midline, and arms alongside trunk. Lower limbs in extended position.	On side being tested, rater placed one hand under ball of foot, while other hand stabilized limb around ankle joint. Ankle was moved from maximum plantarflexion into maximum dorsiflexion.

patients, the assessment order of the muscles was randomized. The same physiotherapist performed a second assessment 2 days after the first. Patients were instructed to relax during the test and to not resist the passive movements applied by the physiotherapist. The joints were moved with a fast-stretching velocity by counting "one-thousand-and-one" as suggested by Bohannon and Smith [5]. The passive movement was repeated three times at each joint.

Data Analysis

Descriptive statistics were calculated for subjects and variables with SPSS, version 11.5 (SPSS Inc; Chicago, Illinois). The quadratic weighted kappa statistic was used to calculate reliability. The reliability results were interpreted as follows [23]: very good 0.81–1.00, good 0.61–0.80, moderate 0.41–0.60, fair 0.21–0.41, and poor <0.21. The chi-square test was performed to analyze the difference between the weighted kappa values for each muscle group [24]. Statistical significance was set at $p < 0.05$.

RESULTS

Twenty-three patients (fourteen women, nine men) with a mean ± standard deviation (SD) age of 37.3 ± 14.1 years were examined in this study. Eighteen patients had MS and five patients had hemiplegia due to a single stroke. The mean ± SD ages of patients with stroke and MS were 61.6 ± 12.1 years and 33.1 ± 9.4 years, respectively. The mean ± SD time poststroke was 517.6 ± 1,138.9 days. The patients with MS had a mean ± SD history of MS of 2,615.7 ± 1,658.3 days. A total of 34 limbs were examined for intrarater reliability because eleven patients with MS were bilaterally involved. However, 101 muscle spasticity assessments were obtained because one patient found it difficult to stay in the side-lying position for the knee extensor muscle test. In this study, all MMAS grades from 0 to 4 were scored, but the patients were most often assigned the scores of 0 and 1 across all muscle groups. Most agreement was obtained for grade 0 followed by grade 1 (**Table 2**).

For hip adductor and knee extensor muscle groups, no subjects were graded 3 or 4. Patients were most often assigned grades of 0 and 1. For ankle plantar flexor muscles, the patients were mostly given grades of 2 and 1, but patients did attain scores of 3 and 4. **Table 3** shows the weighted agreement for each of the muscles. The weighted kappa was moderate for the hip adductors, good for the knee extensors, and very good for the ankle plantar flexors. The kappa value for overall agreement was very good.

Table 2.
Total assignments by rater for three lower-limb muscle groups using Modified Modified Ashworth Scale (MMAS).

MMAS Scores: Assessment 1	MMAS Scores: Assessment 2					Total
	0	1	2	3	4	
0	42	5	1	0	0	48
1	10	14	0	0	0	24
2	0	9	7	1	0	17
3	0	0	2	8	0	10
4	0	0	0	0	2	2
Total	52	28	10	9	2	101

Note: Overall $\kappa_w = 0.87$ (standard error = 0.03), $p < 0.001$.

Table 3.
Weighted agreement within rater (intrarater) in Modified Modified Ashworth Scale scores for three muscle groups of lower limbs.

Muscle Group	% Weighted Agreement	κ_w	95% CI	SE	*p*-Value	Interpretation
Hip Adductors	89	0.45	0.13–0.77	0.16	0.007	Moderate
Knee Extensors	96	0.62	0.39–0.85	0.12	<0.001	Good
Ankle Plantar Flexors	98	0.85	0.77–0.94	0.05	<0.001	Very Good
Overall	98	0.87	0.81–0.93	0.03	<0.001	Very Good

CI = confidence interval, SE = standard error.

The chi-square test showed a significantly higher weighted kappa value for the ankle plantar flexors than for the hip adductors ($p < 0.05$). The difference between the weighted kappa values of the knee extensors and those of either hip adductors or ankle plantar flexors was not statistically significant.

DISCUSSION

The results of the present study demonstrated the intrarater reliability of the MMAS in measuring lower-limb muscle spasticity in patients with neurological conditions. The overall reliability for lower-limb muscle spasticity was very good.

The rater in this study was not trained in the use of the MMAS. In actual clinical situations, very little time exists for training clinicians. Therefore, we offered no training to the rater. We also expected the training to be unnecessary because she was experienced in handling neurological patients and had previous experience using the Bohannon-Smith modified Ashworth scale [5].

