

## Validity of Modified Ashworth Scale as a Measure of Wrist Spasticity in Stroke Patients

Mohammad Heidari, MSc

Department of Occupational Therapy, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran

Shahram Abootalebi\*, MD

University of Social Welfare and Rehabilitation Sciences, Pediatric Neurorehabilitation Research Center, Tehran, Iran

Seyed Ali Hosseini, PhD

Pediatric Neurorehabilitation Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran

**Objective:** There are some controversies about the value of modified Ashworth Scale (MAS) for assessing spasticity. The goal of this study was to investigate if there is any correlation between scores obtained from MAS for wrist spasticity and electrophysiological recordings as the objective measure of spasticity.

**Methods:** In this cross-sectional study, 34 stroke patients were employed. Wrist spasticity was clinically measured by means of MAS. Also, an electromyogram (EMG) machine was used to elicit Hmax and Mmax from the flexor carpi radialis muscle. Spearman's correlation coefficient test was used to investigate potential correlation between clinically and electrophysiologically measures of spasticity.

**Results:** The observed relation between MAS and EMG recordings was not statistically significant ( $\rho=0.183$   $P>0.05$ ).

**Discussion:** Our findings suggest that MAS may be a useful tool for grading hypertonia, but it is not a valid measure of spasticity in selected patients.

**Keywords:** Validity, Modified Ashworth Scale, Spasticity, Stroke

### Introduction

Spasticity has been defined as a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes with exaggerated tendon jerk resulting from hyperexcitability of the stretch reflex, as one component of the upper motor neuron (UMN) syndrome (1). According to some recent studies, spasticity can lead to motor dysfunction and limitation of activity after stroke (2-4). Thus, managing of spasticity should be considered as a part of rehabilitation plan (5) and it is obvious that proper measurement is necessary for adequate results (6). Currently, various methods are used for measuring spasticity that generally categorized into three groups including: biomechanical, neurophysiological and clinical tools which none of them have widely acceptance (6-11).

Although Modified Ashworth Scale (MAS) is likely most common tool for assessing spasticity both in research and clinical practice, its methodological

limitations are now increasingly being addressed (6, 7, 12, 13]. One of these limitations is lack of a standardized method for assessing spasticity (6, 11). For example some clinicians assess limb spasticity from the rest position without any previous limb stretching while others move the limb several times in the flexion-extension pattern before the assessment have been done. Therefore, this difference in performing test may interfere with the results because the excitability of the stretch reflex maybe different in two conditions (6). Another discussable issue about MAS is that, it is not obviously determined that it should be considered as an ordinal or a nominal scale for assessment of spasticity because of the grade 1<sup>+</sup> added to five-grade original Ashworth scale (7, 13).

Although, it is suggested that most of the limitations of the MAS can be overcome especially at the wrist joint, as it has been reported high inter and intra rater reliability of MAS for wrist spasticity in some

►This paper has been prepared on the ground of a student research project

\*All correspondences to: Email; Abootalebi@uswr.ac.ir

studies (9, 14, 15), some authors still claim that MAS can not be a valid tool for assessing spasticity because of low ability of this scale for discriminating spasticity from the other factors contribute to hypertonia (mostly biomechanical changes in involved muscles) seen after central neurological damages include stroke (12, 15, 16). In addition, during the test examiner needs to rapidly move a particular joint and simultaneously and subjectively determine the amount of resistance to passive stretch (7).

However, it seems to be reasonable the weaknesses be ignored if the MAS be correlated meaningfully to an objective measure of spasticity (6). The ratio of maximum amplitudes of H reflex and its muscle response ( $H_{max}/M_{max}$ ) is a parameter of electromyography (EMG) which used as a neurophysiological measure of spasticity (1, 9, 12, 17). Although this measurement is expensive and time-consuming and thus has not wide acceptance (14), it remains as a valuable tool for validation of some clinical scales like MAS (6). Despite some studies around validity of MAS have reported good relationship between data obtained from this scale and EMG results (18, 19), but others equally suggested that poor to moderate correlation exists between them (14). In summary, previous studies are inconclusive and it seems that additional studies is required (11, 13). In this study we investigated the relationship between scores obtained from MAS and EMG recordings to measure wrist spasticity in stroke patients.

## Methods

**Table 1.** Modified Ashworth Scale for grading spasticity

score	description
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
1+	slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the ROM
2	more marked increase in muscle tone through most of the ROM, but affected part(s) easily moved
3	considerable increase in muscle tone, passive movement difficult
4	affected part(s) rigid in flexion or extension

$H_{max}/M_{max}$  ratio

In this cross-sectional study, 34 stroke patients were selected randomly from those referred to outpatient Rehabilitation Centers of University of Social Welfare and Rehabilitation Sciences (USWRS), Tehran, between August 2008 and April 2009. All participants signed a consent form, approved by Ethic Committee of USWRS, before the study.

