



# An Overview of Clinical Scales for Assessment of Spasticity in Multiple Sclerosis

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## Abstract

**Background:** Spasticity is a core clinical presentation of Multiple Sclerosis, associated with disease progression, significantly affecting patients' and caregivers' quality of life. Numerous clinical scales have been developed to assess the impact and severity of spasticity in patients with Multiple Sclerosis. Yet, a consensus on the best tool still needs to be reached.

**Objective:** To provide an overview of the clinical scales most often used when studying spasticity in Multiple Sclerosis, including studies utilizing these tools.

**Methods:** We extensively searched the MEDLINE (PubMed) database; articles published in English between November 2003 and July 2023 were included. We utilized the Cochrane's Methods Executive tools for bias assessment. The extracted data was synthesized to provide a comprehensive overview of the current evidence about the clinical scales used to assess and quantify muscle spasticity in MS.

**Results:** The final analysis included 13 articles. Six studies focused on the assessment of spasticity scales. The remaining articles involved interventions and observational studies. The Modified Ashworth Scale and Ashworth Scale were the most frequently used scales (38.4% each), with approximately 30% of studies employing multiple scales for assessment.

**Discussion:** Quantifying spasticity by clinical scales is necessary for correct grading and evaluation of treatment responses. The studies selected for this review showed significant variability in the spasticity measure scales utilized. The most prevalent choices were the MAS and AS, independently used or combined with other tools. A detailed rationale for the choice of scale was absent in all of the included studies. Further research is crucial to determine the most suitable scale for assessing spasticity in multiple sclerosis in the setting of clinical research.

## Introduction

Multiple Sclerosis (MS) is the most common immune-mediated inflammatory demyelinating disease of the Central Nervous System. It commonly affects individuals between the ages of 15 and 45, with progression over 20 to 30 years, causing substantial disability. 60% to 84% of patients experience muscle spasticity, leading to considerable pain, compromised quality of life, and increased need for assisted care (Thompson et al., 2018).

Spasticity's impact extends to various body parts, including legs, arms, and hands, resulting in difficulty in extending or flexing the limbs due to either flexor or extensor spasticity. It can be triggered by factors such as temperature fluctuations, abrupt changes in movement or posture, or infections (McGinley et al., 2021; National MS Society, s. f.).

An in-depth evaluation of a patient's spasticity should encompass a comprehensive spectrum of factors ranging from the presence or absence of muscle spasms, resistance to passive muscle stretching, pain, and the patient's perception of muscle tightness (Chokshi & Flanagan, 2021). Assessment methods include clinical scales, biomechanical devices, neurophysiologic techniques, and other reflex studies. The clinical scales consider the patients' and physicians' perspectives, combining what the patient feels with what the physician observes. Hugos et al.'s review describes the tools available for measuring spasticity in multiple sclerosis. However, the current literature lacks a standardized approach for addressing spasticity in this population.

We conducted this systematic review to explore the tools used to evaluate spasticity in MS. Our main objective is to identify the most commonly used scales for assessing spasticity in MS and to examine their applications in recent studies published in the literature.

## Materials and Methods

Given the nature of this mini-review, our search was confined to the MEDLINE database (accessed through PubMed) exclusively, focusing on articles published in English between 2003 and 2023 to ensure that our bibliography is recent and up-to-date. This mini-review adhered to the

Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. The search was performed using the keywords (Muscle spasticity [Title/Abstract][Mesh] AND (multiple sclerosis[Title/Abstract][Mesh] AND ((assessment[Title/Abstract]) OR (scale[Title/Abstract]) OR (scales[Title/Abstract]))). Pertinent studies were also identified through reference lists on related reviews and meta-analyses.

Study inclusion criteria required a focus on MS-related muscle spasticity indicated by specific MeSH terms within the title or abstract. Additionally, studies had to employ scales to assess muscle spasticity in this population, excluding spasticity related to other diseases. Non-English publications and studies where spasticity is not measured through clinical scales are excluded.

