Standardized Assessments for the Management of Children with Motor Disorders

MODIFIED ASHWORTH SCALE (MAS)

Assessment Authors: Bohannon & Smith (1987)

Description of Assessment

Purpose: Evaluation of Hypertonia. Most studies of clinical spasticity measurement and treatment of spastic paresis have consistently utilized the Modified Ashworth Scale, a tone or stiffness measuring scale, that has become a de facto criterion standard. However, the scale simply measures the resistance to passive movements of a joint which is not an exclusive measure of spasticity.

Therefore, to be more precise, the purpose of the MAS is the evaluation of hypertonia.

Hypertonia is defined as abnormally increased resistance to externally imposed movement about a joint. It may be caused by (1) spasticity, (2) dystonia, (3) rigidity (immovable joint), or (4) a combination of features.

Assessment Details

In an effort to improve the reliability of the MAS, Bohannon and Smith (1987) proposed to:

- Test the patient in the supine position.
- Extend the joint from a position of maximal possible flexion to maximal possible extension.
- Standardize hand positioning and the resting limb position before stretch. However, Bohannon and Smith provided instructions for the elbow only. For the purposes of this educational program, specific step by step procedure guidelines were developed by the investigators for 2 upper limb and 2 lower limb joints.
- Standardize the timing of the extension of the limb: Use a duration of about one second (by counting “one thousand one”).
- Keep repeated movement cycles at a minimum. Repeat the measurement 5 to 8 times and choose the most reliable / consistent measurement.

To further improve the reliability of the MAS, investigators for this educational program propose that the available range of motion be subdivided into quarters. Increased muscle tone, resistance, catch & release or clonus will be rated according to the location within these quarters:

1	1+	2 or 3
Refers to a catch and release / clonus OR minimal resistance in the 4th quarter of the available range of motion.	Refers to a catch and release / clonus followed by minimal resistance in the 3rd quarter of the available range of motion.	Refers to an increase in muscle tone that begins in the 1st or 2nd quarter of the available range of motion.

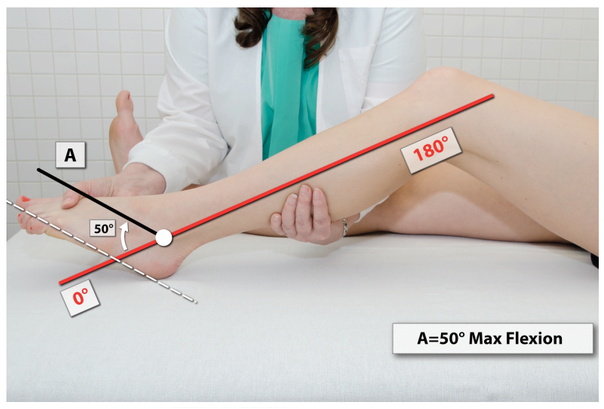
Key components of reliably measuring tone using the MAS include:

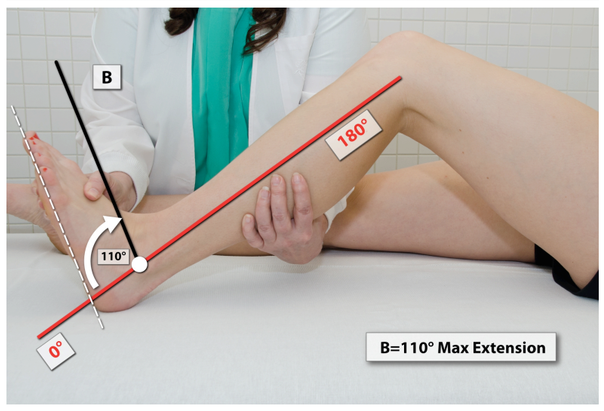
1. Understanding of MAS definitions and accurately calculating the quarters of available range.
2. Keeping the patient's body and limb position the same & stabilization of the proximal limb segment.
3. Using standardized hand placement for the clinicians.
4. Using a consistent speed of movement of one second for the full available range.
5. Ability of clinicians to recognize the different manifestations of muscle resistance.
6. Ability of clinicians to identify maximum flexion, maximum extension, and pinpoint the location where resistance begins.
7. Accurate recording of all measurements and calculations.
8. The need to practice of standardized process to gain proficiency and accuracy - even for skilled clinicians.

