

**Research Summary – Ashworth (original, modified and V-MAS) – Spasticity**

Author Year Research Design Setting (country)	Demographics and Injury Characteristics of Sample	Validity	Reliability	Responsiveness Interpretability
<p><a href="#">Sinovas-Alonso et al. 2023</a></p> <p>Observational, cross-sectional study</p> <p>Spain</p>	<p>N= 35 adults with incomplete SCI (24M, 11F). Average age: 35.2 (17.2) years</p> <p>N= 50 non-SCI participants with no gait impairments (19M, 31F). Average age: 34.6 (15.2) years</p>	<p>No significant correlation was found between the SCI Gait Deviation Index (SCI-GDI) the MAS (P = .528).</p>		
<p><a href="#">Akpinar et al. 2017</a></p> <p>Psychometrics Study</p> <p>Inpatient rehabilitation clinics at two state hospitals</p>	<p>N=58 Mean Age: 44 ± 14 years M/F= 37/21 Mean time since injury: 49 ± 60 months Age range: 18-88 years AIS A= 13 AIS B= 8 AIS C= 16 AIS D= 21</p>	<p>Significant correlations between MAS and MTS X grades for all muscles r:0.791 (Hip adductor muscles) r:0.920 (hip extensor muscles) r:0.539 (knee extensor muscles) r:0.562 (knee flexor muscles) r:0.864 (ankle plantar flexor muscles)</p>	<p><b>Test-retest, Inter-rater, Intra-rater: Inter-rater (MAS)</b> K = 0.531-0.774</p> <p><b>Test-retest (MAS)</b> K=0.580-0.716</p>	

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<p><a href="#">Baunsgaard et al. 2016</a></p> <p>Intra and inter-rater reliability study</p> <p>Clinic for Spinal Cord Injuries, Rigshospitalet, Hornbaek, Denmark</p>	<p>N= 31                      Mean Age: 48.3 ± 20.2 years                      Age range: 15-88 years                      17 traumatic, 14 non traumatic                      M/F= 20/11                      AIS A,B,C (C1-C4) = 3                      AIS A, B,C (C5-C8) = 6                      AIS A,B,C (T1-S5) = 9                      All AIS D = 13</p>	<p>Spearman's r</p> <p>Correlations between Modified Ashworth (hip, knee, ankle) vs Spasm Frequency Scale</p> <p>See table 1.</p>	<p><b>Intra-rater:</b>                      Kappa weighted: 0.81 (Hip right flexors)                       Simple Kappa: 0.38 (Hip)</p> <p><b>Inter-rater:</b>                      Kappa weighted: 0.54 (Hip right flexors)                       Simple Kappa: 0.17 (Hip right flexors)</p>																																					
<p>Table 1.</p> <table border="1" data-bbox="474 1008 1260 1341"> <thead> <tr> <th></th> <th>Hip</th> <th>Knee</th> <th>Ankle</th> </tr> </thead> <tbody> <tr> <td>Right Flexors</td> <td>0.9</td> <td>0.21</td> <td></td> </tr> <tr> <td>Left Flexors</td> <td>0.13</td> <td>0.03</td> <td></td> </tr> <tr> <td>Right Extensors</td> <td>0.21</td> <td>0.01</td> <td></td> </tr> <tr> <td>Left Extensors</td> <td>0.08</td> <td>-0.13</td> <td></td> </tr> <tr> <td>Right Dorsiflexors</td> <td></td> <td></td> <td>-0.04</td> </tr> <tr> <td>Left Dorsiflexors</td> <td></td> <td></td> <td>0.03</td> </tr> <tr> <td>Right Plantarflexors</td> <td></td> <td></td> <td>0.18</td> </tr> <tr> <td>Left Plantarflexors</td> <td></td> <td></td> <td>0.18</td> </tr> </tbody> </table>						Hip	Knee	Ankle	Right Flexors	0.9	0.21		Left Flexors	0.13	0.03		Right Extensors	0.21	0.01		Left Extensors	0.08	-0.13		Right Dorsiflexors			-0.04	Left Dorsiflexors			0.03	Right Plantarflexors			0.18	Left Plantarflexors			0.18
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<p><a href="#">Mishra et al.</a> 2014</p> <p>Cross sectional</p> <p>Tested plantar flexor muscle</p>	<p>N= 38(6F, 32 M) Age: 31.94 ±12.63 Time since SCI (months): 7.89 ±5.58 (Range: 2 to 24) AIS A: 10 AIS B: 9 AIS C: 10 AIS D: 9</p>		<p><b>Test-retest, Intra-rater, Inter-rater:</b> Interrater: Gastrocnemius: Kappa: 0.70 (good; p&lt; 0.001) Kendall tau-b: 0.77 (strong, p&lt; 0.001) Soleus: Kappa: 0.75 (good; p&lt; 0.001) Kendall tau-b: 0.88 (strong, p&lt; 0.001)</p>	
<p><a href="#">Craven &amp; Morris</a> 2010</p> <p>Observational study</p> <p>Tertiary Academic Rehab Centre in Toronto, Canada</p>	<p>N=20 (M=17, F=3) Mean Age = 38.9±13.6y Mean time after SCI = 8.89±8.0y</p> <p>Chronic SCI C4-T10 &gt;12 months after injury</p> <p>Para AIS A = 3 Para AIS B-D = 5</p>		<p><b>Test-retest, Intra-rater, Inter-rater:</b> For Rater A, the intra-rater reliability for lower extremity MAS was substantial to high (0.6&lt;k&lt;1.0) for three of six muscle groups. Muscle groups with poor reliability were the knee extensor, ankle plantarflexor and</p>	

