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Tremor and Other Hyperkinetic Movements

Articles

# The Most Cited Works in Essential Tremor and Dystonia

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## Abstract

**Background:** The study of the most cited works in a particular field gives an indication of the important advances, developments, and discoveries that have had the highest impact in that discipline. Our aim was to identify the most cited works in essential tremor (ET) and dystonia.

**Methods:** A bibliometric search was performed using the ISI Web of Science database using selected search terms for ET and dystonia for articles published from 1900 to 2015. The resulting citation counts were analyzed to identify the most cited works, and the studies were categorized.

**Results:** Using the criterion of more than 400 citations, there were four citation classics for ET and six for dystonia. The most cited studies were those on pathophysiology followed by medical treatments, clinical classification, genetic studies, surgical treatments, review articles, and epidemiology studies. A comparison of the most cited articles for ET and dystonia showed that there was a divergence, with ET and dystonia having a higher number of epidemiologic and genetic studies, respectively. Whereas the peak period for the number of publications was 2000–2004 for ET, it was 1995–1999 for dystonia.

**Discussion:** Given the large number of patients with these disorders, there appears to be an unmet need for further research advances in both areas, but particularly for ET as the most common movement disorder.

**Keywords:** Essential tremor, dystonia, citation analysis

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**Ethics Statement:** Not applicable for this Review.

## Introduction

The study of the most cited works in a particular field gives an indication of the most impactful advances, developments, and discoveries that have been instrumental in driving research in that discipline.[1,2] This analysis also offers insight into where the field has been, where the unmet needs are, and where the field may be heading.[1] Such snapshots of the most important works have previously been generated for several areas of neurology and neurosurgery.[1,3–8] A recent study examined citations related to essential tremor (ET),[8] but a similar analysis has however not yet been carried out for dystonia. Importantly, no study has compared the literature in the two different but linked fields of ET and dystonia. Here we compared and contrasted these two research areas to produce a more comprehensive review and identify the most highly cited ET and dystonia articles.

## Methods

We used a search strategy similar to one we have previously used for bibliometric analysis in other fields.[1,9] A search was performed in January 2016 using the bibliometric database ISI Web of Science for articles published between 1900 and 2015 using the topic search terms "(essential OR benign OR familial) and tremor*" for ET. For

dystonia, the search terms were "dystoni* OR meige syndrome OR writer cramp OR torticollis." Alternative terms were also searched to identify additional citations: "professional cramp OR musician cramp OR eyelid opening apraxia OR Brueghel syndrome OR Oppenheim disease." The "OR" is a Boolean operator to find records containing any of the terms, and the parentheses were used to define operator precedence such that the expression inside the parentheses is executed first. The asterisk was included as a wild card character. The search terms for ET returned 4,578 articles with the earliest published in 1903. The search terms for dystonia returned 18,839 articles with the earliest published in 1901. The two results were separately sorted by number of citations from highest to lowest and were manually examined to identify the top 100 cited articles related to the field. Articles were considered "citation classics" if they received 400 or more citations as previously defined.[2]

## Results

We first conducted a broad search to identify the relative publication activity across each of the main movement disorders as identified by PubMed (Table 1). Relative to Parkinson's disease (PD), the number of papers identified in PubMed on dystonia was approximately one fifth and on ET was approximately one twentieth.

The 100 most cited articles showed that the number of citations per article for ET ranged from 79 to 846 (median 100) compared to a range from of 137 to 560 (median 179) for dystonia. The articles were ranked by citations, and those articles that were ranked in the top 100 are shown in Table 2 for ET and Table 3 for dystonia. Out of these articles, there were four citation classics receiving 400 or more citations for ET[10–13] and six citation classics for dystonia,[14–19] representing 0.09% and 0.03% of all search results, respectively.

For further analysis of the most cited works, each article was classified into one of seven categories: epidemiology, laboratory genetic studies, laboratory pathophysiological studies, clinical classification, clinical medical therapies, clinical surgical therapies, and review articles. The numbers of articles in each category by field of study (ET and dystonia) are shown in Figure 1.

Table 1. **Number of Papers Available in PubMed for the Main Movement Disorders**

| Disorder (Search Term)[1] | Number of Citations in PubMed (up to December 31, 2015) |
|---|---|
| "Parkinson's disease" | 59,140 |
| "Essential tremor" | 2,930 |
| "Dystonia" | 12,978 |
| "Myoclonus" | 8,969 |
| "Chorea" | 6,742 |
| "Tic" | 5,952 |
| "Tics" | 3,502 |

[1]Each search term was entered as indicated in PubMed for the period of January 1, 1900 to December 31, 2015.

### *Epidemiology*

Studies were included in this category if they described the epidemiology of the condition including prevalence, incidence, comparisons, and trends over time. For ET, there were 15 studies in this category. Out of these, eight studies investigated the incidences of ET in different regions or countries. The remaining seven examined the association of ET with dementia, PD, and other functional measures. By comparison, there were only four dystonia articles in this category. These studies investigated the prevalence of dystonia in different population subgroups.

### *Clinical: classification*

This broad category included new description of the disease, new diagnostic features, its classification into subtypes, as well as condition-specific measures and rating scales. There were 18 articles in this category, including one citation classic for ET.[11] Similarly, there were 13 articles for dystonia and one citation classic.[16]

### *Laboratory: genetic studies*

Studies were included in this category if they were genetic studies. There were seven studies for ET, including investigations in the familial essential tremor gene *FET1*, fragile X premutation, variants in the sequences of the *LINGO1* gene and the dopamine D-3 receptor, GABA(A) alpha 1 receptor knockout, polymorphism of NACP-Rep1, and methodologic issues in ET research. For dystonia, there were 19 studies including two citation classics.[14,15] These two genetic studies were the first and third most highly ranked articles by citations in the dystonia field. There were five studies on the early onset dystonia gene (*DYT1*),;four on idiopathic dystonia; two on the genetics of dopa-responsive dystonia; one on Leber optic atrophy and dystonia; one on lacZ transgene insertion; and one each on mutations of the deafness/dystonia peptide (*DDP*) gene, GTP cyclohydrolase-1 gene, epsilon sarcoglycan gene, dystonia musculorum gene, Na+/K+-ATPase alpha 3 gene, and phospholipase A2 group VI (*PLA2G6*) gene.

