

## ORIGINAL ARTICLE

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## RELATIONSHIP BETWEEN MODIFIED ASHWORTH SCALE AND ALPHA MOTONEURON EXCITABILITY IN SPINAL CORD LESIONS

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## ABSTRACT

**Background:** Spasticity is one of the major neurological complications occurring in people with Spinal Cord Lesions due to loss of supra-spinal and spinal control over alpha motor neuron activity. Its accurate assessment is necessary for tailoring patient specific rehabilitation program. Clinical assessment is commonly done through Modified Ashworth Scale where in the examiner subjectively judges resistance to passive range of motion whereas, electrophysiological quantification of spasticity can be done through Hoffman's Reflex which is an estimate of alpha motor neuron activity.

**Methods:** This co-relational study establishes an association between MAS and H reflex in a sample of both traumatic and non-traumatic Spinal Cord lesion patients. A sample of 22 patients was obtained who were rated for MAS grades 0,1,1+,2 and 3 in bilateral gastro soleus and consequent H reflex elicitation was done.

**Results:** Karl Pearson Correlation coefficient was calculated between MAS and H amplitude ( $r = 0.342$ ,  $p < 0.05$ ); MAS and h latency ( $r = 0.013$ ,  $p > 0.05$ ); MAS and H/M ratio ( $r = 0.190$ ,  $p > 0.05$ ).

**Conclusion:** It was concluded that there exists a weak but significant correlation between MAS and H amplitude but non-significant relationship between MAS and H latency; MAS and H/M ratio.

**Keywords:** Spasticity, Modified Ashworth Scale, Alpha motoneuron Excitability, H reflex, Spinal Cord Lesions.

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## INTRODUCTION

Distinctive syndromes related to physiological and anatomic features of Spinal Cord are known as Spinal Cord Lesions (Myelopathy) which affect its functions of sensorimotor conduction and reflex activity. Spinal Cord Lesions can be divided into traumatic and non-traumatic lesions [1]. The incidence as well as prevalence of spinal cord lesions is on rise worldwide as estimated by various studies [2]. Amongst the range of medical complications, commonest and major neurological / musculoskeletal consequence following Spinal Cord Lesions is spasticity (an accompaniment of upper motor neuron lesions) besides others like urinary tract infection, pressure sores, neuropathic pain and various systemic problems [3,4]. Spasticity accounts for 17.3% cases in traumatic lesions and in 7.9% cases of non-traumatic lesions [5]. It is defined by Lance in 1980 as “a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex” which presents as exaggerated movements in the tendons associated with hypertonia and hyperreflexia due to the neuronal hyperexcitability as one of the signs of upper motor neuron syndrome [6].

The reduced brain control over the cord by neurological disorders and intact segmental peripheral input transforms the spinal interneuronal network activity to generate exaggerated muscle tone, lower threshold of stretch reflexes, their increased gain, widening trigger area for local cutaneo-muscular withdrawal reflex responses and from reduced to absent voluntary movement, up to involuntary movements [7]. After Spinal Cord Injury there is fundamental loss of modulation of activity of a given motor pool voluntarily and deficit of coordination among motor pools and the interneurons projecting to these motor pools [8]. Variety of clinical, biomechanical and neurophysiological techniques and procedures have so far been developed to assess and quantify spasticity [9,10]. The Modified Ashworth Scale (MAS) is an ordinal scale used as a common clinical measure to assess the resistance encountered during passive muscle stretching that does not require any instrumentation and is quick to perform [11]. On the other hand, electrophysiological assessment of spasticity can be done by testing of monosynaptic reflex response by H reflex (8). The Hoffman reflex described by Paul Hoffman in 1910, is an electrical analogue to the mechanically induced spinal stretch reflex [12]. It is a stimulated reflex bypassing the muscle spindle sense organs thus sensitive of direct motoneuron activity [13]. It gives an impression of alpha motoneuron excitability in Spinal Cord [14].

Spasticity is a complex phenomenon and it is important to diagnose, evaluate and understand multidimensional characteristics and presentations for better solution of rehabilitation protocols for better prognosis. But there still exists a dilemma about association between clinical method of assessment and estimation of alteration of alpha motor neuron excitability in spasticity due to Spinal

Cord Lesions. Thus, there is a need to find co-relational basis between MAS and electrophysiological parameters H reflex amplitude, H reflex latency and H/M ratio for spasticity after Spinal Cord lesions.

