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Editorial

A century of research on spasticity: Editors' opinion



This issue of the journal corresponds to our second special issue (SI) on spasticity published in 2019. The first one, published in July, was dedicated to treatment [1]. Some articles are already well cited, which is good for the immediate citation index [2]. This second SI on spasticity is dedicated to other domains such as the pathophysiology, assessment and epidemiological aspects. These two issues on spasticity gather 24 papers, either spontaneously submitted and meeting the quality level now required by the journal [3,4] or written by recognized authors invited through international networks of the International Society for Physical and Rehabilitation Medicine [5] and the World Federation of Neuro-Rehabilitation.

Their preparation gave us the opportunity to carefully look at the spasticity literature through an editorial prism. We are pleased to share our thoughts.

First, few journals have published an SI (or a supplement) dedicated to spasticity, and we are delighted to have accomplished this project started 3 years ago, to fill a gap. We hope readers will appreciate these papers.

Second, we analyzed the evolution during the last century of this literature devoted to spasticity. We searched the Web of Science (all databases, Clarivate Analytics) from 1919 to November 1, 2019 for items with “spasticity” in the title, regardless of language for the main text. We adopted this simple approach because spasticity is a MeSH term in the US National Library of Medicine. After excluding items corresponding to abstracts, book chapters, news, corrections, biographies, and even retractions (2 items), we retained 3562 papers, mostly written in English (89%) and otherwise in German, Korean, French, Russian, Spanish etc. Fig. 1 presents the annual evolution of the publication of papers related to spasticity. This evolution clearly went through three successive phases, corresponding to the main discoveries in the field. During 1919 to 1945, publications were occasional (1 or 2 per year) and mainly focused on the description, semiology and gross neural correlates of this symptom. Then the interest in the field slowly and firmly increased until the beginning of the 1980s. Great advances were achieved in terms of the central and peripheral mechanisms underlying spasticity, and standardized clinical assessments were implemented. The first treatments were tested, combining oral drugs and surgical treatments involving neurosurgery and orthopedic surgery. In a more exploratory way, local treatment was tested by phenol neurolysis, with the first attempts at neuromodulation by various techniques. Then, from the middle of the 1980s, the number of publications skyrocketed, doubling

every decade, to reach more than 200 papers each year by 2018. This third phase is supported by great advances in medical therapeutics, supported by intrathecal baclofen, intramuscular injection of botulinum toxin, and cannabinoid intake. Debates about the objectives (function or comfort), strategies, doses, and appropriate times to treat are synthesized by numerous reviews and several consensus papers. This third phase also included useful epidemiological works, describing the prevalence, typology, and course of spasticity for each relevant neurological condition, as well as the non-systematic detrimental role of spasticity on functions and activities. The two SI on spasticity in the *Annals* represents this third-phase vein, allowing for better understanding spasticity, its course and treatment, with a focus on adjuvant treatments or insufficiently explored aspects of botulinum toxin treatment. They also includes French clinical guidelines for peripheral motor nerve blocks in a physical and rehabilitation medicine setting and one trial of botulinum toxin independent of industry.

Third, we analyzed the typology and domains covered by the 3,562 papers with “spasticity” in the title since 1919. Most are full papers (92%), including 514 reviews (14%) and 465 trials (13%). Editorials represent 4% of items. Neurological conditions specifically investigated were sought by crossing additional terms in the titles: stroke ($n = 524$, 15%), cerebral palsy ($n = 301$, 8%), spinal cord ($n = 277$, 8%), multiple sclerosis ($n = 243$, 7%), and traumatic brain injury ($n = 31$, 1%). About 1% of the literature concerned spastic hereditary diseases. This literature covers many domains classified

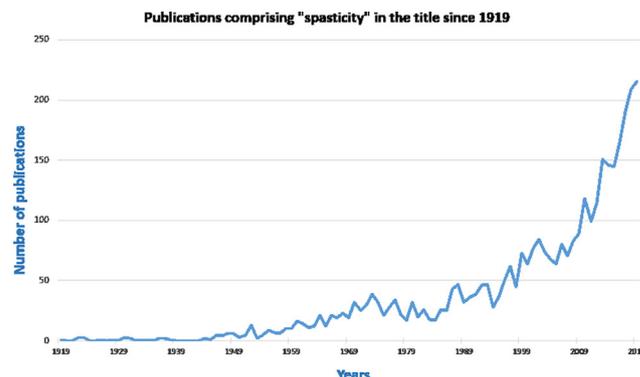


Fig. 1. Evolution of the annual number of spasticity papers published from 1919 to 2019.