### *Laboratory: pathophysiology*

Studies investigating the pathophysiologic mechanisms underlying ET and dystonia were included in this category. There were 21 studies for ET, including 10 that employed imaging techniques. There were four studies on the physiology of ET, five on pathology, and the remaining studies on pharmacology or biochemical analysis of cerebrospinal fluid. For dystonia, there were 20 studies with 13 on neurophysiology, six on imaging, and one on pharmacology.

Table 2. **Summary of Top 100 articles for Essential Tremor (Ranked in Order of Citations)**

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 1 | 1 | 846 | Benabid AL, Pollak P, Gervason C, et al. Long-term suppression of tremor by chronic stimulation of the ventral intermediate thalamic nucleus. *Lancet* 1991;337:403–406 | Clinical: Surgery |
| 2 | 2 | 809 | Deuschl G, Bain P, Brin M. Consensus statement of the Movement Disorder Society on tremor. *Mov Disord* 1998;13 Supplement:2–23 | Clinical: Classification |
| 3 | 3 | 652 | Benabid AL, Pollak P, Gao DM, et al. Chronic electrical stimulation of the ventralis intermedius nucleus of the thalamus as a treatment of movement disorders. *J Neurosurg* 1996;84:203–214 | Clinical: Surgery |
| 4 | 4 | 484 | Schuurman PR, Bosch DA, Bossuyt PMM, et al. A comparison of continuous thalamic stimulation and thalamotomy for suppression of severe tremor. *N Engl J Med* 2000;342:461–468 | Clinical: Surgery |
| 5 | 5 | 294 | Koller W, Pahwa R, Busenbark K, et al. High-frequency unilateral thalamic stimulation in the treatment of essential and Parkinsonian tremor. *Ann Neurol* 1997;42:292–299 | Clinical: Surgery |
| 6 | 6 | 291 | Limousin P, Speelman JD, Gielen F, et al. Multicentre European study of thalamic stimulation in parkinsonian and essential tremor. *J Neurol Neurosurg Psychiatry* 1999;66:289–296 | Clinical: Surgery |
| 7 | 7a | 220 | Louis ED, Ottman R, Hauser WA. How common is the most common adult movement disorder? Estimates of the prevalence of essential tremor throughout the world. *Mov Disord* 1998;13:5–10 | Review |
| 8 | 7b | 220 | Critchley M. Observations on essential (heredo-familial) tremor. *Brain* 1949;72:113–139 | Review |
| 9 | 8 | 215 | Benabid AL, Benazzouz A, Hoffmann D, et al. Long-term electrical inhibition of deep brain targets in movement disorders. *Mov Disord* 1998;13 Supplement:119–125 | Clinical: Surgery |
| 10 | 9 | 214 | Bain PG, Findley LJ, Thompson PD, et al. A study of hereditary essential tremor. *Brain* 1994;117:805–824 | Review |
| 11 | 10 | 212 | Blond S, Caparros-Lefebvre D, Parker F, et al. Control of tremor and involuntary movement-disorders by chronic stereotaxic stimulation of the ventral intermediate thalamic nucleus. *J Neurosurg* 1992;77: 62–68 | Clinical: Surgery |
| 12 | 11 | 212 | Lou JS, Jankovic J. Essential tremor: clinical correlates in 350 patients. *Neurology* 1991;41:234–238 | Clinical: Classification |

**Table 2.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 13 | 12 | 210 | Louis ED, Faust PL, Vonsattel JP, et al. Neuropathological changes in essential tremor: 33 cases compared with 21 controls. *Brain* 2007;130:3297–3307 | Lab: Patho-physiology |
| 14 | 13 | 198 | Deuschl G, Raethjen J, Lindemann M, et al. The pathophysiology of tremor. *Muscle Nerve* 2001;24:716–735 | Review |
| 15 | 15 | 177 | Jenkins IH, Bain PG, Colebatch JG, et al. A positron emission tomography study of essential tremor: evidence for overactivity of cerebellar connections. *Ann Neurol* 1993;34:82–90 | Lab: Patho-physiology |
| 16 | 15 | 174 | Bain PG, Findley LJ, Atchison P, et al. Assessing tremor severity. *J Neurol Neurosurg Psychiatry* 1993;56:868–873 | Clinical: Classification |
| 17 | 16 | 172 | Brooks DJ, Playford ED, Ibanez V, et al. Isolated tremor and disruption of the nigrostriatal dopaminergic system: an 18F-dopa PET study. *Neurology* 1992;42:1554–1560 | Lab: Patho-physiology |
| 18 | 17 | 169 | Jankovic J, Cardoso F, Grossman RG, et al. Outcome after stereotaxic thalamotomy for parkinsonian, essential, and other types of tremor. *Neurosurgery* 1995;37:680–686 | Clinical: Surgery |
| 19 | 18 | 167 | Rajput AH, Offord KP, Beard CM, et al. Essential tremor in Rochester, Minnesota: a 45-year study. *J Neurol Neurosurg Psychiatry* 1984;47:466–470 | Epidemiology |
| 20 | 19 | 166 | Tasker RR. Deep brain stimulation is preferable to thalamotomy for tremor suppression. *Surg Neurol* 1998;49:145–153 | Clinical: Surgery |
| 21 | 20 | 164 | Benito-León J, Bermejo-Pareja F, Morales JM, et al. Prevalence of essential tremor in three elderly populations of central Spain. *Mov Disord* 2003;18:389–394 | Epidemiology |
| 22 | 21a | 158 | Deuschl G, Wenzelburger R, Loffler K, et al. Essential tremor and cerebellar dysfunction: clinical and kinematic analysis of intention tremor. *Brain* 2000;123:1568–1580 | Review |
| 23 | 21b | 158 | Louis ED. Essential tremor. *Lancet Neurol* 2005; 4:100–110 | Review |
| 24 | 22 | 154 | Gulcher JR, Jonsson P, Kong A, et al. Mapping of a familial essential tremor gene, FET1, to chromosome 3q13. *Nat Genet* 1997;17:84–87 | Lab: Genetic studies |
| 25 | 23 | 149 | Koller WC, Busenbark K, Miner K, et al. The relationship of essential tremor to other movement-disorders: report on 678 patients. *Ann Neurol* 1994;35:717–723 | Epidemiology |
| 26 | 24 | 142 | Louis ED, Ferreira JJ. How common is the most common adult movement disorder? Update on the worldwide prevalence of essential tremor. *Mov Disord* 2010;25:534–541 | Review |