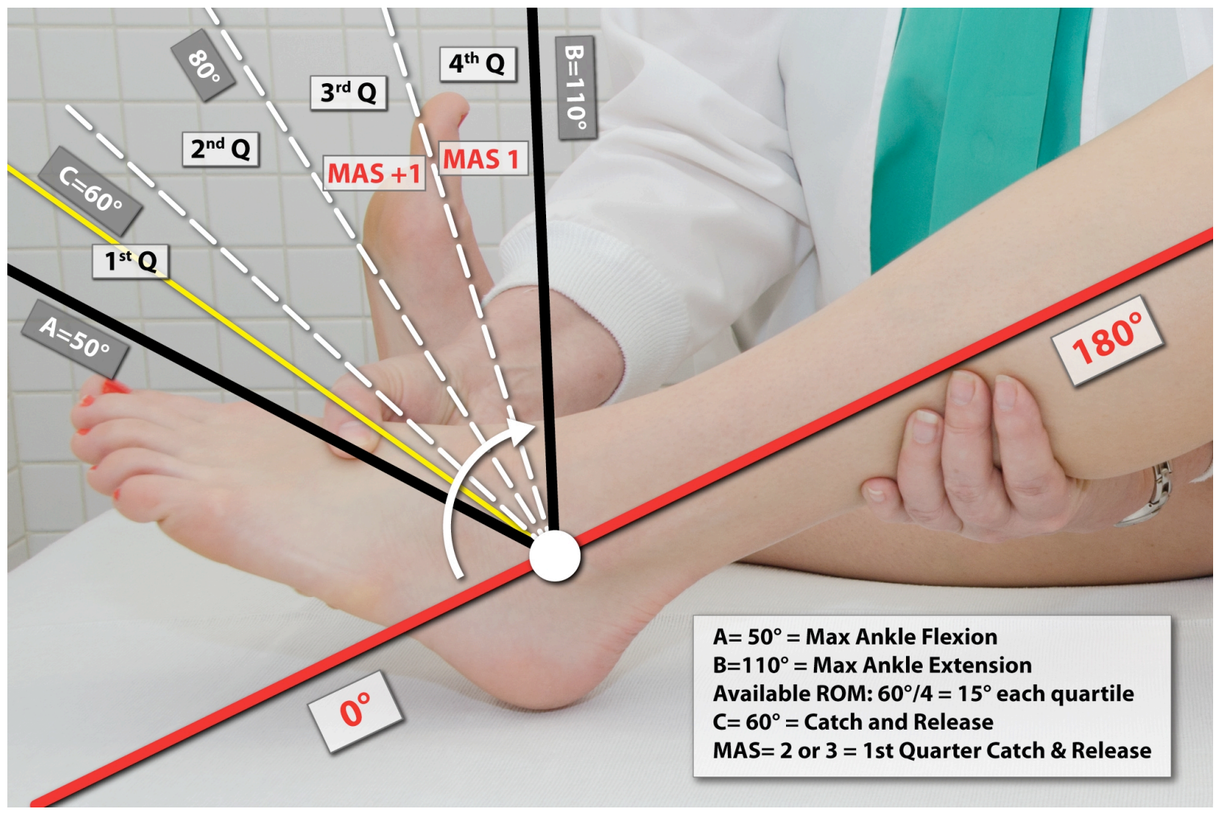
Rating System

Simple numerical rating of the resistance to passive movement about a joint measured on a scale of 0 (no resistance) to 4 (immovable joint).