So far, the findings on the reliability of the MMAS have been good and very good [17–21]. In this study, moderate reliability was observed for the hip adductors and good reliability for knee extensors; however, these are lower than previous measures of intrarater reliability [17]. One possible reason could be the clinical environment in the hospital. At times the hospital was not quiet. Muscle spasticity in patients with UMN lesions fluctuates because of environmental stimuli [25].

Another explanation for the lower reliability of the hip adductors could be the larger mass of the lower limb. The rater reported that the difference in the reliability for the hip adductors and ankle plantar flexors was because she had more control over the ankle.

Another possible reason for the lower reliability in this study was that the patients were undergoing medical treatment. This implies that the patients were not clinically stable. The unstable condition of the patients combined with medication usage could have affected the tone of the muscles.

Although these factors could have affected the consistency of the results on the reliability of the MMAS, the following points should also be considered. First, the intrarater reliability in this study was good and very good for the knee extensors and ankle plantar flexors. Second, the interrater reliability of the MMAS had been previously investigated by two inexperienced physiotherapy students in a hospital setting and very good agreement was found for each muscle and the overall weighted kappa [21]. In this investigation of intrarater reliability, the overall weighted kappa value for the three muscle groups was very good.

In patients with UMN lesions, multiple muscles in a limb are involved. Establishing reliability for individual muscle groups is important. However, reliable assessment of the entire affected limb is desirable, especially for clinical purposes. The overall agreement for the muscles in a limb gives a general idea about the reliability of the assessment. Therefore, the reliability of a scale in individual joints needs to be considered in light of the overall reliability obtained in the limb. In this study, the overall very good agreement for the muscles indicates the reliable assessment of spasticity for the limb has been achieved. Accordingly, the MMAS showed a high degree of intrarater reliability for lower-limb muscle spasticity among patients with neurological conditions that makes it suitable for initial evaluation and reassessment. However, we must note that the time interval between the two assessments was short and the rater could remember her original scores. The rater might have been influenced by her memory of the result of her first assessment.

CONCLUSIONS

The present study demonstrated that the MMAS has overall very good intrarater reliability in patients with lower-limb muscle spasticity. A statistically higher reliability for distal ankle plantar flexors than for proximal hip adductors was noted. The MMAS showed adequate reliability for the measurement of lower-limb muscle spasticity over time.

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Study concept and design: N. Nakhostin Ansari, N. Ghotbi.
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REFERENCES

1. Watkins CL, Leathley MJ, Gregson JM, Moore AP, Smith TL, Sharma AK. Prevalence of spasticity post stroke. Clin Rehabil. 2002;16(5):515–22. [PMID: 12194622] DOI:10.1191/0269215502cr512oa
2. Hobart JC, Riazi A, Thompson AJ, Styles IM, Ingram W, Vickery PJ, Warner M, Fox PJ, Zajicek JP. Getting the measure of spasticity in multiple sclerosis: The Multiple Sclerosis Spasticity Scale (MSSS-88). Brain. 2006;129(Pt 1):224–34. [PMID: 16280352] DOI:10.1093/brain/awh675
3. Lance JW. The control of muscle tone, reflexes, and movement: Robert Wartenberg Lecture. Neurology. 1980;30(12):1303–13. [PMID: 7192811]
4. Ashworth B. Preliminary trial of carisoprodol in multiple sclerosis. Practitioner. 1964;192:540–42. [PMID: 14143329]
5. Bohannon RW, Smith MB. Interrater reliability of a modified Ashworth scale of muscle spasticity. Phys Ther. 1987;67(2):206–7. [PMID: 3809245]
6. Ansari NN, Naghdi S, Hasson S, Azarsa MH, Azarnia S. The Modified Tardieu Scale for the measurement of elbow flexor spasticity in adult patients with hemiplegia. Brain Inj. 2008;22(13–14):1007–12. [PMID: 19117179] DOI:10.1080/02699050802530557
7. Haugh AB, Pandyan AD, Johnson GR. A systematic review of the Tardieu Scale for the measurement of spasticity. Disabil Rehabil. 2006;28(15):899–907. [PMID: 16861197] DOI:10.1080/09638280500404305
8. Morris S. Ashworth and Tardieu scales: Their clinical relevance for measuring spasticity in adult and paediatric neurological populations. Phys Ther Rev. 2002;7(1):53–62. DOI:10.1179/108331902125001770
9. Gracies JM, Marosszeky JE, Renton R, Sandanam J, Gandevia SC, Burke D. Short-term effects of dynamic lycra splints on upper limb in hemiplegic patients. Arch Phys Med Rehabil. 2000;81(12):1547–55. [PMID: 11128888] DOI:10.1053/apmr.2000.16346
10. Ansari NN, Naghdi S, Moammeri H, Jalaie S. Ashworth Scales are unreliable for the assessment of muscle spasticity. Physiother Theory Pract. 2006;22(3):119–25. [PMID: 16848350] DOI:10.1080/09593980600724188
11. Tederko P, Krasuski M, Czech J, Dargiel A, Garwacka-Jodzis I, Wojciechowska A. Reliability of clinical spasticity measurements in patients with cervical spinal cord injury. Ortop Traumatol Rehabil. 2007;9(5):467–83. [PMID: 18026067]
12. Ansari NN, Naghdi S, Arab TK, Jalaie S. The interrater and intrarater reliability of the Modified Ashworth Scale in the assessment of muscle spasticity: Limb and muscle group effect. NeuroRehabilitation. 2008;23(3):231–37. [PMID: 18560139]
13. Naghdi S, Ansari NN, Mansouri K, Olyaei GR, Asgari A, Kazemnejad A. The correlation between Modified Ashworth Scale scores and the new index of alpha motoneurones excitability in post-stroke patients. Electromyogr Clin Neurophysiol. 2008;48(2):109–15. [PMID: 18435215]
14. Alibiglou L, Rymer WZ, Harvey RL, Mirbagheri MM. The relation between Ashworth scores and neuromechanical measurements of spasticity following stroke. J Neuroeng Rehabil. 2008;5:18. [PMID: 18627628] DOI:10.1186/1743-0003-5-18
15. Craven BC, Morris AR. Modified Ashworth scale reliability for measurement of lower extremity spasticity among patients with SCI. Spinal Cord. 2010;48(3):207–13. [PMID: 19786977] DOI:10.1038/sc.2009.107