**Table 2.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 27 | 25 | 138 | Elble RJ. Physiological and essential tremor. *Neurology* 1986;36:225–231 | Clinical: Classification |
| 28 | 26 | 131 | Ondo W, Jankovic J, Schwartz K, et al. Unilateral thalamic deep brain stimulation for refractory essential tremor and Parkinson's disease tremor. *Neurology* 1998;51:1063–1069 | Clinical: Surgery |
| 29 | 27a | 128 | Geraghty JJ, Jankovic J, Zetusky WJ. Association between essential tremor and Parkinson's disease. *Ann Neurol* 1985;17:329–333 | Epidemiology |
| 30 | 27b | 128 | Winkler GF, Young RR. Efficacy of chronic propranolol therapy in action tremors of familial, senile or essential varieties. *New Engl J Med* 1974;290:984–988 | Clinical: Medicine |
| 31 | 28a | 127 | Higgins JJ, Pho LT, Nee LE. A gene (ETM) for essential tremor maps to chromosome 2p22–p25. *Mov Disord* 1997;12:859–864 | Review |
| 32 | 28b | 127 | Koller WC, Lyons KE, Wilkinson SB, et al. Long-term safety and efficacy of unilateral deep brain stimulation of the thalamus in essential tremor. *Mov Disord* 2001;16:464–468 | Clinical: Surgery |
| 33 | 29 | 126 | Colebatch JG, Findley LJ, Frackowiak RSJ, et al. Preliminary-report: activation of the cerebellum in essential tremor. *Lancet* 1990;336:1028–1030 | Lab: Patho-physiology |
| 34 | 30a | 125 | Rehncrona S, Johnels B, Widner H, et al. Long-term efficacy of thalamic deep brain stimulation for tremor: Double-blind assessments. *Mov Disord* 2003;18:163–170 | Clinical: Surgery |
| 35 | 30b | 125 | Wills AJ, Jenkins IH, Thompson PD, et al. Red nuclear and cerebellar but no olivary activation-associated with essential tremor: a positron emission tomographic study. *Ann Neurol* 1994;36:636–642 | Lab: Patho-physiology |
| 36 | 31 | 123 | Zesiewicz TA, Elble R, Louis ED, et al. Practice parameter: Therapies for essential tremor – Report of the quality standards subcommittee of the American Academy of Neurology. *Neurology* 2005;64:2008–2020 | Clinical: Classification |
| 37 | 32a | 121 | Bucher SF, Seelos KC, Dodel RC, et al. Activation mapping in essential tremor with functional magnetic resonance imaging. *Ann Neurol* 1997;41:32–40 | Lab: Patho-physiology |
| 38 | 32b | 121 | Stolze H, Petersen G, Raethjen J, et al. The gait disorder of advanced essential tremor. *Brain* 2001;124:2278–2286 | Clinical: Classification |
| 39 | 33a | 118 | Benito-León J, Louis ED. Essential tremor: emerging views of a common disorder. *Nat Clin Pract Neurol* 2006;2:666–678 | Review |
| 40 | 33b | 118 | Dogu O, Sevim S, Camdeviren H, et al. Prevalence of essential tremor – Door-to-door neurologic exams in Mersin Province, Turkey. *Neurology* 2003;61:1804–1806 | Epidemiology |

**Table 2.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 41 | 34a | 116 | Benamer HTS, Patterson J, Grosset DG, et al. Accurate differentiation of Parkinsonism and essential tremor using visual assessment of [I-123]-FP-CIT SPECT imaging: The [I-123]-FP-CIT study group. *Mov Disord* 2000;15:503–510 | Clinical: Classification |
| 42 | 34b | 116 | Rautakorpi I, Takala J, Marttila RJ, et al. Essential tremor in a Finnish population. *Acta Neurol Scand* 1982;66:58–67 | Epidemiology |
| 43 | 35 | 115 | Louis ED, Ottman R, Ford B, et al. The Washington Heights-Inwood Genetic Study of Essential Tremor: Methodologic issues in essential-tremor research. *Neuroepidemiology* 1997;16:124–133 | Lab: Genetic studies |
| 44 | 36 | 113 | Critchley E. Clinical manifestations of essential tremor. *J Neurol Neurosurg Psychiatry* 1972;35:365–372 | Clinical: Classification |
| 45 | 37a | 112 | Lombardi WJ, Woolston DJ, Roberts JW, et al. Cognitive deficits in patients with essential tremor. *Neurology* 2001;57:785–790 | Clinical: Classification |
| 46 | 37b | 112 | Benito-León J, Louis ED, Bermejo-Pareja F. Population-based case-control study of cognitive function in essential tremor. *Neurology* 2006;66:69–74 | Epidemiology |
| 47 | 38 | 102 | Jankovic J, Schwartz K, Clemence W, et al. A randomized, double-blind, placebo-controlled study to evaluate botulinum toxin type A in essential hand tremor. *Mov Disord* 1996;11:250–256 | Clinical: Medicine |
| 48 | 39a | 101 | Wilms H, Sievers J, Deuschl G. Animal models of tremor. *Mov Disord* 1999;14:557–571 | Review |
| 49 | 39b | 101 | Bain P, Brin M, Deuschl G, et al. Criteria for the diagnosis of essential tremor. *Neurology* 2000;54:S7–S7 | Clinical: Classification |
| 50 | 39c | 101 | Sydow O, Thobois S, Alesch F, et al. Multicentre European study of thalamic stimulation in essential tremor: a six year follow up. *J Neurol Neurosurg Psychiatry* 2003;74:1387–1391 | Epidemiology |
| 51 | 40a | 99 | Asenbaum S, Pirker W, Angelberger P, et al. [I-123] beta-CIT and SPECT in essential tremor and Parkinson's disease. *J Neural Transm (Vienna)* 1998;105:1213–1228 | Clinical: Classification |
| 52 | 40b | 99 | Growdon JH, Shahani BT, Young RR. Effect of alcohol on essential tremor. *Neurology* 1975;25:259–262 | Lab: Patho-physiology |
| 53 | 40c | 99 | Alesch F, Pinter MM, Helscher RJ, et al. Stimulation of the ventral intermediate thalamic nucleus in tremor dominated Parkinson's disease and essential tremor. *Acta Neurochir (Wien)* 1995;136:75–81 | Clinical: Surgery |
| 54 | 41 | 98 | Hornabrook RW, Nagurney JT. Essential tremor in Papua, New Guinea. *Brain* 1976;99:659–672 | Epidemiology |