The study selection included all search results to be screened based on title and abstract to determine their relevance. Three independent reviewers conducted full-text analysis in the selection process to minimize bias; the most experienced was the one who solved disagreements.

Data extraction involved two independent reviewers recording methodological details, participant demographics, employed assessments or scales, identified limitations, and overall outcomes in an Excel spreadsheet. A third experienced reviewer resolved disagreements.

We utilized the Cochrane's Methods Executive tools for bias assessment. This evaluation was done employing different tools based on the study design. Risk of Bias 2 (RoB2) assessed randomized controlled trials (RCT), while ROBINS-I (of Interventions) evaluated non-RCTs, and ROBINS-E (of Exposure) rated observational studies.

When there were divergent results, a third reviewer was asked to give his evaluation.

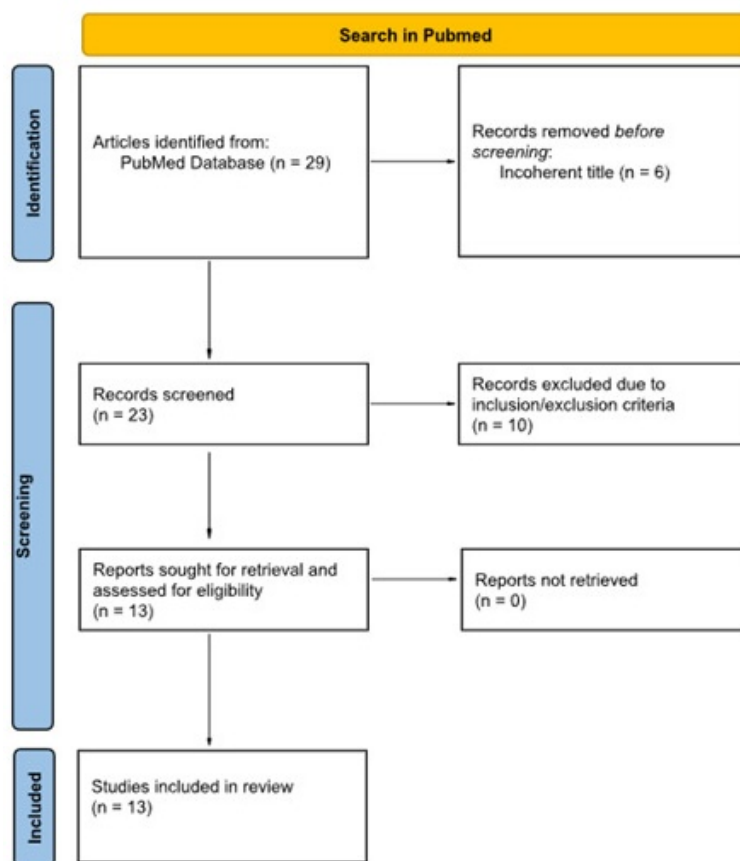
Finally, the extracted data was synthesized to provide an overview of the current evidence about the clinical scales used to assess and quantify muscle spasticity in MS.

## Results

The initial search retrieved 29 studies. Upon title review, six articles were unrelated and thus were primarily excluded. Ten more articles were omitted after an abstract review. The main reasons for exclusion were the absence of MS patients or an unclear patient cohort (n=3), study protocols (n=1), case reports (n=3), and review articles (n=3). The final analysis included 13 papers; in 10, scales are used as outcome measures, while in 3, the studies assess the scale's accuracy and psychometric properties (Table 1, Table 2). Six focused on the assessment of spasticity scales.

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**Figure 1:** PRISMA flow diagram.

The remaining articles involved interventions and observational studies (Figure 1).