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	Tetra AIS A = 3 Tetra AIS B-D = 9		dorsiflexor muscle groups.  For rater B, reliability varied between sessions: <ul style="list-style-type: none"> <li>- in session 1, reliability was poor-to-fair (<math>k &lt; 0.4</math>), except for ankle plantarflexors and contrarily were substantial-to-high (<math>0.6 &lt; k &lt; 1.0</math>) for session 5 for all except knee quadriceps and hamstrings</li> </ul> Inter-session reliability was fair-to-good ( $0.4 < ICC < 0.75$ )	

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			<p>for all muscle groups. The ICC for the knee flexors, knee extensors and adductors were lower (<math>0.4 &lt; ICC &lt; 0.4</math>) than the ankle plantarflexors (<math>ICC = 0.75</math>). These results indicate that lower extremity MAS score reliability is much lower than the clinically desired value (<math>ICC &gt; 0.75</math>) for all but one muscle group (Right knee hamstrings).</p> <p>Inter-rater reliability was poor-to-moderate (<math>k &lt; 0.6</math>) for all muscle groups except the hip adductors. The agreement between</p>	

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			the two raters was inconsistent across muscle groups and sessions and much lower than the desired Kappa ( $k > 0.81$ )	
<a href="#">Tederko et al.</a> 2007  Observational study  Inpatient	N = 30 M/F=23/7 Mean age = 33.9±14.7 (17-65y)  Cervical SCI Tetraplegia = 16 Tetraparesis = 14 Mean time since injury = 14.1m(4 - 66m)		<b>Test-retest, Intra-rater, Inter-rater:</b> Mean ICC for MAS = 0.56 (adequate reliability, averaged from scores from age, sex, neurological status, site of injury, functional status, pharmacotherapy for spasticity, rating by specialist, rating by resident)	
<a href="#">Lechner et al.</a> 2006  Cross-sectional study and	Cross-sectional study: N=47 Age 44.1y (21.5-75)			

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Longitudinal study  Paraplegic Centre - outpatient	Longitudinal study: N=8 Age (31-59) SCI C6-T10 AIS A or B Time since injury=14.3y (1.7-51y)  C6-T10 AIS A or B Time since injury=9y (1.5-21y)			
<a href="#">Aydin et al. 2005</a>  Cohort  Réhabilitation Centre	N= 21 traumatic SCI M/F=6/15 C/T=5/16 AIS A/B/C/D=10/3/7/1  Traumatic SCI			<b>Responsiveness:</b> Baclofen (n=10) Pre-post Spasm Frequency Score (SFS) and Lower Limb Ashworth Score (LLAS) were -28±30 and -28±22, respectively. TENS (transcutaneous electrical nerve stimulation) (n=11) pre-post SFS and LLAS was -16±16 and -