**Table 2.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 55 | 42a | 97 | Rajput AH, Rozdilsky B, Ang L, et al. Clinicopathological observations in essential tremor: report of 6 cases. *Neurology* 1991;41:1422–1424 | Lab: Patho-physiology |
| 56 | 42b | 97 | Lee RG, Stein RB. Resetting of tremor by mechanical perturbations – a comparison of essential tremor and Parkinsonian tremor. *Ann Neurol* 1981;10:523–531 | Clinical: Medicine |
| 57 | 43 | 96 | Marshall J. Observations on essential tremor. *J Neurol Neurosurg Psychiatry* 1972;25:122–125 | Clinical: Classification |
| 58 | 44a | 95 | Gironell A, Kulisevsky J, Barbanoj M, et al. A randomized placebo-controlled comparative trial of gabapentin and propranolol in essential tremor. *Arch Neurol* 1999;56:475–480 | Clinical: Medicine |
| 59 | 44b | 95 | Louis ED, Zheng W, Jurewicz EC, et al. Elevation of blood beta-carboline alkaloids in essential tremor. *Neurology* 2002;59:1940–1944 | Lab: Patho-physiology |
| 60 | 44c | 95 | Singer C, Sanchezramos J, Weiner WJ. Gait abnormality in essential tremor. *Mov Disord* 1994;9:193–196 | Clinical: Classification |
| 61 | 44d | 95 | Benito-León J, Bermejo-Pareja F, Louis ED. Incidence of essential tremor in three elderly populations of central Spain. *Neurology* 2005;64:1721–1725 | Epidemiology |
| 62 | 44e | 95 | Raethjen J, Lindemann M, Schmaljohann H, et al. Multiple oscillators are causing Parkinsonian and essential tremor. *Mov Disord* 2000;15:84–94 | Lab: Patho-physiology |
| 63 | 44f | 95 | Stefansson H, Steinberg S, Petursson H, et al. Variant in the sequence of the LINGO1 gene confers risk of essential tremor. *Nat Genet* 2009;41:277–279 | Lab: Genetic studies |
| 64 | 45a | 94 | Busenbark KL, Nash J, Nash S, et al. Is essential tremor benign? *Neurology* 1991;41:1982–1983 | Epidemiology |
| 65 | 45b | 94 | Louis ED, Shungu DC, Chan S, et al. Metabolic abnormality in the cerebellum in patients with essential tremor: a proton magnetic resonance spectroscopic imaging study. *Neurosci Lett* 2002;333:17–20 | Lab: Patho-physiology |
| 66 | 45c | 94 | Hariz MI, Shamsgovara P, Johansson F, et al. Tolerance and tremor rebound following long-term chronic thalamic stimulation for parkinsonian and essential tremor. *Stereotact Funct Neurosurg* 1999;72:208–218 | Clinical: Surgery |
| 67 | 46a | 93 | Kumar R, Lozano AM, Sime E, et al. Long-term follow-up of thalamic deep brain stimulation for essential and Parkinsonian tremor. *Neurology* 2003;61:1601–1604 | Clinical: Surgery |
| 68 | 46b | 93 | Boecker H, Wills AJ, Ceballos-Baumann A, et al. The effect of ethanol on alcohol responsive essential tremor: a positron emission tomography study. *Ann Neurol* 1996;39:650–658 | Lab: Patho-physiology |

**Table 2.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 69 | 47a | 92 | Louis ED, Barnes L, Albert SM, et al. Correlates of functional disability in essential tremor. *Mov Disord* 2001;16:914–920 | Clinical: Classification |
| 70 | 47b | 92 | Hubble JP, Busenbark KL, Wilkinson S, et al. Deep brain stimulation for essential tremor. *Neurology* 1996;46:1150–1153 | Clinical: Surgery |
| 71 | 47c | 92 | Rajput A, Robinson CA, Rajput AH. Essential tremor course and disability – A clinicopathologic study of 20 cases. *Neurology* 2004;62:932–936 | Lab: Patho-physiology |
| 72 | 47d | 92 | Bermejo-Pareja F, Louis ED, Benito-León J. Risk of incident dementia in essential tremor: A population-based study. *Mov Disord* 2007;22:1573–1580 | Epidemiology |
| 73 | 48 | 91 | Louis ED, Ottman R. How familial is familial tremor? The genetic epidemiology of essential tremor. *Neurology* 1996;46:1200–1205 | Review |
| 74 | 49a | 90 | Louis ED, Marder K, Cote L, et al. Differences in the prevalence of essential tremor among elderly African-Americans, whites, and Hispanics in northern Manhattan, NY. *Arch Neurol* 1995;52:1201–1205 | Epidemiology |
| 75 | 49b | 90 | Findley LJ, Koller WC. Essential tremor: a review. *Neurology* 1987;37:1194–1197 | Review |
| 76 | 49c | 90 | Hellwig B, Haussler S, Schelter B, et al. Tremor-correlated cortical activity in essential tremor. *Lancet* 2001;357: 519–523 | Lab: Patho-physiology |
| 77 | 50a | 88 | Helmchen C, Hagenow A, Miesner J, et al. Eye movement abnormalities in essential tremor may indicate cerebellar dysfunction. *Brain* 2003;126:1319–1332 | Lab: Patho-physiology |
| 78 | 50b | 88 | Hallett M, Dubinsky RM. Glucose-metabolism in the brain of patients with essential tremor. *J Neurol Sci* 1993;114:45–48 | Lab: Patho-physiology |
| 79 | 50c | 88 | Louis ED, Ford B, Frucht S, et al. Risk of tremor and impairment from tremor in relatives of patients with essential tremor: a community-based family study. *Ann Neurol* 2001;49:761–769 | Epidemiology |
| 80 | 51a | 87 | Jeanneteau F, Funalot B, Jankovic J, et al. A functional variant of the dopamine D-3 receptor is associated with risk and age-at-onset of essential tremor. *Proc Natl Acad Sci U S A* 2006;103:10753–10758 | Lab: Genetic studies |