Table 1
Top journals publishing papers on spasticity. Left, best-ranked journals in the category “Rehabilitation” of the Journal Citation Report (Clarivate Analytics^R); right, journals belonging to other categories.

Twenty best ranked rehabilitation journals (2018 IF) editing spasticity papers	Number of papers with spasticity in the title (since 1919)	Thirty best ranked journals (2018 IF) of other categories editing spasticity papers	Number of papers with spasticity in the title (since 1919)
<i>Archives of Physical Medicine and Rehabilitation</i> (IF 2.7)	159	<i>JNNP</i> (IF 8.3)	67
<i>Journal of Rehabilitation Medicine</i> (IF 1.9)	76	<i>Lancet</i> (IF 59.1)	35
<i>American Journal of PMR</i> (IF 1.9)	70	<i>Brain</i> (IF 11.8)	27
<i>Spinal Cord</i> (IF 1.9)	49	<i>Cochrane Database of Systematic Reviews</i> (IF 7.8)	15
<i>Clinical Rehabilitation</i> (IF 2.7)	48	<i>Annals of Neurology</i> (IF 9.5)	14
<i>Disability and Rehabilitation</i> (IF 2)	43	<i>Drugs</i> (IF 5)	14
<i>PM&R</i> (IF 1.9)	26	<i>JAMA</i> (IF 51.3)	12
<i>Physical Therapy</i> (IF 3)	25	<i>New England Journal of Medicine</i> (IF 70.7)	11
<i>Neurorehabilitation and Neural Repair</i> (IF 3.8)	23	<i>Stroke</i> (IF 6.1)	10
<i>European Journal of PRM</i> (IF 2.1)	22	<i>Movement Disorders</i> (if 8.2)	9
<i>Topics in Stroke Rehabilitation</i> (IF 2)	22	<i>Anesthesiology</i> (IF 6.4)	9
<i>Annals of Physical and Rehabilitation Medicine</i> (IF 4.2)	17	<i>Multiple Sclerosis Journal</i> (IF 5.6)	9
<i>Journal of Neuroengineering and Rehabilitation</i> (IF 3.6)	14	<i>Neurology</i> (IF 8.7)	8
<i>PMR Clinics of North America</i> (IF 2.2)	11	<i>British Medical Journal</i> (IF 17.2)	7
<i>Journal of Head Trauma Rehabilitation</i> (IF 2.7)	10	<i>Canadian Medical Association Journal</i> (IF 6.9)	5
<i>IEEE Trans. Neural Systems and Rehabil. Engineering</i> (IF 3.5)	9	<i>Nature Medicine</i> (IF 30.6)	4
<i>Journal of Electromyography and Kinesiology</i> (IF 1.7)	9	<i>Lancet Neurology</i> (IF 28.9)	4
<i>Physiotherapy</i> (IF 2.5)	7	<i>American Journal of Human Genetics</i> (IF 9.9)	4
<i>Journal of Physiotherapy</i> (IF 5.6)	6	<i>Journal of Neuroscience</i> (IF 6.1)	4
<i>Journal of Neurologic Physical Therapy</i> (IF 2.6)	1	<i>Journal of Physiology-London</i> (IF 5)	4
		<i>British Journal of Pharmacology</i> (if 6.6)	3
		<i>Neurotherapeutics</i> (IF 5.6)	3
		<i>Nature Reviews Drug Discovery</i> (IF 57.6)	2
		<i>European Urology</i> (IF 17.3)	2
		<i>FASEB Journal</i> (IF 5.4)	2
		<i>Nature</i> (IF 43.1)	1
		<i>Science</i> (IF 41.1)	1
		<i>Neuroscience and Biobehavioral Reviews</i> (IF 8)	1
		<i>Autoimmunity Reviews</i> (IF 7.7)	1
		<i>Pain</i> (IF 6)	1

as follows by the Web of Science: Neurosciences and Neurology, 85%; Pharmacology and Pharmacy, 40%; Rehabilitation, 30%; Anatomy and Morphology, 28%; Orthopedics, 27%; Physiology, 24%; Pediatrics, 20%; Geriatrics and Gerontology, 18%; Behavioral Sciences, 17%; Biochemistry and Molecular Biology, 16%; Surgery, 14%; Healthcare Sciences Services, 12%; General and Internal Medicine, 11%; Immunology, 10%; Psychology, 7%; Toxicology, 8%, etc. This multidisciplinary approach helps make the spasticity field very attractive, especially for young doctors.

