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Intraobserver reliability of modified Ashworth scale and modified Tardieu scale in the assessment of spasticity in children with cerebral palsy

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Objective: The aim of this study was to analyze the intraobserver reliability of the Modified Ashworth Scale (MAS) and Modified Tardieu Scale (MTS) in the assessment of spasticity in children with cerebral palsy (CP).

Methods: Elbow flexor muscles, wrist flexor muscles, hip adductors, hamstrings, gastrocnemius and soleus muscles of 37 children (mean age: 8.97±4.41) with spastic CP were evaluated using the MAS and MTS according to the severity of spasticity.

Results: Intraobserver reliability of MAS was significant for all assessments ($p<0.01$) and reliability ranged from 'low' to 'average'. The reliability of MTS was significant for all assessments ($p<0.01$) and intraobserver reliability ranged among 'average', 'good' and 'excellent'.

Conclusion: Although the high intraobserver reliability for MTS to assess spasticity level in muscles of children with CP will improve usage of this scale, new research testing the intraobserver reliability of this scale is needed.

Key words: Cerebral palsy; intraobserver reliability; Modified Ashworth Scale; Modified Tardieu Scale; spasticity.

Cerebral palsy (CP) refers to a non-progressive central nervous system deficit. The lesion may be in single or multiple locations of the brain, resulting in definite motor and some degree of sensory abnormality as well as other associated disabilities.[1] Spasticity, dyskinesia, ataxia and hypotonia are muscle tonus problems seen in children with CP. Spasticity is the most common muscle tonus problem and leads to loss of performance and retardation of motor functional capacity development.[2,3] Although spasticity arises from lesions in the brain, brainstem or spinal cord, it ultimately leads to abnormalities at all motor system levels, including muscles, joints, bones and tendons.[4]

The increase in the muscle tonus limits functional skills, inhibits isolated joint movement, interrupts voluntary movements, interrupts sleep with spasms, and in severe cases causes delay in motor development stages and negatively effects ambulation and hygiene.[5-7] One of the most important goals of rehabilitation in children with CP is to reduce spasticity because of its disabling effects.

Correct evaluation of spasticity is important to determine appropriate therapy strategies and evaluate effectiveness. Body-environment temperature, the position of extremities and the body, fatigue, physiologic factors and other similar variables can affect the severity of spastici-

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ty. However, because of its nature, it is difficult to determine the severity of spasticity in children with CP. Age, mental status and cooperation of the children can affect the evaluation.

The Modified Ashworth Scale (MAS) is the most common clinical scale used to to assess spasticity (*see* Appendix). Despite its widespread clinical use, the reliability of the scale has been questioned in some studies.[8-10] Recent publications report that more studies are needed on the scales reliability.[11-14] Like the MAS, the Modified Tardieu Scale (MTS) is another clinical scale used to assess spasticity. Its use is not as widespread as the MAS but it has recently been recommended as a more effective method in assessing spasticity due to its evaluation of the resistance to passive movement using two different velocities (*see* Appendix).[8,13,15,16]

The aim of this study was to analyze the intraobserver reliability of two different clinical methods used to assess spasticity in children with CP in the muscles of the lower and upper extremities.

Patients and methods

Participants were recruited from the CP Unit of Physiotherapy and Rehabilitation Department of the Faculty of Health Sciences, Hacettepe University, Ankara, Turkey. Children with spastic CP of different topographic distributions (hemiparetic, diparetic, quadriparetic) between the ages of 2 and 18 years were included. Children suffering from other types of CP (such as dyskinetic, ataxic, and mixed types of CP) or who have had surgery or Botox application during the last 6 months were excluded.

The study initially included 50 participants. Thirteen did not complete the first assessment and were not included in the second assessment because of cooperation problems and irritation. Thirty-seven participants (20 female and 17 male; mean age: 8.97±4.41 years, range: 2 to 16 years) comprised the study group. According to extremity dispersal, 15 (41%) of the participants were hemiparetic, 12 (32%) of the participants were diparetic and 10 (27%) of the participants were quadriparetic (Table 1). Gross motor function was assessed using the Gross Motor Function Classification System (GMFCS) (Table 2).