**Table 2.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 81 | 51b | 87 | Jefferson D, Jenner P, Marsden CD. Beta-adrenoreceptor antagonists in essential tremor. *J Neurol Neurosurg Psychiatry* 1979;42:904–909 | Clinical: Medicine |
| 82 | 52a | 86 | Benito-León J, Louis ED, Bermejo-Pareja F. Elderly-onset essential tremor is associated with dementia. *Neurology* 2006;66:1500–1505 | Clinical: Classification |
| 83 | 52b | 86 | Deuschl G, Elble R. Essential tremor–neurodegenerative or nondegenerative disease towards a working definition of ET. *Mov Disord* 2009;24:2033–2041 | Review |
| 84 | 53a | 86 | Shahed J, Jankovic J. Exploring the relationship between essential tremor and Parkinson's disease. *Parkinsonism Relat Disord* 2007;13:67–76 | Review |
| 85 | 53b | 86 | Leehey MA, Munhoz RP, Lang AE, et al. The fragile X premutation presenting as essential tremor. *Arch Neurol* 2003;60:117–121 | Lab: Genetic studies |
| 86 | 54a | 85 | Koller W, Biary N, Cone S. Disability in essential tremor: effect of treatment. *Neurology* 1986;36:1001–1004 | Clinical: Medicine |
| 87 | 54b | 85 | Deng H, Le W, Jankovic J. Genetics of essential tremor. *Brain* 2007;130:1456–1464 | Review |
| 88 | 55a | 84 | Gasparini M, Bonifati V, Fabrizio E, et al. Frontal lobe dysfunction in essential tremor: a preliminary study. *J Neurol* 2001;248:399–402 | Lab: Patho-physiology |
| 89 | 55b | 84 | Shill HA, Adler CH, Sabbagh MN, et al. Pathologic findings in prospectively ascertained essential tremor subjects. *Neurology* 2008;70:1452–1455 | Lab: Patho-physiology |
| 90 | 56 | 83 | Koller WC, Vetere-Overfield B. Acute and chronic effects of propranolol and primidone in essential tremor. *Neurology* 1989;39:1587–1588 | Clinical: Medicine |
| 91 | 57a | 82 | Jain S, Lo SE, Louis ED. Common misdiagnosis of a common neurological disorder : how are we misdiagnosing essential tremor? *Arch Neurol* 2006;63:1100–1104 | Clinical: Classification |
| 92 | 57b | 82 | Jankovic J. Essential tremor: a heterogeneous disorder. *Mov Disord* 2002;17:638–644 | Clinical: Classification |
| 93 | 57c | 82 | Troster AI, Woods SP, Fields JA, et al. Neuropsychological deficits in essential tremor: an expression of cerebello-thalamo-cortical pathophysiology? *Eur J Neurol* 2002;9:143–151 | Lab: Patho-physiology |
| 94 | 57d | 82 | Axelrad JE, Louis ED, Honig LS, et al. Reduced Purkinje cell number in essential tremor. *Arch Neurol* 2008;65: 101–107 | Lab: Patho-physiology |

**Table 2.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 95 | 58 | 81 | Brin MF, Lyons KE, Doucette J, et al. A randomized, double masked, controlled trial of botulinum toxin type A in essential hand tremor. *Neurology* 2001;56:1523–1528 | Clinical: Medicine |
| 96 | 59a | 80 | Wills AJ, Jenkins IH, Thompson PD, et al. A positron emission tomography study of cerebral activation-associated with essential and writing tremor. *Arch Neurol* 1995;52:299–305 | Lab: Patho-physiology |
| 97 | 59b | 80 | Louis ED, Ford B, Lee H, et al. Diagnostic criteria for essential tremor: a population perspective. *Arch Neurol* 1998;55:823–828 | Clinical: Classification |
| 98 | 59c | 80 | Kralic JE, Criswell HE, Osterman JL, et al. Genetic essential tremor in gamma-aminobutyric acidA receptor alpha 1 subunit knockout mice. *J Clin Invest* 2005;115: 774–779 | Lab: Genetic studies |
| 99 | 60a | 79 | Cleeves L, Findley LJ, Koller W. Lack of association between essential tremor and Parkinson's disease. *Ann Neurol* 1988;24: 23–26 | Epidemiology |
| 100 | 60b | 79 | Tan EK, Matsuura T, Nagamitsu S, et al. Polymorphism of NACP-Rep1 in Parkinson's disease: An etiologic link with essential tremor? *Neurology* 2000;54: 1195–1198 | Lab: Genetic studies |

### *Clinical: medical therapies*

Only those studies dealing with the application of medical and nonsurgical treatments were included in this category. For ET, there were eight articles on medical treatment with two studies on propranolol and primidone, and one study each on gabapentin and propranolol, on propranolol alone, on alcohol, on botulinum toxin, and on mechanical displacement. For dystonia, there were 30 articles including one citation classic.[18] The effect of botulinum toxin was investigated in 19 out of the 30 articles. The remaining articles included five studies on transcranial magnetic stimulation; three studies on levodopa; and one study each on baclofen, lidocaine, and anticholinergic treatment.

### *Clinical: surgical therapies*

Only those studies that dealt primarily with surgical treatment were included in this category. In several studies, the primary aim of the surgical treatment was for tremor whose etiology could either be due to PD or ET; these were also included. For ET, there were 16 articles with three citation classics.[10,12,13] There was one article on the effect of thalamotomy and two articles comparing thalamotomy with deep brain stimulation (DBS); the 13 remaining articles investigated the effects of thalamic stimulation of the ventral intermediate nucleus. For dystonia, there were nine articles on surgical therapies, all of which were studies of globus pallidus internus (GPi) DBS.