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				17±17, respectively. All other spasticity related measures progressed in the same direction also.																												
<a href="#">Benz et al.</a> 2005  Cross-sectional study  Rehab lab and Outpatient medical clinic	N=17 Age 22-63  C5-T10 AIS A-D Time since injury=24-372m	Spearman r Correlations between Ashworth (hip, knee, ankle) vs Spinal Cord Assessment Tool for Spastic Reflexes (SCATS) (clonus, flexion, extension) vs Penn Spasm Frequency Scale (PSFS) See table 1.																														
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<p><a href="#">Boviatsis et al.</a> 2005</p> <p>Cohort</p> <p>Neurosurgical unit</p>	<p>N=22; MS=15 SCI=7 M/F=12/10 SCI Age 27-49 y SCI M/F=5/2</p> <p>MS, SCI C4-T11, Duration of symptoms: 1-5 years for total N, Avg disease duration SCI: 2.71y</p>			<p><b>Responsiveness:</b> From pre-tx to final post-tx, Ashworth decreased from 4.57 to 2.57 (P=.0134). Concomitant reduction in spasm scores from 3.71 to 1.27 (P=.00006).</p>
<p><a href="#">Smith et al.</a> 2002</p> <p>Cross-sectional study</p> <p>Out/In-patient, tertiary care</p>	<p>N=22 Mean Age=33.4 ±12.5 (16-63y)</p> <p>14 quads, 8 paras 4 incomplete (18 complete)</p> <p>Time since injury = 29.8m±43.2 (4-172m)</p>	<p>Spearman r between MAS and PT= -0.69 (no 95% CI) V-MAS and PT=0.83 (95% CI=0.73-0.89)</p>	<p><b>Test-retest, Intra- rater, Inter-rater:</b> Mean Kappa values MAS=0.14-0.35</p> <p>Mean ICC for V-MAS = 0.59-0.88</p> <p>Spearman's correlation coefficient=0.73</p>	
<p><a href="#">Sherwood et al.</a> 2000</p>	<p>N=97 Mean age = 45y (21-82) M/F=95/2</p>	<p>There was a significant difference between average</p>		<p><b>Interpretability:</b> *</p>

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Cohort  Dept of Physical Medicine and Rehabilitation, Veteran Affairs Medical Center	C/T=62/35  SCI Time since injury=0.5- 39y	sEMG scores for those with average Ashworth 0 vs 2&3, and 1 vs 2&3 (P<0.001) but not between 0 and 1.  However, when assessing individual muscles, the sEMG is more discriminatory.			
Table 1. Subject characteristics by Ashworth score:					
		Ashworth score			
Subcategory :		0	1	2	3
Gender	M	24	33	22	16
	F	1	/	1	/
ASIA	A	12	14	9	6
	B	10	10	5	3
	C	/	6	7	4
	D	3	3	2	3
Level	Cervical	12	21	17	12
	Thoracic	13	12	6	4
Motor	Mean	41.5	35.9	28.5	34.9
	SD	20.0	21.8	20.1	21.1
Age	Mean	42.3	46.1	49.4	43.7
	SD	13.2	13.3	17.1	13.7
Mean		7.6	8.4	6.4	8.6

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	Time post- injury	SD	9.4	7.7	6.5	7.7			
<p><a href="#">Skold</a> 2000</p> <p>Part I: Observational, prospective cross-sectional study; Part II: experimental, prospective longitudinal study.</p> <p>Regional SCI centre - outpatient</p>	<p>N=45 M/F=39/6 Mean age=26y (17-47)</p> <p>Cervical and Thoracic AIS A-D Time since injury=11y (3-26)</p>	<p>Spearman r Correlations between self-rated and modified Ashworth before and after passive movement session. <u>Muscle before after</u> Rt Quad 0.49 0.56 Rt Ham 0.49 0.48 Lt Quad 0.44 0.62 Lt Ham 0.50 0.61</p>			<p><a href="#">Haas et al.</a> 1996</p> <p>Inter rater reliability</p>	<p>N=30 M/F=24/6 Mean age = 40.3y (17- 72)</p>		<p><b>Test-retest, Intra- rater, Inter-rater:</b> Mean Kappa values: Original=0.41</p>	<p><b>Interpretability:</b> See table 1.</p>