From the 13 articles selected for review, a cohort of 2,087 patients underwent evaluation for diagnostic purposes or as participants in clinical trials focusing on approved or prospective treatments targeting spasticity. Different scales were used, both alone or combined with other methods. The employed scales encompassed the Modified Ashworth Scale (MAS), Ashworth Scale (AS), Modified Modified Ashworth Scale (MMAS), Modified Tardieu Scale (MTS), Penn Spasm Frequency Scale (PSFS), Muscle Elastography MS Scale (MeMSs) and the Numeric Rating Scale (NRS).

Modified Ashworth Scale and Ashworth Scale are the most frequently used (38.4% each), with approximately 30% of studies employing multiple scales for assessment. In four studies, MAS was the only tool used for spasticity assessment. In the analysis by Picelli et al., the MAS was used without explicit justification for its selection. In a separate study, Wagner et al. favored the MAS due to its widespread utilization and acceptance within the field. Conversely, Meca-Llana et al. opted for the MAS with PSFS scores to assess patients' physical condition after receiving glatiramer acetate, citing MAS's extensive recogni-

tion in quantifying MS spasticity (Meca-Lallana et al., 2010).

The AS was the exclusive measuring instrument for assessing spasticity in three studies (Zajicek et al., 2005; Zajicek et al., 2003; Skoog et al., 2019). Illomei et al. investigated the utilization of real-time elastography (RTHE) ultrasounds for assessing muscle fiber status, along with changes following a novel antispasticity treatment. The study comprised 110 MS patients evaluated with the AS and RTHE. RTHE images were scored using a new 1-5 muscle fibers rigidity imaging scale, MEMSs (Muscle Elastography Multiple Sclerosis Score). A statistically significant correlation was observed between AS and MEMSs (Illomei et al., 2017). In a separate investigation, Reis et al., 2019, evaluated the safety and efficacy of intrathecal baclofen infusion pumps for spasticity treatment. They combined the AS with the PSFS to measure clinical response to treatment. The findings revealed noteworthy enhancement in scores across both scales, comparing pre- and post-treatment stages across all patient subgroups.

The MMAS was used in only one study by Ghotbi et al. They investigated the intra-rater reliability of the MMAS for spasticity assessment in the hip adductors, knee extensors, and ankle plantar flexors of 23

Authors	Design	Country (ies)	Disease (s)	No. of patients	Spasticity assessment method	Main findings related to the spasticity scale(s)
Norbye et al. (2019) *	Cross-sectional	Norway	MS (primary progressive, secondary progressive and relapsing-remitting MS)	30	MAS	Basal spasticity MAS scores 0-3. Strong negative correlation of maximal MAS score of lower limb and gait distance (measured with 2 minute walk test), moderate correlations with both ankle plantar flexors and knee extensors.
Picelli et al., (2017) *	Single center observational	Italy	Secondary progressive MS /Chronic stroke	76 (38 MS/38 stroke)	MAS/Tardieu scale	MAS at the ankle is statistically higher in stroke than MS patients. No differences of Tardieu spasticity grade at ankle between groups. 45% MS patients (16/29) had consistent moderate MAS scores for both limbs (median maximal plantarflexor MAS of 2.0 (1–3)). Minimal associations between MAS-assessed spasticity and walking impairment.
Wagner et al. (2014) *	Cross-sectional study	United States	MS	56 (42 MS/14 without disability)	MAS	Minimal associations between MAS-assessed spasticity and walking impairment.
Reis et al. (2019)	Retrospective cohort study	Portugal	Patients with spasticity (34% trauma; 14% cerebral palsy; 12% MS; 12% stroke)	155	AS/PSFS	Significant reduction of 2 points in AS and 3 points in PSFS after treatment.
Skoog et al. (2019)	Retrospective observational study	Sweden	Spinal cord injury or MS	41 (19 SCI/22 MS)	AS	Low levels of spasticity after 7 and 10 years on intrathecal baclofen pump with low AS scores (0–1). Reduced spasticity (MAS lower limb score and PSFS score) after intervention. No decrease after 24 months. No significant change in upper limb spasticity.
Stampacchia et al. (2016)	Prospective observational study	Italy	MS	14	MAS/PSFS	Non-significant improvement in NRS score in ITT analysis. >30% improvement from baseline in PP population (79% participants) in intervention group.
Collin et al. (2010)	RCT	UK and Czech Republic	MS	337 (167 in treated group/170 in placebo group)	NRS	Significant reductions in MAS and PSFS scores in IFN-β cohort.
Meca-Lallana et al. (2010)	Prospective, nonrandomized, open-label, uncontrolled, observational pilot study	Spain	Relapsing-remitting MS	28 (13 previously treated with IFN-β/15 treatment-naive)	MAS and PSFS	ITT small treatment effect on muscle spasticity (change in AS).
Zajicek et al. (2005)	RCT	UK	MS	502 (172 in oral cannabis extract group/154 in 9-tetrahydrocannabinol group/176 in placebo group)	AS	No significant treatment effects.
Zajicek et al. (2003)	RCT	United Kingdom	MS	630 (211 oral cannabis extract group/206 9-tetrahydrocannabinol/213 placebo group)	AS	

