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

RELIABILITY STUDIES WITH PEDIATRIC SUBJECTS:

RESEARCH STUDY	SUBJECTS	INTRA-RATER RELIABILITY	INTER-RATER RELIABILITY
Clopton et al. (2005) 5 Raters 6 Upper/Lower limb muscle groups MAS	N=17 Children with hypertonia	0.54 - 0.80 ICC Elbowflexors=0.58(0.39-0.76) Hamstrings=0.80(0.69-0.88) Hip adductor=0.63(0.45-0.76) Quadriceps=0.67(0.51-0.79) Gastroc=0.64(0.44-0.77) Soleus=0.54(0.33-0.69)	0.33 - 0.79 ICC Elbowflexors=0.79(0.67-0.88) Hamstrings=0.79(0.67-0.87) Hip adductor=0.33(0.70-0.54) Quadriceps=0.4(0.17-0.59) Gastroc=0.45(0.24-0.64) Soleus=0.33(0.09 -0.54)
Fosang et al. (2003) 6 Raters 3 Lower limb muscle groups MAS and Tardieu and PROM	N=18 Children with spastic cerebral palsy	0.66 - 0.85 ICC Intraclass Correlation Coefficients (ICC) Hamstring=0.66-0.80 Calf=0.21-0.72 Hip Adductors=0.59-0.85	0.27 - 0.56 ICC Intraclass Correlation Coefficients (ICC) Hamstring=0.37-0.48 Calf=0.27-0.45 Hip Adductors=0.54-0.56
Klingels et al. (2010) 2 Raters 8 Upper limb muscle groups MAS, PROM, MMT, Grip Strength, House Thumb & Zancolli classification and sensory function	N=30 Children with hemiplegic cerebral palsy	0.57 - 0.85 ICC	0.52 - 0.83 ICC
Mutlu et al. (2008) 3 Raters 5 Lower limb muscle groups MAS vs Ashworth	N=38 Children with diplegic cerebral palsy	0.36 - 0.83 ICC Hips 0.36-0.83 Hamstrings 0.54-0.69 Plantar Flexors 0.56-0.70	0.61 - 0.87 ICC Hips 0.61-0.87 Hamstrings 0.73-0.76 Plantar Flexors 0.64-0.68
Numanoğlu & Günel (2012) 1 Rater 6 Upper/Lower limb muscle groups MAS and MTS	N=37 Children with spastic cerebral palsy	0.26 - 0.66 ICC Elbow=0.66 Wrist=0.57 Hip Adduct=0.64 Hamstrings=0.26	Not performed

		Gastrocs=0.35 Soleus=0.46	
Yam & Leung (2006) 2 Raters 2 Lower limb muscle groups MAS and MTS	N=17 Children with cerebral palsy	Not performed	0.41-0.73 ICC Hip Adductors 0.41-0.73 Plantar flexors 0.46-0.56

Delgado Clegg et al. (2020) [In Process] 3 Untrained Raters 3 Trained Raters 4 Upper/Lower Limb Muscle Groups	N=17 Children with cerebral palsy	Untrained: 0.37- 0.81 ICC κ=0.387 - 0.822 Trained: 0.71 - 0.85 ICC κ=0.724 - 0.853	Untrained: 0.27 - 0.29 ICC κ=0.233 - 0.269 Trained: 0.716 - 0.717 ICC κ=0.663 - 0.717

RELIABILITY STUDIES WITH ADULT SUBJECTS:

RESEARCH STUDY	SUBJECTS	INTRA-RATER RELIABILITY	INTER-RATER RELIABILITY
Akpinar et al. (2017) 2 Raters 3 Lower limb muscle groups MAS and Modified Tardieu Scale (MTS)	N=65 Adults with spinal cord injuries	Kappa Coefficients: Hip adductor κ=0.580 Hip extensor κ=0.716 Knee flexor κ=0.636 Knee extensor κ=0.644 Ankle plantar flexor κ=0.682	Kappa Coefficients: Hip adductor κ=0.580 Hip extensor κ=0.574 Knee flexor κ=0.607 Knee extensor κ=0.531 Ankle plantar flexor κ=0.774
Allison et al. (1996) 2 Raters 1 Lower limb muscle group (Ankle plantar flexors) MAS and Ashworth	N=30 Adults with traumatic brain injury	48-53% Agreement Spearman's correlation coefficient=0.550-0.741 Cohen's κ=0.286-0.694 Kendall's tau-b=0.478-0.674	55% Agreement Spearman's correlation coefficient=0.727 Cohen's κ=0.397 Kendall's tau-b=0.647
Ansari et al. (2006) 2 Raters 1 Upper limb muscle group (Elbow flexors) MAS	n=13 Adults and n=2 Children with hemiplegia	Not performed	46.7% Agreement Kappa = 0.21
Ansari et al. (2008) 2 Raters 6 Upper/Lower limb muscle groups MAS	N=30 Adults with spastic hemiplegia	71% Agreement Upper limb=75% Agreement Lower limb=68% Agreement κ=0.590 (0.30-0.74) Upper limb=0.64 Lower limb=0.54	66% Agreement Upper limb=64% Agreement Lower limb=67% Agreement κ=0.514 (0.35-0.61) Upper limb=0.51 Lower limb=0.52
Blackburn et al. (2002) 2 Raters 3 Lower limb muscle groups MAS	N=36 Adults with poststroke spasticity	73.3% (57.5-85%) Agreement 0.567 Kendall tau-b Kendall's tau-b ratings: Gastrocnemius= 0.443 Soleus= 0.585 Quadriceps femoris= 0.660	45% (42.5-50%) Agreement 0.062 Kendall tau-b Kendall's tau-b ratings: Gastrocnemius = 0.158 Soleus = 0.197 Quadriceps femoris = 0.289