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National Spinal Injuries Centre (Inpatient)	SCI C2-L1 Frankel A-D Mean time since injury = 17.2m (1-294m)		Adductor=0.61 to Plantarflexor=0.21  Modified=0.34 Adductor=0.62 to Plantarflexor=0.20																																																	
<p>Table 1. Number of assignments and agreements for each score for the Ashworth and Modified Ashworth scale:</p> <table border="1" data-bbox="474 727 1785 951"> <thead> <tr> <th><i>Original scale</i></th> <th><b>0</b></th> <th><b>1</b></th> <th><b>/</b></th> <th><b>2</b></th> <th><b>3</b></th> <th><b>4</b></th> <th><b>Total</b></th> </tr> </thead> <tbody> <tr> <td>Assignments</td> <td>152</td> <td>115</td> <td>/</td> <td>129</td> <td>68</td> <td>8</td> <td>472</td> </tr> <tr> <td>Agreements</td> <td>62</td> <td>27</td> <td>/</td> <td>29</td> <td>17</td> <td>1</td> <td>136</td> </tr> <tr> <th><i>Modified scale</i></th> <th><b>0</b></th> <th><b>1</b></th> <th><b>1+</b></th> <th><b>2</b></th> <th><b>3</b></th> <th><b>4</b></th> <th></th> </tr> <tr> <td>Assignments</td> <td>149</td> <td>55</td> <td>77</td> <td>117</td> <td>66</td> <td>8</td> <td>472</td> </tr> <tr> <td>Agreements</td> <td>61</td> <td>6</td> <td>6</td> <td>26</td> <td>17</td> <td>1</td> <td>117</td> </tr> </tbody> </table>					<i>Original scale</i>	<b>0</b>	<b>1</b>	<b>/</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>Total</b>	Assignments	152	115	/	129	68	8	472	Agreements	62	27	/	29	17	1	136	<i>Modified scale</i>	<b>0</b>	<b>1</b>	<b>1+</b>	<b>2</b>	<b>3</b>	<b>4</b>		Assignments	149	55	77	117	66	8	472	Agreements	61	6	6	26	17	1	117
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<a href="#">Priebe et al.</a> 1996  Case Series/Cross-sectional study  VAMC-SCI service in/out-patient	N=85 Mean age=46y±13 (21-82) AIS A/B/C/D=37/20/16/12  SCI C3-T10 AIS A-D	Polychoric correlations Ashworth & Clonus=0.267 Patellar tap=0.553 Achilles tap=0.235 Adductor tap=0.340 Plantar=0.205																																																		

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	Duration of injury: 1m to 25y			
<a href="#">Skold et al. 1998</a>  Cross-sectional study  Outpatient	N=15 All male Mean Age=33 (21-48y)  SCI C4-C8 AIS A/B = 10/5 Time since injury=9y(1-21y)	64 (80%) of EMG measures correlated significantly with MAS (P<.05).  However, when subjects scoring 0 were removed from the analysis, only 25% of correlations were significant suggestive of an end-of-range effect.		
Lee et al. 1989  Cohort  Depts of Neurology, PT and OT.	N=12 No ages specified  SCI, MS (multiple sclerosis)		<b>Test-retest, Intra-rater, Inter-rater:</b> With 4 raters: Kendall 0.92 Avg. Spearman rank correlation of 0.89 with 95% CI (7.5-1.0)  7.2-9.4 intra-rater variability (coefficient of repeatability) with a	

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			coefficient of variation 5.4-7.7%	
<a href="#">Penn et al.</a> 1989  Cohort  Depts of Neurosurgery, Physiology, PM&R; PE	N=20 Age 23-62 M/F=11/9 MS/SCI=10/10 C5-T9  SCI, MS			<b>Responsiveness:</b> IT Baclofen, Ashworth was reduced from 4.0±1.0 to 1.2 ±0.4 (P<.0001), concomitant decrease in spasm frequency 3.3 ±1.2 to 0.4± 0.8 (P<.0005). After mean follow-up of 19.2months, Ashworth was 1.0± 0.1 and SFS (Spasm Frequency Scale) was 0.3± 0.6.