16. Fleuren JF, Voerman GE, Erren-Wolters CV, Snoek GJ, Rietman JS, Hermens HJ, Nene AV. Stop using the Ashworth Scale for the assessment of spasticity. J Neurol Neurosurg Psychiatry. 2010;81(1):46–52. [PMID: 19770162] DOI:10.1136/jnnp.2009.177071
17. Ansari NN, Naghdi S, Younesian P, Shayeghan M. Inter- and intrarater reliability of the Modified Modified Ashworth Scale in patients with knee extensor poststroke spasticity. Physiother Theory Pract. 2008;24(3):205–13. [PMID: 18569857] DOI:10.1080/09593980701523802
18. Naghdi S, Ansari NN, Azarnia S, Kazemnejad A. Interrater reliability of the Modified Modified Ashworth Scale (MMAS) for patients with wrist flexor muscle spasticity. Physiother Theory Pract. 2008;24(5):372–79. [PMID: 18821443] DOI:10.1080/09593980802278959
19. Ansari NN, Naghdi S, Hasson S, Mousakhani A, Nouriyan A, Omidvar Z. Inter-rater reliability of the Modified Modified Ashworth Scale as a clinical tool in measurements of post-stroke elbow flexor spasticity. NeuroRehabilitation. 2009;24(3):225–29. [PMID: 19458429] DOI:10.3233/NRE-2009-0472
20. Ansari NN, Naghdi S, Hasson S, Fakhari Z, Mashayekhi M, Herasi M. Assessing the reliability of the Modified Modified Ashworth Scale between two physiotherapists in adult patients with hemiplegia. NeuroRehabilitation. 2009;25(4):235–40. [PMID: 20037215] DOI:10.3233/NRE-2009-0520
21. Ghotbi N, Ansari NN, Naghdi S, Hasson S, Jamshidpour B, Amiri S. Inter-rater reliability of the Modified Modified Ashworth Scale in assessing lower limb muscle spasticity. Brain Inj. 2009;23(10):815–19. [PMID: 19697170] DOI:10.1080/02699050903200548
22. Naghdi S, Ansari NN, Mansouri K, Asgari A, Olyaei GR, Kazemnejad A. Neurophysiological examination of the Modified Modified Ashworth Scale (MMAS) in patients with wrist flexor spasticity after stroke. Electromyogr Clin Neurophysiol. 2008;48(1):35–41. [PMID: 18338533]
23. Brennan P, Silman A. Statistical methods for assessing observer variability in clinical measures. BMJ. 1992; 304(6840):1491–94. [PMID: 1611375]
24. Fleiss JL. The measurement of interrater agreement. In: Fleiss JL, editor. Statistical methods for rates and proportions. New York (NY): Wiley; 1981. p. 222.
25. Blackburn M, Van Vliet P, Mockett SP. Reliability of measurements obtained with the modified Ashworth scale in the lower extremities of people with stroke. Phys Ther. 2002;82(1):25–34. [PMID:11784275]

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