The study received ethical approval (number: LUT 08/63-44) from Hacettepe University Ethics Committee. Informed consent was obtained from each child's parent.

One physiotherapist with 3 years of experience in handling children with CP assessed muscle tone for each child. The rater was blinded to the results of the other measures during the measurement session. All testing procedures were completed in a single session.

Elbow flexor and wrist flexor muscles in the upper extremity and the hip adductors, hamstrings, gastrocnemius and soleus muscles in the lower extremity were evaluated using the MAS and MTS according to the severity of spasticity. To ascertain the intraobserver reliability, assessments were repeated one week later with the same physiotherapist for each subject.

Before initiating the testing session, the children were asked to wait on the therapy couch to allow them to become emotionally stable to avoid affecting the muscle tone. The rater scored the muscles first with the MAS and second with the MTS. There was a minimum of 10 minutes of rest between the two assessments.

Results were entered into a separate recording sheet for each assessment. Starting positions and velocities adopted in testing the muscles were standardized.

The MAS is a 6-point rating scale which assesses muscle tone by manually manipulating the joint through its available range of motion and clinically recording the resistance to passive movements.

Each participant was examined lying supine on a couch in a relaxed position. The head of the participant was maintained neutral to avoid eliciting asymmetric tonic neck reflex. For standardization of stretching speed passive movements were made in one second as recommended by Bohannon and Smith.[17]

The MTS is a 6-point rating scale to assess spasticity. The MTS includes two parameters, X and Y.

For the MTS, two angles (R1 and R2) were determined. The angle of muscle reaction (R1) was defined as

Table 1. Extremity dispersal of participants.

	n	%
Diparetic	12	33
Hemiparetic	15	40
Quadriparetic	10	27

Table 2. Gross motor function levels of participants.

	n	%
Level 1	16	44
Level 2	5	13
Level 3	6	16
Level 4	3	8
Level 5	7	19

the point in the joint range in which a velocity-dependent 'catch' or clonus was felt during a quick stretch of the muscle[18] and measured the point of resistance to a rapid velocity stretch. The R1 angle can be measured by moving the limb with the velocity V2 or V3.

The angle of full range of motion (R2) was equivalent to the passive range of motion. This gives an indication of muscle length at rest. The R2 angle can be measured by moving the limb with the velocity V1.[18]

A large difference between R1 and R2 implies a large dynamic component, whereas a small difference between R1 and R2 means that there is predominantly fixed contracture in the muscle.[18]

In this study, V3 was used to measure the R1 angle and V1 to measure the R2 angle. Both R1 and R2 were measured relative to the neutral position or resting anatomic position of the joints. For each muscle group reaction to stretch is rated at a specified stretch velocity with two parameters (X, Y). All measurements were made first with the V1 and second with the V3. Bony landmarks were determined for standardization of goniometric measurements. For the measurements of the Y parameter (R1 and R2) all muscles were assessed 3 times.

Upper limb testing was done in a sitting position, and lower limb testing in the supine with the head in midline.

For every muscle, the beginning position was determined as zero, with the exception of the elbow and knee flexors in which full extension was determined as zero.

Measurements made at different times on the same child were used to determine the intraobserver reliability. The intraobserver reliability of the MAS scores, MTS scores, and R1, R2, and R2-R1 was tested with the intraclass correlation coefficient (ICC). ICC values were calculated with the SPSS v15.0 (SPSS Inc., Chicago, IL, USA) software. ICC values indicating <0.50 were determined as 'low', 0.50 to 0.75 'moderate', and >0.75 'high'.[19]

Results

Intraclass correlation coefficient scores for the MAS ranged in the low range between 0.26 and 0.66 and did not reach the acceptable limit of 0.75. Those for the MTS were better, ranging between 0.54 and 0.95. ICCs ranged between 0.86 and 0.92 for R1, between 0.77 and 0.95 for R2, and between 0.67 and 0.91 for R2-R1. ICC scores for the MTS reached the acceptable limit for most of the muscles. Test-retest reliability of the MTS was significantly higher than the reliability of the MAS (Table 3).