## Participants

Following criteria were set for the sample: presence of post-stroke hemiplegia occurred at least six month before the study, detectable spasticity in involved wrist ( $0 < MAS < 4$ ), without fixed joint contracture and skin problems in the involved upper extremity and lack of BONT-A injection during 6 month before the study. Both clinical and neurophysiological assessments of the spasticity were made at the same session in the similar condition.

## The modified Ashworth scale

Wrist spasticity was assessed by means of MAS. This six-fold scale range from 0 (no spasticity) to 4 (fixed muscle contracture) based on the amount of muscle resistance perceived by the examiner in response to passive stretch of particular joint (See table 1). To diminish inter-rater variability of the scale, all subjects were tested by the same person. Resistance to passive muscle stretch was measured at the involved wrist while the subjects have sat on the chair and their involved arm rest on a pillow placed on their leg. For all subjects, wrist stretch was started from the full flexion position without any repeated flexion/extension movement before the test was done.

Surface EMG machine was used to elicit  $H_{max}/M_{max}$  ratio from the *Flexor Carpi Radialis (FCR)* using bipolar, pregelled circular (diameter 10 mm) electrodes. Two electrodes were placed on the belly of the FCR and in the *Cubital Fossa* (to stimulate the median nerve) with 3 cm distance between them. The band-pass filter was set at 2 and 10 KHz (12). According to previous studies, median nerve was stimulated with a rectangular electrical pulse of 1 ms duration and with stimulus frequency of 1 per five seconds (9). The stimulus intensity was increased gradually until  $H_{max}$  and  $M_{max}$  were obtained. The pick to pick form of amplitudes of H and M waves were recorded as  $H_{max}$  and  $M_{max}$  respectively. To avoid variability of  $H_{max}/M_{max}$  ratio due to different degree of muscle contraction, all tests were performed at the rest position of wrist and full supination of forearm.

#### Data analysis

Statistical calculations and analysis were performed with the software package SPSS for windows, version 16.0.

Based on a recent comprehensive review about MAS, it should be treated as a nominal scale for assessing spasticity (15). Therefore, to investigate

relation between MAS scores and EMG recordings, *spearman* correlation coefficient test was used. Statistical significance was set at level of  $P < 0.05$ .

#### Results

To investigate any potential correlation between MAS and  $H_{max}/M_{max}$  ratio scores, evaluated patients were divided into four groups based on their obtained scores from MAS which could be 1, 1<sup>+</sup>, 2 or 3. Therefore, after all tests were performed, six patients were placed in group A (MAS=1), ten in group B (MAS=1<sup>+</sup>), eleven in group C (MAS=2) and seven in group D (MAS=3). Among our samples, twenty-one had involvement of left side against thirteen who had right-side involvement. The ratio of male/female was 19/15. The mean and standard deviation of age and survival duration of participants were  $59.5 \pm 7.41$  and  $15.8 \pm 4.47$  respectively. Also, the distribution of sex, age, involved side and survival duration were statistically similar in four groups ( $P > 0.05$ ). These observations are shown in table 2.

**Table2.** The main demographic features of sample

group	age		Survival duration		sex		involvement	
	mean±std dev.	P-value	mean±std dev.	P-value	M/F	P-value	L/R	P-value
A	59.5±6.89		16.6±2.80		3/3		2/4	
B	58.0±6.86	0.261	15.3±3.59	0.514	7/3	0.710	6/4	0.407
C	63.0±7.16		17.0±5.68		6/5		8/3	
D	56.42±14.00		14.0±4.76		3/4		5/2	
total	59.5±7.41		15.8±4.47		19/15		21/13	

During the performing of EMG tests, the H reflex was not elicited in three cases; therefore, these cases were excluded from the analysis. The mean and standard deviation of  $H_{max}/M_{max}$  ratio in groups A, B, C and D were  $17.1 \pm 2.98$ ,  $20.7 \pm 3.59$ ,  $21.3 \pm 4.56$  and

$19.9 \pm 1.50$  respectively. Also, as shown in table3, the observed correlation between MAS and  $H_{max}/M_{max}$  ratio scores was not statistically significant ( $\rho = 0.183$   $P > 0.05$ ).