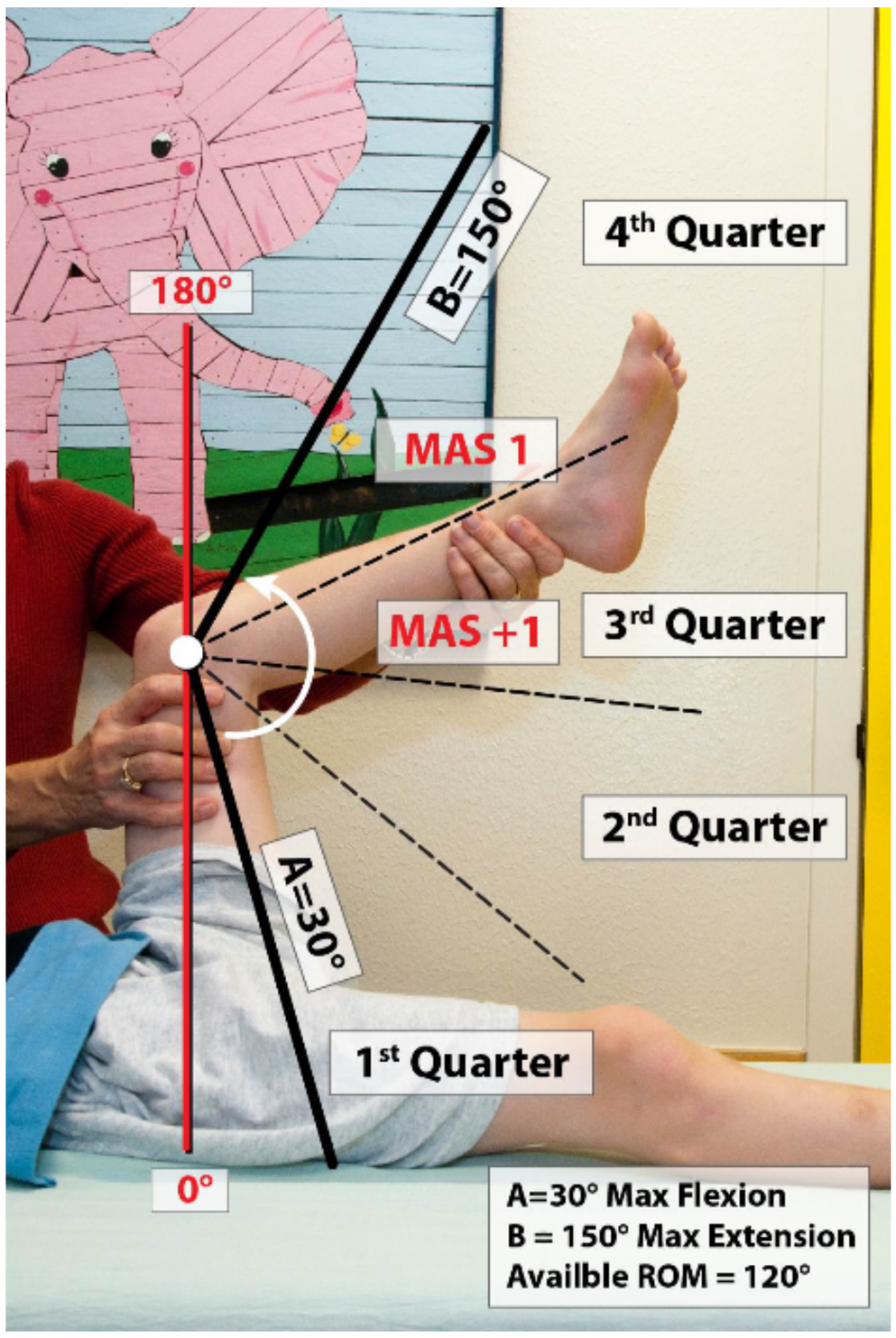
ANKLE



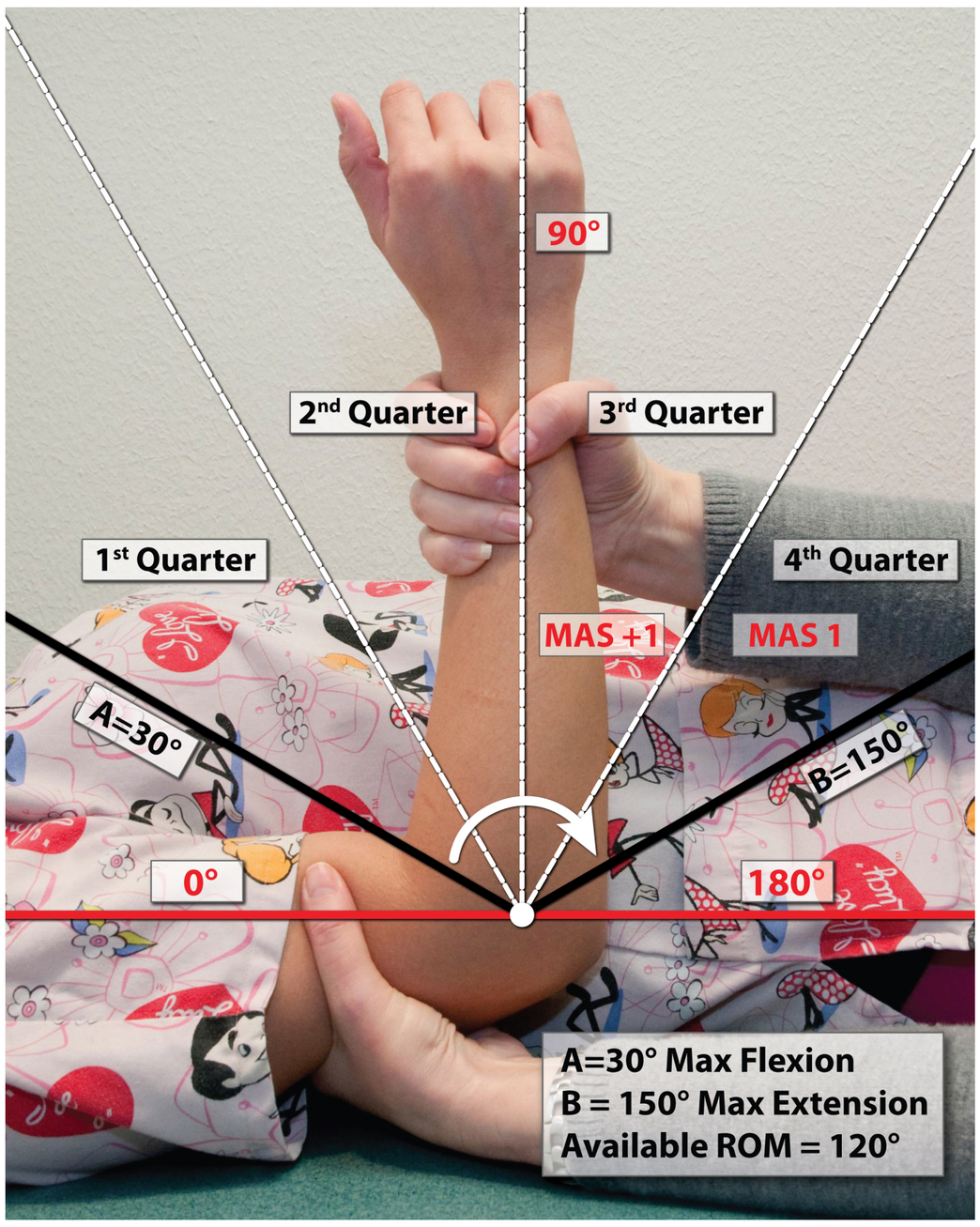




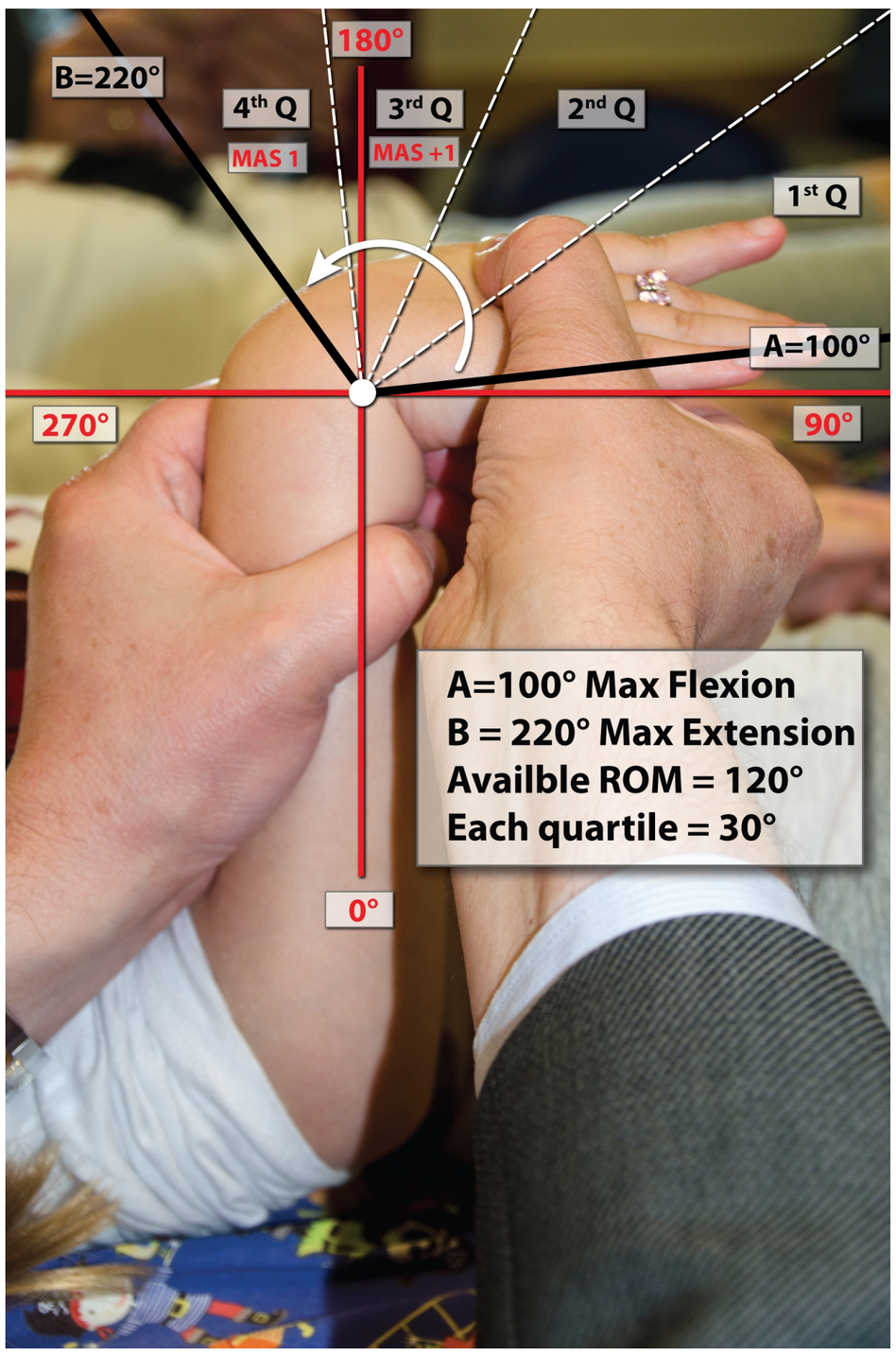
KNEE



ELBOW


90°
2nd Quarter
3rd Quarter
1st Quarter
4th Quarter
MAS +1
MAS 1
A=30°
B=150°
0°
180°
A=30° Max Flexion
B = 150° Max Extension
Available ROM = 120°

WRIST


180°
B=220°
4th Q
3rd Q
2nd Q
MAS 1
MAS +1
1st Q
A=100°
270°
90°
0°
A=100° Max Flexion
B = 220° Max Extension
Availble ROM = 120°
Each quartile = 30°

0	No increase in muscle tone. Normal muscle tone.
1	Slight increased in tone, manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part is moved in flexion or extension. [4th QUARTER]
1+	Slight increased in tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the range of motion. [3rd QUARTER]
2	More marked increase in muscle tone through most of the range of motion, but affected parts are easily moved. [1st or 2nd QUARTER]