## METHODOLOGY

The research work was approved by the Institutional Ethical Committee at Punjabi University, Patiala, Punjab according to the guidelines of Indian Council of Medical Research. The research setting was Research laboratory, Department of Physiotherapy, Punjabi University, Patiala and patients were obtained from clinic of Department of Physiotherapy. From the population of patients suffering with Spinal Cord Lesions, 22 subjects were selected using purposive sampling with their age group 18-65 years and having spasticity in bilateral gastrosoleus muscle. Exclusion criteria were any neurological disease of cerebral origin, symptoms of flaccidity, rigidity, musculoskeletal abnormalities, or any skin diseases. Written Voluntary consent for participation was taken from each subject prior to the study. Screening and sensorimotor assessment were performed along with ASIA scoring and determination of neurological level of lesion.

Tone assessment of gastrosoleus muscle was done and graded according to Modified Ashworth Scale for both right and left limbs. The subject was made to lie down in supine and therapist placed one hand on the knee to stabilize the leg and other hand under the foot with thumb on the lateral aspect of calcaneus, fingers on medial aspect of calcaneus and palm on plantar surface of the foot. The ankle was moved from maximum plantar flexion to maximum dorsiflexion for a duration of one second [15]. Resistance to passive muscle stretch was rated according to degree of muscle hypertonia on six-point ordinal scale ranging from 0 to 4 (0, normal muscle tone; 4, fixed muscle contracture). For co-relational analysis, the ordinal scale value of grade 1+ of Modified Ashworth Scale was converted into ratio type data and used as 1.5 [16].

Leg length was measured as the distance from middle of the mid popliteal crease to the point at the most proximal part of the medial malleolus [17].

H reflex recording was done with patient in prone position and feet suspended of the couch. Skin temperature measured and the skin was cleansed with cotton dipped in alcohol solution to reduce the skin impedance. Room temperature was maintained throughout the procedure from 20 – 23° C using an air conditioner. Recording was done using NCV/EMG machine (Neuroperfect-2000) manufactured and calibrated by Medicaid System (an ISO 9001:2000 certified company), Chandigarh, India. Procedure of H reflex elicitation was adopted from Bakheit et al [18] and Aminoff [19]. Two small (silver-silver chloride) electrodes were used such that Active electrode over the medial head of the gastrocnemius halfway between the medial malleolus and the tibial epicondyle; Reference electrode over the insertion of the Achilles tendon; Earth electrode over the lateral head of the gastrocnemius

muscle between the stimulator and stimulating electrode over the tibial nerve in the popliteal fossa. A subthreshold current was given through a rectangular electrical pulse of 1 ms duration and with a stimulus frequency of 1 per ten seconds. The optimal position for stimulating the tibial nerve in the popliteal fossa was determined by moving the stimulating electrode around until a visible contraction of the gastrocnemius muscle was seen. The response with the largest amplitude was selected as the H max. The H reflex latency was measured from the start of the stimulation to the onset of the initial deflection of the H reflex. The maximum amplitudes of the H reflex and the M wave were measured from the peak of the positive to the peak of the negative deflections. The H max to M max ratio was calculated in the computer itself by dividing the maximum amplitudes of the H reflex by that of the M wave.

**STATISTICAL ANALYSIS** - Mean and standard deviation were calculated for certain parameters in demographic profile. Karl Pearson Correlation was found between MAS grades and H reflex amplitude, latency and H/M ratio. Results were calculated by using 0.05 level of significance. Strength of relationship was assessed with respect to correlation ranges as in  $r = 0.00 - 0.25$  were considered having little or no relationship;  $r = 0.25 - 0.50$  as fair relationship;  $r = 0.50 - 0.75$  as moderate to good relationship and  $r = 0.75- 1.00$  was considered as having good to excellent relationship [20].

**RESULTS**

Out of total subjects, 20 were male and 2 were female. Age was divided into 3 groups such that (50% ) of the total participating subjects were of 18-33 years , 36% of 34 - 49 years and 14 % subjects of 50-65 years age. On the basis of occupational status of subjects, 50% were employed, 23% of the subjects were students, 18% peasants and 9% were unemployed. Demographic profile of the subjects including mean and standard deviation of age, duration of illness, skin temperature, and leg length is shown in table 1.

**Table 1:** Mean and SD of Age, Duration of Illness, Skin Temperature and Leg Length

Demographic data	Mean	Standard deviation
Age (years)	36.136	13.492
Duration of illness (years)	6.082	4.870
Skin temperature	30.88	1.74
Leg length(right side)(cms)	39.684	2.451
Leg length(left side)(cms)	39.824	2.128

77% subjects out of the whole participating population suffered traumatic spinal cord injury while 23% cases were of non-traumatic spinal cord lesions. Mechanisms of traumatic injuries were road traffic accidents in 53% of subjects, fall from height in 29%, and violence , sports related injury and struck by falling object accounted for 6% each. Cervical segments were affected in 37% subjects, thoracic in 36% and lumbar segment in 27 % cases. According to ASIA Impairment Scale classification,

23% of samples were with AIS A type of lesion, 27% with AIS B, 9% with grade C, 36% patients grade D and 5% with AIS E.