### *Review articles*

There were 15 review articles for ET: seven on the general aspects of ET and the remainder reviewing the treatment, pathophysiology, and effect of electrical stimulation. For dystonia, there were five reviews of pathophysiology or diagnostic features.

### *Time trends and journals*

The publication year of the most cited articles are summarized in Figure 2. This showed that there was a peak of the most cited articles for ET for articles published between 2000 and 2004, and for dystonia between 1995 and 1999. The most cited articles were published in 38 journals. The top 10 journals by numbers of articles published and numbers of citations per articles are shown in Figure 3. The top 10 journals accounted for 162 (81%) of the combined 200 most cited articles.

## Discussion

The most highly cited articles in the fields of ET and dystonia were identified (Tables 2 and 3). By category, the most cited studies were those on pathophysiology followed by medical treatments, clinical

Table 3. **Summary of Top 100 Articles on Dystonia Citations for Dystonia (Ranked in Order of Citations)**

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 1 | 1 | 560 | Ozelius LJ, Hewett JW, Page CE, et al. The early-onset torsion dystonia gene (DYT1) encodes an ATP binding protein. *Nat Genet* 1997;17:40–48 | Lab: Genetic studies |
| 2 | 2 | 537 | Burke RE, Fahn S, Marsden CD, et al. Validity and reliability of a rating-scale for the primary torsion dystonias. *Neurology* 1985;35:73–77 | Clinical: Classification |
| 3 | 3 | 523 | Ichinose H, Ohye T, Takahashi E, et al. Hereditary progressive dystonia with marked diurnal fluctuation caused by mutations in the GTP cyclohydrolase-I gene. *Nat Genet* 1994;8:236–242 | Lab: Genetic studies |
| 4 | 4 | 491 | Berardelli A, Rothwell JC, Hallett M, et al. The pathophysiology of primary dystonia. *Brain* 1998;121:1195–1212 | Lab: Patho-physiology |
| 5 | 5 | 453 | Tsui JKC, Stoessl AJ, Eisen A, et al. Double-blind-study of botulinum toxin in spasmodic torticollis. *Lancet* 1986;2:245–247 | Clinical: Medicine |
| 6 | 6 | 438 | Vidailhet M, Vercueil L, Houeto JL, et al. Bilateral deep-brain stimulation of the globus pallidus in primary generalized dystonia. *N Engl J Med* 2005;352:459–467 | Clinical: Surgery |
| 7 | 7 | 391 | Ridding MC, Sheean G, Rothwell JC, et al. Changes in the balance between motor cortical excitation and inhibition in focal, task specific dystonia. *J Neurol Neurosurg Psychiatry* 1995;59:493–498 | Clinical: Medicine |
| 8 | 8 | 363 | Burke RE, Fahn S, Jankovic J, et al. Tardive dystonia: late-onset and persistent dystonia caused by anti-psychotic drugs. *Neurology* 1982;32:1335–1346 | Lab: Patho-physiology |
| 9 | 9 | 362 | Kupsch A, Benecke R, Mueller J, et al. Pallidal deep-brain stimulation in primary generalized or segmental dystonia. *N Engl J Med* 2006;355:1978–1990 | Clinical: Surgery |
| 10 | 10 | 320 | Sheehy MP, Marsden, CD. Writers cramp -a focal dystonia. *Brain* 1982;105: 461–480 | Clinical: Classification |
| 11 | 11 | 312 | Risch N, de Leon D, Ozelius L, et al. Genetic-analysis of idiopathic torsion dystonia in Ashkenazi Jews and their recent descent from a small founder population. *Nat Genet* 1995;9:152–159 | Lab: Genetic studies |
| 12 | 12 | 311 | Byl NN, Merzenich MM, Jenkins WM. A primate genesis model of focal dystonia and repetitive strain injury 1. Learning-induced dedifferentiation of the representation of the hand in the primary somatosensory cortex in adult monkeys. *Neurology* 1996;47:508–520 | Lab: Patho-physiology |

**Table 3.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 13 | 13 | 292 | Vitek JL, Chockkan V, Zhang JY, et al. Neuronal activity in the basal ganglia in patients with generalized dystonia and hemiballismus. *Ann Neurol* 1999;46:22–35 | Lab: Patho-physiology |
| 14 | 14 | 282 | Berardelli A, Rothwell JC, Day BL, et al. Patho-physiology of blepharospasm and oromandibular dystonia. *Brain* 1985;108:593–608 | Lab: Patho-physiology |
| 15 | 15 | 279 | Siebner HR, Tormos JM, Ceballos-Baumann AO, et al. Low-frequency repetitive transcranial magnetic stimulation of the motor cortex in writer's cramp. *Neurology* 1999;52:529–537 | Clinical: Medicine |
| 16 | 16 | 259 | Jankovic J, Orman J. Botulinum-a toxin for cranial-cervical dystonia: a double-blind, placebo-controlled study. *Neurology* 1987;37:616–623 | Clinical: Medicine |
| 17 | 17a | 255 | Elbert T, Candia V, Altenmuller E, et al. Alteration of digital representations in somatosensory cortex in focal hand dystonia. *Neuroreport* 1998;9:3571–3575 | Lab: Patho-physiology |
| 18 | 17b | 255 | Jankovic J, Schwartz K, Donovan DT. Botulinum toxin treatment of cranial-cervical dystonia, spasmodic dysphonia, other focal dystonias and hemifacial spasm. *J Neurol Neurosurg Psychiatry* 1990;53:633–639 | Clinical: Medicine |
| 19 | 17c | 255 | Coubes P, Roubertie A, Vayssiere N, et al. Treatment of DYT1-generalised dystonia by stimulation of the internal globus pallidus. *Lancet* 2000;355:2220–2221 | Clinical: Surgery |
| 20 | 18 | 248 | Zimprich A, Grabowski M, Asmus F, et al. Mutations in the gene encoding epsilon-sarcoglycan cause myoclonus-dystonia syndrome. *Nat Genet* 2001;29:66–69 | Lab: Genetic studies |
| 21 | 19 | 246 | Brin MF, Fahn S, Moskowitz C, et al. Localized injections of botulinum toxin for the treatment of focal dystonia and hemifacial spasm. *Mov Disord* 1987;2:237–254 | Clinical: Medicine |
| 22 | 20 | 242 | Nutt JG, Muenter MD, Aronson A, et al. Epidemiology of focal and generalized dystonia in Rochester, Minnesota. *Mov Disord* 1988;3:188–194 | Epidemiology |
| 23 | 21 | 234 | Greene P, Kang U, Fahn S, et al. Double-blind, placebo-controlled trial of botulinum toxin injections for the treatment of spasmodic torticollis. *Neurology* 1990;40:1213–1218 | Clinical: Medicine |
| 24 | 22 | 233 | Jankovic J, Leder S, Warner D, et al. Cervical dystonia: clinical findings and associated movement-disorders. *Neurology* 1991;41:1088–1091 | Epidemiology |