**NA:** not applicable; **SD:** standard-deviation; **MS:** Multiple Sclerosis; **MAS:** Modified Ashworth Scale; **AS:** Ashworth Scale; **MEMSs:** Muscle Elastography Multiple Sclerosis Score; **MTS:** Modified Tardieu Scale; **MMAS:** Modified Modified Ashworth Scale; **PSFS:** Penn Spasm Frequency Scale; **NRS:** Numeric Rating Scale; **ITT:** Intention to treat; **PP:** per protocol; **RCT:** Randomised Clinical Trial; **UK:** United Kingdom

**Table 1:** Description of the studies in which the scales were used as outcome measures.

Authors	Design	Country (ies)	Disease (s)	No. of patients	Spasticity assessment method	Main findings related to the spasticity scale(s)
Illomeci et al. (2016) *	Cross-sectional study (Study A) / Quasi Experimental study (Study B)	Italy	MS (primary progressive, secondary progressive and relapsing-remitting MS)	Study A: 110 / Study B: 55	AS and MEMSs	Study A: AS for both legs 0-5. Statistically significant positive correlation between AS score and MEMSs. Study B: none AS results.
Naghdi et al. (2017) *	Cross-sectional study	Iran	MS	30	MTS	Bad intra-rater reliability of MTS in lower limb muscle spasticity.
Ghotbi et al. (2011) *	Cross-sectional study	Iran	Stroke or MS	23(18 MS/5 stroke)	MMAS	MMAS has very good intra-rater reliability in lower limb muscle spasticity.

MS: Multiple Sclerosis; AS: Ashworth Scale; MEMSs: Muscle Elastography Multiple Sclerosis Score; MTS: Modified Tardieu Scale; MMAS: Modified Modified Ashworth Scale.

**Table 2:** Description of the studies assessing the scales accuracy and psychometric properties.

patients. Notably, the overall intra-rater agreement reliability of the MMAS yielded highly favorable outcomes within patients exhibiting lower limb muscle spasticity (weighted kappa = 0.87, SE = 0.03,  $p < 0.001$ ). Significantly robust results were evident for the ankle plantar flexors (weighted kappa = 0.85, SE = 0.05,  $p < 0.001$ ) and knee extensors (weighted kappa = 0.62, SE = 0.12,  $p < 0.001$ ) (Ghotbi et al., 2010).

The MTS was used exclusively in one study by Naghdi et al. In this study, they evaluated the intra-rater reliability of the MTS in 30 MS patients. The results failed to establish substantial intra-rater reliability for the MTS when assessing lower limb muscle spasticity by a practitioner unfamiliar with the technique (Naghdi et al., 2017). Furthermore, the determination of the MTS's sensitivity and specificity for spasticity could not be established.

The NRS was used in the RCT conducted by Collin et al. to measure lower limb spasticity. They compared the use of Sativex against placebo in relieving symptoms of spasticity due to MS (Collin et al., 2010); however, the reason for using this scale was not specified.