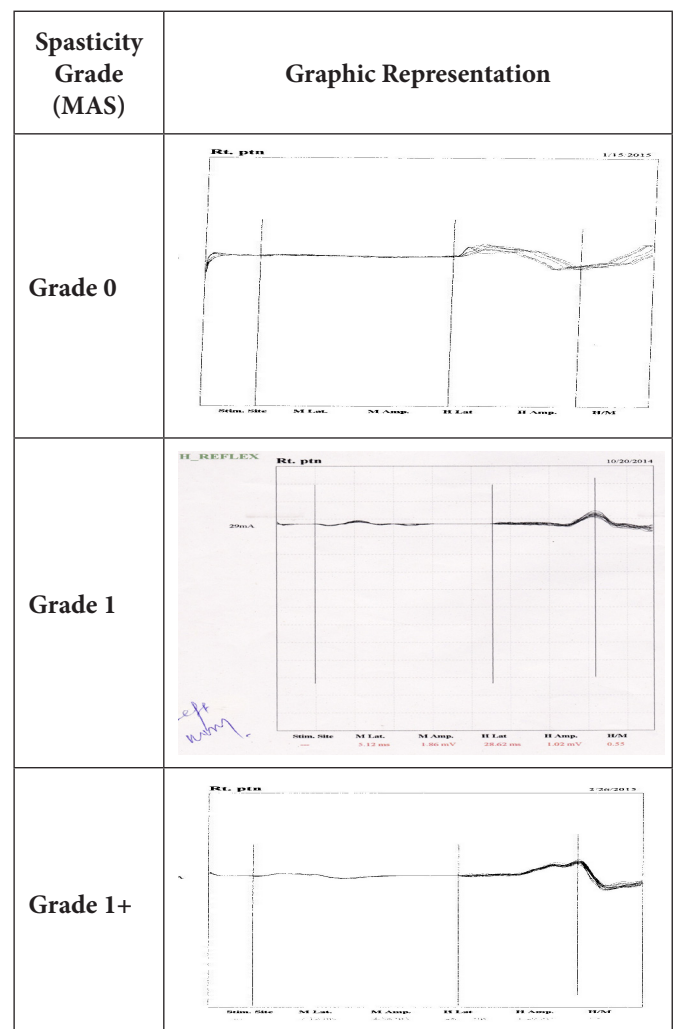
On tone assessment using MAS grades, all grades except grade 4 were identified in the both lower limb calf muscles in the obtained sample. H reflex was elicited 19 out of 22 subjects for right side gastrosoleus and in 17 patients for left side. As the MAS grades were found to different between two limbs, so each limb grade was considered as a single individual variable for correlation data analysis. There exists a significant and fair degree of relationship between MAS and H amplitude as shown in Table 2 whereas no or least relationship between MAS and H/M ratio and between MAS and H latency.

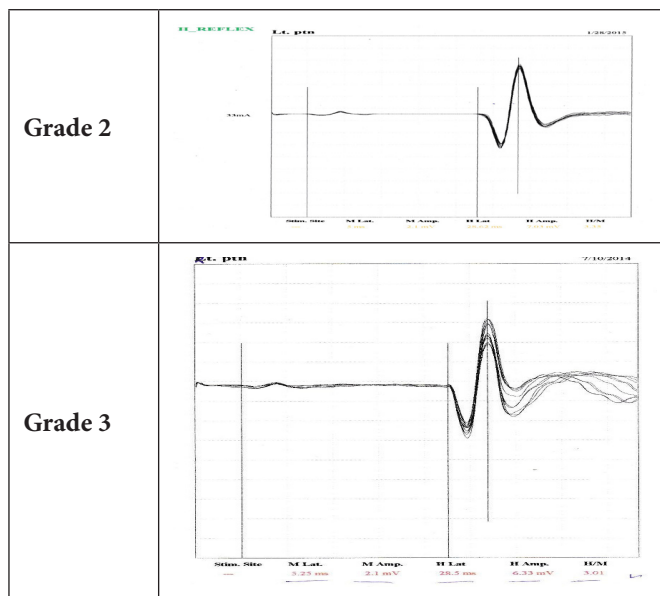
**Table 2:** Depicts Correlation between MAS and H reflex amplitude, H reflex latency and H/M ratio.