Fourth, we analyzed the geographic origin of these papers, together with the contribution of private funding agencies to these studies. The 15 largest contributions were from the United States, 22%; England, 8%; Germany, 6%; Italy and Canada, 5% each; France, 4%; Australia, 3%; China, 3%; and Spain, south Korea, Turkey, Sweden, The Netherlands, Japan, and Belgium, 2% each. Among the 465 papers considered as “trials” by the Web of Science, more than 20% were funded by pharmaceutical or technological companies, which indeed play an important role in the field. This funding likely explains why among the 100 most-cited papers (average citations per year), half deal with treatment, whereas the domains pathophysiology, epidemiology, and assessment represent 15% each.

Fifth, we analyzed the bibliometric indicators of the field. [Table 1](#) shows that many top journals publish papers on spasticity. Also, many of the papers published since 1919 have been highly cited. [Table 2](#) lists the 20 most-cited papers in the field. The paper by Bohannon and Smith [6], about the interrater reliability of the modified Ashworth scale, is by far the most cited, with an average of 88 citations per year since 2007. We further analyzed the citations rate for spasticity papers for the 1,814 full papers published from 1999 to 2018. The median number of citations each year was 0.5 (range 0–31; Q1–Q3 0.3 and 2.7) per paper. The 90th and 95th percentiles were 4.9 and 7.4, respectively.

We hope that the two SIs on spasticity in the *Annals* in 2019 will be appreciated, will contribute to attract clinicians and scientists to the field, and will encourage authors to submit their spasticity papers to the journal. We also hope these two SIs will contribute to the progression of the journal, which has recently been indexed in Journal Citation Reports (Clarivate analytics) [7] and had an impact factor of 4.2 in 2018, second in the Rehabilitation category of the Journal Citation Reports and first among general journals of rehabilitation.

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Table 2

The 20 most-cited papers published since 1919 with the term “spasticity” in the title.