**Table 3.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 25 | 23 | 231 | Greene P, Fahn S, Diamond B. Development of resistance to botulinum toxin type-a in patients with torticollis. *Mov Disord* 1994;9:213–217 | Clinical: Medicine |
| 26 | 24 | 230 | Chan J, Brin MF, Fahn S. Idiopathic cervical dystonia : clinical characteristics. *Mov Disord* 1991;6:119–126 | Clinical: Classification |
| 27 | 25 | 226 | Jun AS, Brown MD, Wallace DC. A mitochondrial-DNA mutation at nucleotide pair-14459 of the NADH dehydrogenase subunit-6 gene associated with maternally inherited Leber hereditary optic neuropathy and dystonia. *Proc Natl Acad Sci U S A* 1994;91:6206–6210 | Lab: Genetic studies |
| 28 | 26a | 225 | Lance JW. Familial paroxysmal dystonic choreoathetosis and its differentiation from related syndromes. *Ann Neurol* 1977;2:285–293 | Clinical: Classification |
| 29 | 26b | 225 | Brin MF, Lew MF, Adler CH, et al. Safety and efficacy of NeuroBloc (botulinum toxin type B) in type A-resistant cervical dystonia. *Neurology* 1999;53:1431–1438 | Clinical: Medicine |
| 30 | 27 | 224 | Siebner HR, Dressnandt J, Auer C, et al. Continuous intrathecal baclofen infusions induced a marked increase of the transcranially evoked silent period in a patient with generalized dystonia. *Muscle Nerve* 1998;21:1209–1212 | Clinical: Medicine |
| 31 | 28 | 222 | Nakashima K, Rothwell JC, Day BL, et al. Reciprocal inhibition between forearm muscles in patients with writers cramp and other occupational cramps, symptomatic hemidystonia and hemiparesis due to stroke. *Brain* 1989;112:681–697 | Lab: Patho-physiology |
| 32 | 29 | 221 | Bara-Jimenez W, Catalan MJ, Hallett M, et al. Abnormal somatosensory homunculus in dystonia of the hand. *Ann Neurol* 1998;44: 828–831 | Lab: Patho-physiology |
| 33 | 30a | 220 | Ceballos-Baumann AO, Passingham RE, Warner T, et al. Overactive prefrontal and underactive motor cortical areas in idiopathic dystonia. *Ann Neurol* 1995;37:363–372 | Lab: Patho-physiology |
| 34 | 30b | 220 | Brashear A, Lew MF, Dykstra DD, et al. Safety and efficacy of NeuroBloc (botulinum toxin type B) in type A-responsive cervical dystonia. *Neurology* 1999;53: 1439–1446 | Clinical: Medicine |
| 35 | 31 | 217 | Breakefield XO, Blood AJ, Li Y, et al. The pathophysiological basis of dystonias. *Nat Rev Neurosci* 2008;9:222–234 | Review |
| 36 | 32 | 213 | Ozelius L, Kramer PL, Moskowitz CB, et al. Human-gene for torsion dystonia located on chromosome 9q32–q34. *Neuron* 1989;2:1427–1434 | Lab: Genetic studies |

**Table 3.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 37 | 33 | 211 | Koehler CM, Leuenberger D, Merchant S, et al. Human deafness dystonia syndrome is a mitochondrial disease. *Proc Natl Acad U S A* 1999;96:2141–2146 | Clinical: Classification |
| 38 | 34 | 210 | Hallett, M. Is dystonia a sensory disorder? *Ann Neurol* 1995;38:139–140 | Clinical: Classification |
| 39 | 35' | 206 | Jankovic J, Ford J. Blepharospasm and orofacial cervical dystonia: clinical and pharmacological findings in 100 patients. *Ann Neurol* 1983;13:402–411 | Epidemiology |
| 40 | 36a | 205 | Jankovic J, Schwartz K. Botulinum toxin injections for cervical dystonia. *Neurology* 1990;40:277–280 | Clinical: Medicine |
| 41 | 36b | 205 | Coubes P, Cif L, El Fertit H, et al. Electrical stimulation of the globus pallidus internus in patients with primary generalized dystonia: long-term results. *J Neurosurg* 2004;101:189–194 | Clinical: Surgery |
| 42 | 37a | 193 | Jankovic J, Vanderlinden C. Dystonia and tremor induced by peripheral trauma: predisposing factors. *J Neurol Neurosurg Psychiatry* 1988;51:1512–1519 | Lab: Patho-physiology |
| 43 | 37b | 193 | Eidelberg D, Moeller JR, Antonini A, et al. Functional brain networks in DYT1 dystonia. *Ann Neurol* 1998;44:303–312 | Lab: Patho-physiology |
| 44 | 38 | 192 | Lozano AM, Kumar R, Gross RE, et al. Globus pallidus internus pallidotomy for generalized dystonia. *Mov Disord* 1997;12:865–870 | Clinical: Surgery |
| 45 | 39 | 189 | Brown A, Bernier G, Mathieu M, et al. The mouse dystonia musculorum gene is a neural isoform of bullous pemphigoid antigen-1. *Nat Genet* 1995;10:301–306 | Lab: Genetic studies |
| 46 | 40 | 185 | Kaji R, Rothwell JC, Katayama M, et al. Tonic vibration reflex and muscle afferent block in writers cramp. *Ann Neurol* 1995;38:155–162 | Clinical: Medicine |
| 47 | 41 | 183 | Marsden CD. Blepharospasm-oromandibular dystonia syndrome (Brueghel's syndrome). A variant of adult-onset torsion dystonia. *J Neurol Neurosurg Psychiatry* 1976;39:1204–1209 | Clinical: Classification |
| 48 | 42 | 181 | Ikoma K, Samii A, Mercuri B, et al. Abnormal cortical motor excitability in dystonia. *Neurology* 1996;46:1371–1376 | Clinical: Medicine |
| 49 | 43 | 180 | Quartarone A, Bagnato S, Rizzo V, et al. Abnormal associative plasticity of the human motor cortex in writer's cramp. *Brain* 2003;126:2586–2596 | Clinical: Medicine |
| 50 | 44 | 179 | Bressman SB, Sabatti C, Raymond D, et al. The DYT1 phenotype and guidelines for diagnostic testing. *Neurology* 2000;54:1746–1752 | Lab: Genetic studies |