3	Considerable increase in muscle tone; passive movements difficult. [1st or 2nd QUARTER]
4	Affected part rigid in flexion or extension.

Background / History

Development of the Assessment

The Ashworth Scale (Ashworth 1964) was initially designed to examine the effects of antispasticity drugs on spasticity in adults with Multiple Sclerosis. Ashworth proposed a method for measuring muscle “spasticity” by manually moving a limb through the range of motion to passively stretch specific muscle groups. The original five-point ordinal scale graded the resistance encountered during such passive muscle stretching on a scale of 0 (no resistance) to 4 (rigidity).

Bohannon and Smith (1987) reported that in their previous experience with the Ashworth scale, many adult patients with hemiplegia demonstrated levels of “spasticity” defined by the grades at the lower end of the Ashworth Scale and that the grade of “1” was indiscrete. To render the scale more discrete, they added a grade of “1+” to indicate resistance through less than half of the movement and slightly modified the definitions. This new scale is commonly referred to as the Modified Ashworth Scale (MAS).

Reliability

The reliability of the MAS is often debated. In addition to questions regarding the relationship of resistance to movement to spasticity and the imprecise descriptions of the various grades on the scale, it is difficult to compare the assessments of reliability of different studies due to a lack of:

- Well defined inclusion/exclusion criteria.
- Specific protocol for the assessment procedure.
- Varied in number of raters used and their experience.
- Adequate sample sizes.
- Focus only on a particular muscle group.
- Reliability results vary by muscle group.
- Wide variety of statistical analyses.
- Varying time between re-testing.