Discussion

In our study, the intraobserver reliability for the MAS ranged between 0.26-0.66 (low to moderate) and did not reach the acceptable level for ICC (0.75) suggested by Portney and Watkins.[19]

When compared with the current literature, our findings are consistent with the study by Clopton et al., in which they found moderate (with the exception of good reliability for hamstrings) intraobserver reliability for the MAS.[20] Mehrholz et al. found intraobserver reliability ranging between 0.47 and 0.62 for the MAS.[13] In a study by Mutlu et al., intraobserver reliability scores were poor to moderate and good (ICC:

Table 3. Intrarater reliability of MAS and MTS (ICC).

	MAS ICC (CI)	MTS (X V1) ICC (CI)	MTS (X V3) ICC (CI)	R1 ICC (CI)	R2 ICC (CI)	R2-R1 ICC (CI)
Elbow flexors	0.66* (0.48-0.79)	0.65* (0.46-0.78)	0.63* (0.44-0.77)	0.90† (0.84-0.94)	0.77† (0.63-0.86)	0.91† (0.86-0.95)
Wrist flexors	0.57* (0.35-0.73)	0.92† (0.86-0.95)	0.76† (0.62-0.86)	0.92† (0.87-0.95)	0.93† (0.89-0.96)	0.86† (0.76-0.91)
Hip adductors	0.64* (0.45-0.78)	0.66* (0.47-0.79)	0.94† (0.90-0.96)	0.86† (0.66-0.87)	0.79† (0.66-0.87	0.83† (0.72-0.90)
Hamstrings	0.26 (-0.02-0.51)	0.93† (0.89-0.96)	0.92† (0.87-0.96)	0.87† (0.79-0.93)	0.87† (0.79-0.93)	0.77† (0.63-0.87)
Gastrocnemius muscle	0.35 (0.09-0.57)	0.63* (0.42-0.74)	0.55* (0.32-0.71)	0.91† (0.86-0.95)	0.91† (0.86-0.95)	0.78† (0.65-0.87)
Soleus muscle	0.46 (0.21-0.65)	0.56* (0.40-0.68)	0.54* (0.32-0.71)	0.87† (0.91-0.97)	0.95† (0.91-0.97)	0.67* (0.49-0.80)

X V1: MTS muscle reaction quality in V1; X V3: MTS muscle reaction quality in V3; ICC: intraclass correlation coefficient; CI: confidence interval, R1: MTS Y parameter in V3; R2: MTS Y parameter in V3; R2-R1: V3 Y-V1 Y; *moderate, †high.

0.36-0.83) for the MAS.[21] Our results were inconsistent with those of Gregson et al., in which they found intraobserver agreement to be moderate and good to very good for the MAS.[22]

In this study, we found lower test-retest reliability scores for the MAS in comparison to other studies. A different patient population could be the reason behind this matter.

There is uncertainty in the literature about the reliability of the MAS. Some studies support its reliability while others do not. Tederko et al.[23] found a low reliability for the MAS. They reported that subjective concepts, such as 'slight increase', 'catch and release', 'affected part is easily moved' and 'considerable increase' lead to uncertainty and confusion about scoring and negatively affect the reliability. Ghotbi et al. reported that their study results suggested that the MAS cannot distinguish between the reflexive and non-reflexive components of the hypertonicity in ankle plantar flexors.[24] Craven and Morris reported that the MAS was not reliable as an intraobserver tool for all raters, and showed poor interobserver and modest intersession reliability.[12] Some studies reported that the MAS was insufficient to differentiate the static and dynamic components of spasticity.[8-10,24]