Bodin & Morris (1991) 2 Raters 1 Upper limb muscle group (Wrist flexors) MAS	N=18 Adults with poststroke wrist flexor spasticity	Not performed	76% Agreement 0.857 Kendall tau correlation κ=0.745 Cohen's
Bohannon & Smith (1987) 2 Raters 1 Upper limb muscle group (Elbow flexors) MAS	N=30 Adults with CNS lesions	Not performed	86.7% Agreement 0.847 Kendall tau correlation κ=0.826 Cohen's
Craven & Morris (2010) 2 Raters 3 Lower limb muscle groups MAS	N=20 Adults with spinal cord injury	Cohen's Kappa κ=0.190 - 1.00 Ankle κ=0.363 – 1.00 Knee κ=0.190 – 0.853 Hip κ=0.317 – 0.843	Cohen's Kappa κ= -0.013 - 0.458 Ankle κ=0.177 – 0.458 Knee κ=-0.013 - 0.352 Hip κ=0.220 – 0.401 Intraclass Correlation Coefficients (ICC) Ankle κ=0.005 - 0.486 Knee κ=-0.071 - 0.316 Hip κ=0.175 - 0.612
Gregson et al. (1999) 2 Raters 1 Upper limb muscle group (Elbow flexors) MAS vs Tone Assessment Scale	N=32 Adults with acute stroke	Weighted kappa = 0.83 Intra-rater Observed Agreement=.32	Weighted kappa = 0.84 Inter-rater Observed Agreement=.66
Gregson et al. (2000) 2 Raters 4 Upper/Lower limb muscle groups MAS and MRC scale	N=35 Adults with poststroke spasticity	Elbow flexors κ=0.39-0.53 κW=0.77-0.83 Wrist Flexors κ=0.35-0.48 κW=0.80-0.88 Knee Flexors κ=0.27-0.54 κW=0.77-0.94 Plantar Flexors κ=0.17-0.34 κW=0.59-0.64	Elbow flexors κ=0.34-0.67 κW=0.77-0.96 Wrist Flexors κ=0.43-0.51 κW=0.84-0.89 Knee Flexors κ=0.21-0.36 κW=0.73-0.79 Plantar Flexors κ=0.06-0.09 κW=0.45-0.51
Haas et al. (1996) 2 Raters 3 Lower limb muscle groups MAS vs Ashworth	N=30 Adults with spinal cord injury	Not performed	40.0-70.0% Agreement κ=0.20 - 0.62 Mean κ=0.34
Kaya et al. (2011) 2 Raters 1 Upper limb muscle group (Elbow flexors) MAS vs MMAS	N=64 Adults with poststroke hemiplegia	Not performed	55.5-91.7% Agreement κW=0.868
Li et al. (2014) 2 Raters 2 Upper/Lower limb muscle groups	N=51 Adults with postroke hemiplegia	Kappa Statistics: Elbow flexors=0.69 Plantar flexors=0.48	Kappa Statistics: Elbow flexors=0.66 Plantar flexors=0.48

MAS and MTS			
Mehrholz et al. (2005) 4 Raters 6 Upper/Lower limb muscle groups MAS and Modified Tardieu	N=30 Adults with severe cerebral damage either from stroke, traumatic brain injury or cerebral hypoxia	κ=0.47 - 0.62 Cohen's kappa Flexion & Extension: Shoulder = 0.55 & 0.47 Elbow = 0.47 & 0.53 Wrist = 0.58 & 0.51 Hip = 0.53 & 0.49 Knee = 0.52 & 0.55 AnkleExtension(knee flexed) = 0.62 AnkleExtension(knee extend) = 0.47	κ=0.14 - 0.42 Cohen's kappa Flexion & Extension: Shoulder = 0.29 & 0.16 Elbow = 0.33 & 0.42 Wrist = 0.34 & 0.30 Hip = 0.31 & 0.24 Knee = 0.28 & 0.35 AnkleExtension(knee flexed) = 0.20 AnkleExtension(knee extend) = 0.14
Sloan et al. (1992) 4 Raters 2 Upper/Lower limb muscle groups MAS	N=34 Adults with hemiplegia	Not performed	Elbow = 0.71 (0.56-0.9) Knee = 0.45 (0.26-0.62)
Tederko et al. (2007) 6 Raters 11 Upper/Lower limb muscle groups MAS and Myoclonic & tendon reflex exam (MTR) and Babinski	N=30 Adults with cervical spinal cord injury	Not performed	0.56 ICC Overall Resident Raters=0.55 Specialist Raters=0.56 Mean muscular tone ratings Pearson coefficients Resident Raters=0.66 Specialist Raters=0.75
Waninge et al. (2011) 2 Raters 2 Upper/Lower limb muscle groups MAS and MTS	N=35 Adults with profound intellectual & multiple disabilities	0.813 - 0.853 ICC κ=0.60 - 0.92 Spearman's coefficient 0.757 - 0.808	0.894 - 0.895 ICC κ=0.67 - 0.97 Spearman's coefficient 0.858 - 0.907