Validity

Most validity studies aim to correlate the MAS with other clinical measurements of spasticity, neurophysiological measures, or biomechanical indices or test the sensitivity of the MAS to detect changes after treatment.
Some studies fail to support the validity of the MAS while other studies support the validity. And an equal number of studies provide evidence for both conclusions (positive correlations for only certain neurophysiological or biomechanical measures or support for only specific muscle groups). It is important to note that many of these studies provide little information about the subjects, protocol for assessment, or other aspects of the study, not only making comparisons difficult but also making it difficult to critically examine the results. Furthermore, many studies have small subject numbers or restrict the assessments to only one or two muscle groups. Additionally, the very definition of a correlation being classified as poor, fair, adequate, good, or excellent vary from study to study.
Finally, some studies failed to understand that this is a nominal or potentially ordinal scale and should not be used as an interval or ratio scale.

In general, there is sufficient evidence to conclude that the MAS is a valid measure of resistance to passive movement.

For any study using the MAS, it is critical that inclusion and exclusion criteria are clearly defined, a standardized protocol of how to assess a muscle group (patient & limb position, number of times to repeat the measurement, speed, etc.) is utilized as well as precise definitions of the various scores be established.

Pros & Cons

Pros

- Free.
- Simple rating scale.
- Can be used for most muscle groups.
- No additional equipment needed.
- Used in children and adults.
- Used in any populations with hypertonicity.
- Standardization of the assessment technique (patient position, examiner hand positioning, speed, etc.) and adequate training increases reliable and valid measurements.

Cons

Tools such as the Ashworth and the Modified Ashworth Scales have been used in clinical trials under the assumption that they measure spasticity. However, it is now established that these instruments evaluate a combination of soft tissue contracture and spastic dystonia, in addition to spasticity itself.

In the description of the grades in the Ashworth Scale, grade 1 is the only one describing an unequivocal spastic reaction: that is a “catch-and-release” or a minimal resistance through some of the range of motion. These two events are typical of muscle contraction under stretch. The “catch-and-release” corresponds to the clasp knife phenomenon (sudden abolition of resistance during the stretching movement). The continuous minimal resistance corresponds to a discharge of motor units, which is not synchronous enough to produce a torque that can arrest the movement of the examiner. A resistance due to passive tissue would increase along the range of motion and would not stay “minimal”.

The description for grades 2 to 4 is purely subjective and may encompass resistance due to:

- Muscle or joint contracture.
- Spastic dystonia.
- Muscle contraction under stretch (the only one which is truly spasticity).

Therefore, the Ashworth Scale is not spasticity specific. In addition, the notion of velocity dependence does not appear.

Additional concerns have been noted:

- Some muscle groups are more reliable than others.
- Results may vary due to improper positioning of the patient:
  - Difficulty maintaining head alignment and opposite limb positioning.
  - Difficulty stabilizing proximal limb.
- The size of patient may affect results: (especially patients with large extremities):
  - Inability to produce enough speed at the knee joint to produce a consistent catch.
  - Difficulty to stabilize the proximal limb appropriately.
- Size of examiner may affect results:
  - A short examiner may have difficulty stabilizing if the patient is on a high surface.
  - A short examiner may place hands at different places than a tall examiner on a long extremity.
  - A tall examiner may have difficulty visualizing joint angle due to having to bend down.
- Strength of examiner may cause error in measurements:
  - A stronger examiner may produce a different speed at any one joint especially at the knee.
  - A weaker examiner may not be able to generate enough speed to create a catch on a large extremity.
- Lack of experience may affect the results:
  - Fear of hurting patient when breaking through dystonia to achieve full range of motion.
- Speed of movement will affect the results:
  - Up to 300 degrees per second needed to elicit a catch and release.
  - Some joint's lever arms are better designed for speed.
- Relaxation level of patient will affect results:
  - Cocontraction at a joint will cause variability.
  - Excitement level of child.
- Deformities can alter the results:
  - Femoral anteversion will tend to cause a rotation when performing evaluations on knee flexors.
  - Tibial internal or external rotation.
  - Hind foot valgus associated with midfoot break down can make it difficult to maintain a foot in subtalor neutral with high velocity movements.
  - Hip subluxation or dislocation can alter muscle length tension ratios.
  - Joint contractures.