	Mean ± Standard Deviation	r	P
H amplitude	29.019 ± 2.458	<b>0.342*</b>	<b>0.041</b>
H latency	1.973 ± 2.108	0.013 <sup>NS</sup>	0.942
H/M ratio	1.063 ± 1.258	0.190 <sup>NS</sup>	0.266

NS (Non-significant) =  $r_{(34, 0.05)} < 0.325$  and  $(p > 0.05)$  , \* significant =  $r_{(34, 0.05)} > 0.325$  and  $(p < 0.05)$

**Table 3:** Depicts Graphical Representation for each Grade of Spasticity





## DISCUSSION

Injury to Spinal Cord affects conduction of sensory and motor signals [21]. Lesion to the upper motor neurons result in decentralization of the nervous system and motor, sensory and reflex activities occur in lack control from brain resulting in spastic paralysis and exaggerated sensorimotor reflexes below the injury [22]. This state of reflex behaviour and muscle mechanics in patients with spasticity can be evaluated in passive (clinical) and active non-functional (laboratory setting) form [23]. This co-relational study was undertaken to understand any association or relation between clinical evaluation of muscular characteristics by Modified Ashworth Scale and neurobiological measures like H amplitude, H latency, H/M ratio parameters measuring alpha motor neuron excitability for spasticity after spinal cord lesions. There had been significant increase in H amplitude with increase in spasticity grades but not significant with H/M ratio and H latency. There is increase in H/M ratio with increase in spasticity but in a nonlinear manner such that no correlation is seen with clinical spasticity.

Similar non-significant rise was found in H/M ratio with increase in spasticity in patients with multiple sclerosis [24] in cerebral lesion, myelopathy and spastic paraparesis [25]. Shorter H latencies and a non-significant increase in H/M ratio in patients with mild to moderate post stroke spasticity suggested a non-linear relation between MAS and  $\alpha$  motor neuron excitability (18). On the other hand, contrasting significant correlation had been found between MAS and H/M ratio in 15 Spinal Cord Injury patients, 19 stroke patients and 23 neurologically normal subjects on elicitation of H reflex [26].

Analogous results were found for spasticity in children with cerebral palsy. Kohan et al., (2010) noted no significant relationship between electrophysiological parameters H/M ratio and H latency [27] whereas Tekgul et al.,(2013) noticed that H latencies were significantly shorter in children with spastic cerebral palsy and H/M ratio were significantly higher showing that there is relation with increase in spasticity[28].

Thus, incongruence still remains between clinical measurement of spasticity by MAS and laboratory quantification of alpha motoneuron excitability through H reflex in patients with Spinal Cord Lesions. Modified Ashworth Scale measures only the level of resistance to passive movement [9] or muscle hypertonia rather than spasticity [18]. It is also inherent to the subjective judgement of the tester testing velocity dependent resistance to passive range of motion.

The ratio between the maximum amplitude of H-wave (Hmax) and that of M-wave (Mmax), shows the percentage of excited alpha motor neurons upon electrical stimulation of all the alpha motor neurons that dominate the targeted muscle (i.e. soleus muscle)[29,19]. Change in H-reflex amplitude reflects changes in the excitability of the reflex pathway [30]. Spasticity is a multidimensional phenomenon with different neurophysiological mechanisms involved and associated variable presentation. So there may be effect of various intrinsic and extrinsic factors related to the patient and condition. Significant H reflex suppression was obtained in acute group and chronically paralysed soleus displayed low frequency depression of H reflex [30]. This shows effect of time duration since injury in acute and chronic Spinal Cord Injury. It is indicated that H reflex excitability is correlated with adaptability of neuromuscular system [30] as might come with rehabilitation or activity level of patient suffering with Spinal Cord Lesions.

Limitation of the study was that it was a one-time study and recordings seemed to be an incidental finding. Sample size was also small with no homogeneity present. Long term changes in clinical spasticity and changes in H reflex due to variable factors and demographic parameters cannot be considered. Intergrade correlation also could not be done. Therefore in future large sample size can be considered along with homogeneity in sample may be on the basis of type of lesion or association with type of injury according ASIA Impairment Scale classification. A follow up or longitudinal study can be undertaken to detect the long term changes and scrutinize the effect of various factors affecting elicitation or changes in H reflex.

## CONCLUSION

The present study concludes that H amplitude significantly increases with increase in spasticity whereas no significant relation is present between Modified Ashworth Scale and H / M ratio; Modified Ashworth Scale and H latency. There is poor correlation between results of test of alpha motor neuron excitability (H reflex) and degree of spasticity according to MAS. Thus expressing spasticity measurement by Modified Ashworth Scale as a ratio with H reflex is an elusive measure, nevertheless the neurophysiological test is the precise measurement of integrity of the stretch reflex pathway and alterations in alpha motor neuron excitability in spasticity.

## Authors Contribution

NA is the prime researcher& author of the present study. PKB facilitated in implementation of the concept and

conduct of the study. GK conducted the work as per the instructions and framework of the study designed by NA.

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