Title	Authors	Journal name	Year	Citations per year
Interrater Reliability of a Modified Ashworth Scale of Muscle Spasticity	Bohannon RW, Smith MB	<i>Physical Therapy</i>	1987	88.3
Practice guideline update summary: Botulinum neurotoxin for the treatment of blepharospasm, cervical dystonia, adult spasticity, and headache Report of the Guideline Development Subcommittee of the American Academy of Neurology	Simpson DM, Hallett M, Ashman EJ, Comella CL, Green MW, Gronseth GS, Armstrong MJ, Gloss D, Potrebic S, Jankovic J, Karp BP, Naumann M, So Yuen T, Yablon SA	<i>Neurology</i>	2016	30.7
Down-regulation of the potassium-chloride cotransporter KCC2 contributes to spasticity after spinal cord injury	Boulenguez P, Liabeuf S, Bos R, Bras H, Jean-Xavier C, Brocard C, Stil A, Darbon P, Cattaert D, Delpire E, Marsala M, Vinay L	<i>Nature Medicine</i>	2010	28.3
Cannabinoids for treatment of spasticity and other symptoms related to multiple sclerosis (CAMS study): multicentre randomised placebo-controlled trial	Zajicek J, Fox P, Sanders H, Wright D, Vickery J, Nunn A, Thompson A	<i>Lancet</i>	2003	27.3
Spasticity after stroke – Its occurrence and association with motor impairments and activity limitations	Sommerfeld DK, Eek EUB, Svensson AK, Holmqvist LW, von Arbin MH	<i>Stroke</i>	2004	23.9
A randomized, double-blind, placebo-controlled, parallel-group, enriched-design study of nabiximols (Sativex (R)), as add-on therapy, in subjects with refractory spasticity caused by multiple sclerosis	Novotna A, Mares J, Ratcliffe S, Novakova I, Vachova M, Zapletalova O, Gasperini C, Pozzilli C, Cefaro L, Comi G, Rossi P, Ambler Z, Stelmasiak Z, Erdmann A, Montalban X, Klimek A, Davies P	<i>European Journal of Neurology</i>	2011	22.8
Intramuscular injection of botulinum toxin for the treatment of wrist and finger spasticity after a stroke	Brashear A, Gordon MF, Elovic E, Kassicieh VD, Marciniak C, Lee CH, Jenkins S, Turkel C	<i>NEJM</i>	2002	22
A review of the properties and limitations of the Ashworth and modified Ashworth Scales as measures of spasticity	Pandyan AD, Johnson GR, Price CIM, Curless RH, Barnes MP, Rodgers H	<i>Clinical Rehabilitation</i>	1999	21.7
Assessment: Botulinum neurotoxin for the treatment of spasticity (an evidence-based review) – Report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology	Simpson D M, Gracies JM, Graham HK, Miyasaki JM, Naumann M, Russman B, Simpson L, So Y	<i>Neurology</i>	2008	21.6
Stop using the Ashworth Scale for the assessment of spasticity	Fleuren JFM, Voerman GE, Erren-Wolters CV, Snoek GJ, Rietman JS, Hermens HJ, Nene AV	<i>JNNP</i>	2010	20.4
Cannabinoids control spasticity and tremor in a multiple sclerosis model	Baker D, Pryce G, Croxford JL, Brown P, Pertwee RG, Huffman JW, Layward L	<i>Nature</i>	2000	19.2
Spasticity: Clinical perceptions, neurological realities and meaningful measurement	Pandyan AD, Gregoric M, Barnes MP, Wood D, Van Wijck F, Burridge J, Hermens H, Johnson GR	<i>Disability and Rehabilitation</i>	2005	17.9
European Consensus table on the use of Botulinum Toxin TypeA In Adult Spasticity	Wissel J, Ward AB, Erztgaard P, Bensmail D, Hecht MJ, Lejeune TM, Schnider P, Altavista MC, Cavazza S, Deltombe T, Duarte E, Geurts ACH, Gracies JM, Haboubi NHJ, Juan FJ, Kasch H, Kaetterer C, Kirazli Y, Manganotti P, Parman Y, Paternostro-Sluga T, Petropoulou K, Prempeh R, Rousseaux M, Slawek J, Tieranta N	<i>Journal of Rehabilitation Medicine</i>	2009	17.5
Occurrence and Clinical Predictors of Spasticity After Ischemic Stroke	Urban PP, Wolf T, Uebele M, Marx JJ, Vogt T, Stoeter P, Bauermann T, Weibrich C, Vucurevic GD, Schneider A, Wissel J	<i>Stroke</i>	2010	16.8
Prevalence and treatment of spasticity reported by multiple sclerosis patients	Rizzo MA, Hadjimichael OC, Preiningerova J, Vollmer TL	<i>Multiple Sclerosis</i>	2004	16.7
Spasticity after stroke: Physiology, assessment and treatment	Thibaut A, Chatelle C, Ziegler E, Bruno MA, Laureys S, Gosseries O	<i>Brain Injury</i>	2013	15.7
Endocannabinoids control spasticity in a multiple sclerosis model	Baker D, Pryce G, Croxford JL, Brown P, Pertwee RG, Makriyannis A, Khanolkar A, Layward L, Fezza F, Bisogno T, Di Marzo V	<i>FASEB Journal</i>	2001	15.6
Intrathecal Baclofen for Severe Spinal Spasticity	Penn RD, Savoy SM, Corcos D, Latash M, Gottlieb G, Parke B, Kroin JS	<i>NEJM</i>	1989	15.5
Randomized controlled trial of cannabis-based medicine in spasticity caused by multiple sclerosis	Collin C, Davies P, Mutiboko IK, Ratcliffe S	<i>European Journal of Neurology</i>	2007	15.4
Spasticity and muscle contracture following stroke	ODwyer NJ, Ada L, Neilson PD	<i>Brain</i>	1996	15

Disclosure of interest

D. Pérennou is the editor in chief of the *Annals of Physical and Rehabilitation Medicine*. A. Yelnik, I. Laffont, and D. Bensmail have been guest editors for the two SIs Spasticity published in the journal.

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