In the current study, MTS scores demonstrated a good reliability for both upper and lower limb muscles. Our results are consistent with the literature. Gracies et al. found moderate to high and very high reliability for the MTS[25] and Fosang et al. found low, moderate, and high intraobserver reliability for the MTS.[15] Mehrholz et al. also found moderate to high and very high reliability for the MTS.[13]

Although the reliability scores for the MTS were good, we believe that the X parameter in the MTS is not appropriate in assessing the severity of spasticity because the V1 velocity can only score 0 or 1 not to elicit the stretch reflex. We could score 3 and 4 scores with V2 or V3 velocities but they were not appropriate for proximal muscle groups. During testing we observed clonus only in gastrocnemius and soleus muscles.

Advantages of the MAS include its ease of application, short time and lack of requirements for specific equipment. However, it gives less information about the muscles. In this study, we observed that the distinctions between MAS scores depend on the ROM create difficulty in interpreting scores, especially in muscles with muscle shortness and contractures. This is not a problem when we consider for intraobserver reliability but it could be problem for interobserver reliability.

The MTS has both goniometric and subjective sections which makes it superior to the MAS. Different measurement velocities are the most important properties of the MTS. The goniometric measurement made at V1 speed provides information about static muscle length. R2-R1 scores of the MTS could be used to determine what kind of intervention is needed for the child. Great differences between scores show that the spasticity is dominant and may benefit from Botox injection. Small differences show that contractures or muscle length is decreased meaning lengthening interventions are more appropriate for that joint.[18] Additionally, the goniometric sections could be helpful in observing the differences before and after interventions.

In our study, we observed only the intraobserver reliability for both scales. Future studies on the interobserver reliability would be useful. In addition, it could be useful to assess spasticity using laboratory measures in comparison with results of these clinical scales. We assessed spasticity in some large muscle groups but we recommend the addition of more muscle groups in future studies to further identify the reliability of the scales. Another limitation of this study was the small number of participants which can affect statistical analysis.

To our knowledge, this study is the first to use MTS for assessing spasticity in Turkish children with CP. According to our results, the reliability of the MTS was found to be better than the MAS in every tested muscle. Despite its ease and short administration period, the MAS depends on subjective decisions and produces insufficient intraobserver reliability results, which demonstrates that it does not meet the objectives of its clinic use. In contrast, the objective sections of the MTS give valuable information about muscle length and dynamic contracture, making it a more reliable scale for use in assessing spasticity in children with CP.

Conflicts of Interest: No conflicts declared.

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Appendix

Modified Ashworth Scale

- 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 (are) moved in flexion or extension.
- 1+ Slight increase in muscle tone, manifested by a catch followed by minimal resistance through the remainder of the range of motion but the affected part(s) is (are) easily moved.
- 2 More marked increase in muscle tone through most of the range of movement, but the affected part(s) is (are) easily moved.
- 3 Considerable increases in muscle tone, passive movement difficult.
- 4 Affected part(s) is (are) rigid in flexion or extension.

Modified Tardieu Scale

Quality of muscle reaction (X)

- 0 No resistance throughout the course of the passive movement.
- 1 Slight resistance throughout the course of passive movement, no clear catch at a precise angle.
- 2 Clear catch at a precise angle, interrupting the passive movement, followed by release.
- 3 Fatigable clonus (<10 s when maintaining the pressure) appearing at a precise angle.
- 4 Infatigable clonus (> 10 s when maintaining the pressure) at a precise angle.
- 5 Joint immovable.

Angle of muscle reaction (Y)

- Measured relative to the position of minimal stretch of the muscle (corresponding to angle zero) for all joints except hip where it is relative to the resting anatomical position.
- Angle of muscle reaction (Y) should be measured by universal goniometry.

Velocity of stretch

- V1 As slow as possible (slower than the natural drop of the limb segment under gravity).
- V2 Speed of the limb segment falling under gravity.
- V3 As fast as possible (faster than the rate of the natural drop of the limb segment under gravity).