**Table3.** Correlation between MAS and  $H_{max}/M_{max}$  ratio scores

group	N	$H_{max}/M_{max}$	Spearman's rho	P-value
A	5	*17.1±2.98		
B	10	20.7±3.59	0.183	0.323
C	9	21.3±4.56		
D	7	19.9±1.50		
total	31	20.1±3.62		

\*mean ± standard deviation

## Discussion

This study was run to determine if there is any meaningful relationship between scores obtained from MAS and  $H_{max}/M_{max}$  ratio for measuring wrist spasticity in stroke patients; if so, the value of MAS as a clinical tool for measuring spasticity would be increased, because one of the main mechanisms of muscle spasticity is increased  $\alpha$  motor neuron excitability (20-21). Also, the value of  $H_{max}/M_{max}$  ratio for measuring changed observed excitability of  $\alpha$  motor neuron has been confirmed (22-24).

It has been found that the amount of  $H_{max}/M_{max}$  ratio will reach its maximum level in 2 to 6 months after central nervous system damage and then remain stable (25). So it was important to obtain  $H_{max}/M_{max}$  ratio at least six months after occurrence of stroke, as we performed. Also, according to some studies, reliability of MAS in upper limb is higher than lower limb especially in distal segments (9, 14, 26), thus we targeted the wrist joint for assessment to enhance the strength of the study.

However, we observed linear, but not meaningful, correlation between scores obtained from MAS scale and  $H_{max}/M_{max}$  ratio. Therefore, our results support previous studies regarding weakness of MAS as an exclusive measure of spasticity (1, 7, 14, 15).

Bakheit et. al believe that although most of limitations of the MAS can be overcome, its method of scoring the severity of hypertonia remains still controversial (6), because it depends on examiner's

subjective judgment of the perceived degree of resistance against passive muscle stretch (6, 7). Moreover, some authors believe that increased resistance to passive stretch is primary due to an increased reflex response (14, 27), this resistance often reflects a combination of neural and structural components of hypertonia (12, 28-31) which only one of them could be spasticity (32).

Another inherent problem of MAS in measuring spasticity maybe is lack of accounting velocity. Since the spasticity is naturally velocity-dependent and it is not certainly determined which stretch velocity should be applied when performing MAS, it is not possible to distinguish between spasticity and other factors contribute to hypertonia during the test (33).

Based on these findings, the MAS scores and amount of  $\alpha$ -motor neuron excitability do not correlate together and thus, MAS is not a valid measure of spasticity. However it may still remain a helpful tool for some clinical purposes when the hypertonia rather than spasticity is the subject of measurement.

## Acknowledgment

We acknowledge the Occupational Therapy Department, University of Social Welfare and Rehabilitation Sciences for all supports for this study.

## References:

1. Tsai KH, Yeh CYU, Chang H, Chen J. Effects of a single session of prolonged muscle stretch on spastic muscle of stroke patients. *Proc Natl Sci Coun ROC (B)* 2001;25(2):76-81.
2. Bovend'Eerd TJ, Newman M, Barker K, Dawes H, Minelli C, Wade DT. The effects of stretching in spasticity: a systematic review. *Archives of physical medicine and rehabilitation* 2008;89(7):1395-406.
3. Welmer AK, Von AM, Widen HL, Sommerfeld DK. Spasticity and its association with functioning and health-related quality of life 18 months after stroke. *Cerebrovasc Dis* 2006; 21:247-53.
4. Barnes MP, Kent RM, Semlyen JK, McMullen KM. Spasticity in multiple sclerosis. *Neurorehabil Neural Repair* 2003;17:66-70.
5. Abbruzzese G. The medical management of spasticity. *European Journal of Neurology* 2002;9(s1):30-4.
6. Bakheit AMO, Maynard VA, Curnow J, Hudson N, Kodapala S. The relation between Ashworth scale scores and the excitability of  $\alpha$  motor neurones in patients with post-stroke muscle spasticity. *J Neurol Neurosurg Psychiatry* 2003;74:646-648.
7. Johnson GR. Outcome measure of spasticity. *European Journal of Neurology* 2002;9(s1):10-16.
8. Dachy B, Dan B. Electrophysiological assessment of the effect of intrathecal baclofen in spastic children. *Clinical Neurophysiology* 2002;113(3):336-40.
9. Pisano F, Miscio G, Del Conte C, Pianca D, Candeloro E, Colombo R. Quantitative measures of spasticity in post-stroke patients. *Clinical Neurophysiology* 2000;111(6):1015-22.
10. Voerman GE, Gregoric M, Hermens HJ. Neurophysiological methods for the assessment of spasticity: the Hoffmann reflex, the tendon reflex, and the stretch reflex. *Disability & Rehabilitation* 2005;27(1-2):33-68.
11. BurrIDGE JH, Wood DE, Hermens HJ, Voerman GE, Johnson GR, Wijck FV, et al. Theoretical and methodological considerations in the measurement of spasticity. *Disability & Rehabilitation* 2005;27(1-2):69-80.
12. Pizzi A, Carlucci G, Falsini C, Verdesca S, Grippo A. Application of a volar static splint in poststroke spasticity of the upper limb. *Archives of physical medicine and rehabilitation* 2005;86(9):1855-9.
13. Fleuren JFM, Voerman GE, Erren-Wolters CV, Snoek GJ, Rietman JS, Hermens HJ, Nene AV. Stop using Ashworth Scale for the assessment of spasticity. *J Neural Neurosurg Psychiatry* 2010;81:46-53.
14. Blackburn M, Vliet PV, Mockett SP. Reliability of measurements obtained with the Modified Ashworth Scale

