Standardized Assessments for the Management of Children with Motor Disorders

TARDIEU SCALE

Assessment Authors: Tardieu, Held & Pierrot-Deseillingny, Gracies

Description of Assessment

Purpose: The Tardieu Scale is primarily used by clinicians to assess spasticity in individuals with neurological conditions such as stroke, traumatic brain injury, spinal cord injury, multiple sclerosis, and cerebral palsy. Spasticity is defined as a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks resulting from hyper-excitability of the stretch reflex. The Tardieu Scale has gained momentum over the past decade as the preferred clinical assessment of spasticity. The Tardieu Scale assesses resistance to passive movement at slow and fast velocities, therefore broadly differentiating between contracture (non-neural factors) and spasticity (neural factors).

Rating System

Patient must remain in a constant position throughout the test. Head should be in midline or in a constant position each time tested.

Velocity of Stretch is indicated for each muscle and remains the same from one test to another, as follows.

V_1 = The velocity is as ***slow*** as possible (greater than three seconds)

V_3 = The velocity is as ***fast*** as possible (less than one second)

Angle of Resistance is where increased resistance is first felt:

X_{V1} = The angle of arrest at ***slow*** speed of stretch.
(The angle of the end of range or maximum passive range of motion.)

X_{V3} = The angle where the catch-and-release or clonus is first felt at ***fast*** speed (less than one second).

X: SPASTICITY ANGLE:

$X_{V1} - X_{V3} = X$

The Spasticity Angle reflects the velocity-dependence of the stretch reflex.
The larger the spasticity angle, the more spastic the muscle.

Y: SPASTICITY GRADE: Quality of the muscle reaction (GAIN):

0 = No resistance throughout passive movement.

1 = Slight resistance throughout passive movement.

2 = Clear catch at precise angle, interrupting passive movement, followed by a release.

3 = Fatigable clonus (*less* than 10 seconds when maintaining pressure) occurring at a precise angle.

4 = Unfatigable clonus (*more* than 10 seconds when maintaining pressure) occurring at a precise angle.

Catch without release:
Graded 0 if $X_{V1} = X_{V3}$

Catch without release:
Graded 2 if X_{V3} occurs repeatedly at a consistent angle and consistently < X_{V1}

Catch with "minimal" release:
Graded 2 if X_{V3} is consistent and consistently < X_{V1}

Catch with "minimal" release:
Graded 'unratable' if X_{V3} is variable / inconsistent

For grades 0 and 1, Spasticity Angle = 0 by definition.

Tardieu Spasticity Scale

X = Degree, Y = 0 to 4, Indicate "NR" if not ratable.		Left	Right
Muscle Group:	X_{V1}		
	X_{V3}		
	$X_{(V1 - V3)}$ Spasticity Angle		
	Y		

Background / History

Development of the Assessment

In 1954, Guy Tardieu proposed that spasticity was a velocity-dependent exaggeration of the muscle response to phasic stretch. Following his clinical and physiological observations, Tardieu presented the principles of his clinical method for measuring spasticity. In 1966, he described in detail his procedure, muscle group by muscle group. In 1969, Held and Pierrot-Deseillingny used Tardieu's method to develop a "scale" to measure the spasticity. Finally, Gracies worked from the initial modifications by Held and Pierrot-Deseilligny, to simplify and transform Tardieu's clinical method into a scale easily usable by the clinician. In 1999, Boyd and Graham modified the scale and introduced new terms for the measurements and new testing positions. Currently, there are many variations of the original scale currently used in practice with different labels for the measurements and different test positions for specific muscle groups.

There are three key components of the test: (1) the velocity of stretch, (2) the quality of muscle reaction, and (3) the angle of the muscle reaction. The Tardieu Scale involves performing passive muscle stretch at different velocities. The rater derives two parameters: (1) The Spasticity Angle or Angle of Muscle Reaction: the difference between the angles of arrest at slow speed and of catch-and-release or clonus at fast speed and (2) The Spasticity Grade or Quality of the Muscle Reaction: the intensity (gain) of the muscle reaction to fast stretch.

In earlier Tardieu versions, three speeds were performed: a slow speed below that which would not induce the stretch reflex (V_1), a faster speed which corresponded to the limb segment falling under the influence of gravity (V_2), and a very fast speed (<one second through ROM) to trigger the stretch reflex (V_3). Later versions of the scale only have two speeds, "slow" and "fast". Many clinicians choose to remove the V_2 speed (falling under the influence of gravity) from the assessment and only utilize V_3 when assessing at fast velocity. Additionally, later revisions of the scale introduced new terms, namely R1 and R2 to describe the angle of muscle response for V_3 and V_1 respectively.

Finally, different versions of the scale assign various labels to the Spasticity Grade or Quality of the Muscle Reaction. In later revised versions of the scale, the Spasticity Grade is referred to as the 'X value' while the original version refers to the grade as the "Y value" (and refers to the Spasticity Angle as the 'X value'). All versions agree that the Spasticity Grade is an ordinal variable that grades the type and intensity (gain) of the muscle reaction to fast stretch. However, some clinicians use a 5-point scale rather than a 6-point scale to assess the quality of muscle reaction.

For the purposes of this educational program, the original version of the scale will be presented.

The Spasticity Angle or Angle of the Muscle Reaction is the 'X value'. Two speeds will be used: V_1=a slow speed below that which would not induce the stretch reflex (slow passive range of motion) and V_3=a very fast speed to trigger the stretch reflex.

X (Spasticity Angle) = X_{V1} (angle of maximum range of motion obtained at slow speed) minus X_{V3} (angle of spastic catch at fast speed).