## Discussion

Clinical measurements of spasticity in patients with MS are complex due to its broad spectrum of signs and symptoms (Balci, 2018). Quantifying spasticity by clinical scales is necessary for the correct grading and evaluation of treatment responses.

The studies selected for this review showed significant variability in the spasticity measure scales utilized. The most prevalent choices were the MAS and AS, independently used or combined with other tools. They both grade muscle tone escalation on a scale from zero to four. The MAS incorporates a +1 increment to augment sensitivity (Meseguer-Henarejos et al., 2018). The AS was initially designed to assess the spasticity and effectiveness of antispastic drugs in MS patients. However, the MAS, a revised version of the AS, addresses limitations with better reliability and validity (Mohana Sundaram et al., s. f.; Petek Balci, 2018). Both scales have been featured prominently in neurological literature and have gained widespread recognition and clinical acceptance. Moreover, their straightforward adminis-

tration enhances their practicality in clinical settings. The MSSS 88 scale focuses on describing the impact of spasticity on a patient. It considers subscales related to spasticity symptoms, physical and social functioning, and emotional health.

Alternative scales, such as the MTS, offer superior features, including comprehensive spasticity assessment, velocity-dependent evaluation, and quantifying resistance to stretch (Hugos & Cameron, 2019). While MTS is considered to have a higher specificity than MAS, its complexity and the need for trained physicians limit its widespread adoption (Naghdi et al., 2016; Morris & Williams, 2018). However, researchers often incorporate complex scales alongside simpler ones, like the PSFS, with unclear reasons and limited validation studies.

Remarkably, specific well-established spasticity assessment scales, such as the Multiple Sclerosis Spasticity Scale-88 (MSSS-88), remained absent from the hierarchies in the selected papers (Hugos et al., 2019). The reasons behind the omission remain speculative, as again, the underlying rationale for their exclusion needed to be elucidated within the reviewed literature.

Our analysis encountered several limitations, primarily from the absence of explicit indications regarding the rationale behind selecting the employed scales in the reviewed papers. Notably, while many articles described the utilization of various scales, they generally omitted to include any justification of their choice. Language restrictions and the possibility of unpublished data could be additional limitations.

Furthermore, the restricted number of available papers compelled us to rely on all accessible information, which precluded a meaningful comparative analysis. One pivotal factor contributing to this limitation was the inherent heterogeneity among the patient populations under review. While all subjects had MS and spasticity, the diversity in the type and severity of spasticity across the studies hindered direct comparisons.

A consensus-inconsistent use of the same clinical scales could facilitate inter-study comparison and enable the aggregation of findings to conduct systematic reviews and meta-analyses. In addition, integrating multiple assessment scales in clinical practice

and combining subjective measurements with quantitative assessment tools can elevate the precision and comprehensiveness of spasticity quantification and evaluation.

## Conclusion

Spasticity in multiple sclerosis is a crucial symptom that substantially impacts patients and caregivers. Reliable assessment tools are essential to interpret the effectiveness of evolving therapies. While multiple assessment tools exist, consensus on optimal usage remains a challenge. This brief review showed significant variability in the spasticity measure scales utilized. The most prevalent choices were the MAS and AS, independently used or combined with other tools. This provides insight into scale selection for assessing MS-related spasticity. Nevertheless, the scale selection must depend on expertise and resources available, and even though there is no agreement on the best tool, the combination of them, especially with objective methods, could offer a more reliable assessment of this clinical presentation. This integrated approach may provide researchers with a more comprehensive evaluation of spasticity, improving the overall management of multiple sclerosis.

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## Conflicts of Interest

The authors filled out the COI form from ICMJE to declare no conflict of interest, including any financial, personal, or other relationships with other people or organizations within three years of beginning the submitted work that could inappropriately influence or be perceived to influence the present work. All listed authors agree with raising the manuscript and approve the final version.

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