- in the lower extremities of people with stroke. *Physical Therapy* 2002;82(1):25-34.
15. Pandyan AD, Johnson GR, Price CIM, Curless RH, Barnes MP, Rodgers H. A review of the properties and limitations of the Ashworth and Modified Ashworth Scales as measures of spasticity. *Clinical Rehabilitation* 1999;13:373-383.
  16. Kohan AH, Abootalebi Sh, Khoshnevisan AR, Rahgozar M. Comparison of Modified Ashworth Scale and Hoffmann Reflex in study of spasticity. *Acta Medica Iranica* 2010;48(3):154-157.
  17. Levin M, Hui-Chan C. Are H and stretch reflexes in hemiparesis reproducible and correlated with spasticity? *Journal of neurology*. 1993;240(2):63-71.
  18. Cooper A, Musa IM, Deursen RV, Wiles CM. Electromyography characterization of stretch responses in hemiparetic stroke patients and their relationship with the Modified Ashworth Scale. *Neurorehabil Neural Repair* 2009; 23: 287-294.
  19. Sköld C, Harms-ringdahl K, Hultling C, Levi R, Seiger K. Simultaneous Ashworth measurements and electromyographic recordings in tetraplegic patients. *Arch Phys Med Rehabil* 1998; 79: 959-65.
  20. Delwaide PJ. Electrophysiological testing of spastic patients: its potential usefulness and limitations. In: Delwaide PJ, Young RR, eds. *Clinical neurophysiology of spasticity. Contribution to assessment and pathophysiology*. Amsterdam: Elsevier, 1985:185-203.
  21. Fu-Mei L, Mohamed S. Correlation of spasticity with hyperactive stretch reflexes and motor dysfunction in hemiplegia. *Archives of physical medicine and rehabilitation* 1999;80(5):526-30.
  22. Fève A, Decq P, Filipetti P, Verroust J, Harf A, N'Guyen JP, Keravel Y. Physiological effects of selective tibial neurotomy on lower limb spasticity *J Neurol Neurosurg Psychiatry* 1997;63:575-578.
  23. Joodaki MR, Olyaei GR, Bagheri H. The effects of electrical stimulation of the lower extremity on H-reflex and F-wave parameters. *Electromyogr Clin Neurophysiol* 2001;41:21-8.
  24. Rosche J, Rub K, Niemann-Delius B, et al. Effects of physiotherapy on F-wave amplitude in spasticity. *Electromyogr Clin Neurophysiol* 1996;36:509-11.
  25. Hiersemenzel L-P, Curt A, Dietz V. From spinal shock to spasticity. Neuronal adaptations to spinal cord injury. *Neurology* 2000;54:1574-82.
  26. 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. 2008;23(3)231-7.
  27. Kamper DG, Rymer WZ. Quantitative features of the stretch response of extrinsic finger muscles in hemiparetic stroke. *Muscle & nerve* 2000;23(6):954-61.
  28. Deitz V, Quintern J, Berger W. Electrophysiological studies of gait in spasticity and rigidity: evidence that altered mechanical properties of muscles contribute to hypertonia. *Brain* 1981;104:431-49.
  29. Vattanasilp W, Ada L, Crosbie J. Contribution of thixotropy, spasticity, and contracture to ankle stiffness after stroke. *J Neurol Neurosurg Psychiatry* 2000;69:34-9.
  30. Sheean G. The pathophysiology of spasticity. *European Journal of Neurology* 2002;9(Supplement 1):3-9.
  31. Schecker LR, Chesher SP, Ramirez S. Neuromuscular electrical stimulation and dynamic bracing as a treatment for upper-extremity spasticity in children with cerebral palsy. *Journal of Hand Surgery (European Volume)* 1999; 24(2):226.
  32. Blazer J, Leffler JB, Murray CF. How rating scales help assess the impact of movement disorders. *Practical Neurology*. 2007; 2:24-28.
  33. Lannin NA, Cusick A, McCluskey A, Herbert RD. Effects of splinting on wrist contracture after stroke: a randomized controlled trial. *Stroke* 2007;38(1):111.