The Spasticity Grade or Quality of the Muscle Reaction is the 'Y value'. The quality of muscle reaction during fast passive stretch (X_{V3}) is graded based on a 0 to 4 rating and is defined at the Tardieu Scale score.

Reliability

There are very few studies reporting on the reliability of the original Tardieu Scale (TS). Most reliability studies report results for the Modified Tardieu Scale (MTS). The reliability of the MTS has been questioned for various patient populations and for particular muscle groups. Although there have been some studies that found insufficient reliability for the MTS, others report good to excellent test-retest and inter-rater reliability.

For any study using the TS or MTS, 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.

Validity

There are only a limited number of studies exploring the validity of the Tardieu Scale. Most validity studies aim to correlate the Modified Tardieu Scale (MTS) with other clinical measurements of spasticity, neurophysiological measures, or biomechanical indices or test the sensitivity of the MTS to detect changes after treatment.

The results are highly variable. Although several studies did not support the validity of the MTS in a particular population or muscle group for specific laboratory measures, the majority provide evidence that the MTS is a valid tool for the use of assessment of spasticity in adults and children.

It is important to note that some 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.

For any study using the TS or MTS, 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.

Principles

Grading always performed:

- On a muscle at rest prior to the stretch maneuver.
- At a reproducible velocity of stretch. Once the fast velocity is selected for a muscle, it remains the same for all subsequent tests.
- At the same time of the day.
- In a constant body position for a given limb.
- Other joints, particularly the neck, must also remain in a constant position throughout the assessment and for all other assessments.

Velocity of stretch is indicated for each muscle and remains the same from one test to another, as follows:

- V_1 = The velocity is as ***slow*** as possible (greater than three seconds)
- V_3 = The velocity is as ***fast*** as possible (less than one second)

Angle of Resistance is where increased resistance is first felt:

- X_{V1} = The angle of arrest at ***slow*** speed of stretch.
  (The angle of the end of range or maxximum passive range of motion.)
- X_{V3} = The angle where the catch-and-release or clonus is first felt at ***fast*** speed (less than one second).

X: Spasticity Angle:

$X_{V1} - X_{V3} = X$

The Spasticity Angle reflects the velocity-dependence of the stretch reflex.
The larger the spasticity angle the more spastic the muscle.

- By definition, in cases of spasticity grades Y equal to 0 or 1, no spasticity angle is specified and the spasticity angle is then given the value 0 (i.e. $X_{V1} = X_{V3}$) for statistical analysis. The spasticity angle is positive by definition.
- Note: In some cases the Tardieu Scale may also use X_{V2}, which is the velocity of the limb segment naturally falling under gravity. X_{V2} is only practical for knee extensors, wrist extensors, and elbow flexors in severely paretic patients, and will not be evaluated in the current study.

Y: Spasticity Grade or Quality of the Muscle Reaction (GAIN):

Y is an ordinal variable that grades the type and intensity (gain) of the muscle reaction to fast stretch (X_{V3}). The phenomenon associated with each grade can only correspond to muscle contraction induced by stretch reflex, not contracture or inadvertent voluntary contraction, in contrast to other scales that have been assumed to measure spasticity.

- *Grade 0:* No resistance throughout passive movement. A "catch" not followed by release that consistently occurs at the end of the range of passive motion. It represents absent spasticity.
- *Grade 1:* Slight resistance throughout passive movement. Mild resistance slowing down the passive movement without complete interruption. It is likely due to a motor neuron pool discharge that is not sufficiently synchronized to generate an opposing force matching that of the examiner.
- *Grade 2:* Clear catch at precise angle, interrupting passive movement, followed by release. Transient interruption of the passive movement (catch and release). This likely reflects a stronger motor neuron discharge that is sufficiently synchronized to generate an opposing force temporarily matching that of the examiner (catch). The motor neuron discharge then decreases allowing the passive movement to resume (release).
  - In cases where the catch is not followed by obvious release, but occurs repeatedly at a consistent angle less than the passive range of motion, it is still accepted as angle of catch-and-release and the grade Y is still considered 2.
- *Grade 3 and 4:*
  - When the release occurs at a speed that is itself faster than the velocity threshold of the stretch reflex, it triggers a new stretch reflex and thus a clinical sensation of re-catch. Following the re-catch comes a re-release, which in succession is termed clonus.
  - *Grade 3:* Fatigable clonus (less than 10 seconds when maintaining pressure) occurring at a precise angle.
  - *Grade 4:* Unfatigable clonus (more than 10 seconds when maintaining pressure) occurring at a precise angle.
- Non-ratable describes a catch not followed by obvious release that occurs at inconsistent angles upon repeat testing. This may correspond to inadvertent voluntary contractions or to non-spastic dystonia. The spasticity is deemed non-ratable (no value for Grade Y).

- **Catch without release:** Graded 0 if $X_{V1} = X_{V3}$
- **Catch without release:** Graded 2 if X_{V3} is consistent and consistently < X_{V1}
- **Catch with "minimal" release:** Graded 2 if X_{V3} is consistent and consistently < X_{V1}
- **Catch with "minimal" release:** Graded 'unratable' if X_{V3} is variable / inconsistent
- **For grades 0 and 1, Spasticity Angle = 0 by definition.**

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

- Knowledge and experience on hypertonia assessment is needed.
- Other involuntary (e.g. mirror movements, chorea, athetosis) or voluntary movements could alter the scoring in less experienced assessors.
- Some muscle groups are more reliable than others.
- 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.
- Assessor hand positioning and patients´ limb positioning are not clearly standardized.
- 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.
- 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.