**Table 3.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 51 | 45 | 178 | Zuber M, Sebald M, Bathien N, de Recondo J, Rondot P. Botulinum antibodies in dystonic patients treated with type-a botulinum toxin – frequency and significance. *Neurology* 1993;43:1715–1718 | Clinical: Medicine |
| 52 | 46 | 176 | Muenter MD, Sharpless NS, Tyce GM, et al. Patterns of dystonia (I-D-I and D-I-D) in response to l-dopa therapy for Parkinson's disease. *Mayo Clin Proc* 1977;3: 163–174 | Clinical: Medicine |
| 53 | 47 | 175 | Marsden CD, Harrison MJ. Idiopathic torsion dystonia (dystonia musculorum deformans). A review of forty-two patients. *Brain* 1974; 97:793–810 | Review |
| 54 | 48 | 174 | Kumar R, Dagher A, Hutchison WD, et al. Globus pallidus deep brain stimulation for generalized dystonia: clinical and PET investigation. *Neurology* 1999;53: 871–874 | Lab: Patho-physiology |
| 55 | 49 | 173 | Goodchild RE, Kim CE, Dauer WT. Loss of the dystonia-associated protein torsinA selectively disrupts the neuronal nuclear envelope. *Neuron* 2005;48:923–932 | Lab: Genetic studies |
| 56 | 50 | 171 | Cohen LG, Hallett M. Hand cramps – clinical-features and electromyographic patterns in a focal dystonia. *Neurology* 1988;38:1005–1012 | Clinical: Classification |
| 57 | 51 | 170 | Blitzer A, Brin MF, Stewart CF. Botulinum toxin management of spasmodic dysphonia (Laryngeal dystonia): A 12-year experience in more than 900 patients. *Laryngoscope* 1998;108:1435–1441 | Clinical: Medicine |
| 58 | 52a | 169 | Dauer WT, Burke RE, Greene P, et al. Current concepts on the clinical features, aetiology and management of idiopathic cervical dystonia. *Brain* 1998;121:547–560 | Review |
| 59 | 52b | 169 | Irani SR, Michell AW, Lang B, et al. Faciobrachial dystonic seizures precede Lgi1 antibody limbic encephalitis. *Ann Neurol* 2011;69:892–900 | Lab: Patho-physiology |
| 60 | 52c | 169 | Gelb DJ, Lowenstein DH, Aminoff MJ. Controlled trial of botulinum toxin injections in the treatment of spasmodic torticollis. *Neurology* 1989;39:80–84 | Clinical: Medicine |
| 61 | 53 | 167 | Burke RE, Fahn S, Gold AP. Delayed-onset dystonia in patients with static encephalopathy. *J Neurol Neurosurg Psychiatry* 1980;43:789–797 | Clinical: Classification |
| 62 | 54a | 165 | Waddy HM, Fletcher NA, Harding AE, et al. A genetic-study of idiopathic focal dystonias. *Ann Neurol* 1991;29:320–324 | Lab: Genetic studies |

**Table 3.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 63 | 54b | 165 | Krauss JK, Pohle T, Weber S, et al. Bilateral stimulation of globus pallidus internus for treatment of cervical dystonia. *Lancet* 1999;354:837–838 | Clinical: Surgery |
| 64 | 55 | 164 | Odergren T, Hjaltason H, Kaakkola S, et al. A double blind, randomised, parallel group study to investigate the dose equivalence of Dysport (R) and Botox (R) in the treatment of cervical dystonia. *J Neurol Neurosurg Psychiatry* 1998;64:6–12 | Clinical: Medicine |
| 65 | 56a | 163 | Simpson DM, Gracies JM, Graham HK, et al. 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. *Neurology* 2008;70: 1691–1698 | Review |
| 66 | 56b | 163 | Bressman SB, de Leon D, Brin MF, et al. Idiopathic dystonia among Ashkenazi Jews: evidence for autosomal dominant inheritance. *Ann Neurol* 1989;26:612–620 | Lab: Genetic studies |
| 67 | 57a | 162 | Jin H, May M, Tranebjaerg L, et al. A novel X-linked gene, DDP, shows mutations in families with deafness (DFN-1), dystonia, mental deficiency and blindness. *Nat Genet* 1996;14:177–180 | Lab: Genetic studies |
| 68 | 57b | 162 | Nygaard TG, Marsden CD, Fahn S. Dopa-responsive dystonia: long-term treatment response and prognosis. *Neurology* 1991;41:174–181 | Clinical: Medicine |
| 69 | 58a | 161 | Rupniak NMJ, Jenner P, Marsden, CD. Acute dystonia induced by neuroleptic drugs. *Psychopharmacology (Berl)* 1986;88:403–419 | Lab: Patho-physiology |
| 70 | 58b | 161 | Vidailhet M, Vercueil L, Houeto JL, et al. Bilateral, pallidal, deep-brain stimulation in primary generalised dystonia: a prospective 3 year follow-up study. *Lancet Neurol* 2007;6:223–229 | Clinical: Surgery |
| 71 | 58c | 161 | Newton MR, Berkovic SF, Austin MC, et al. Dystonia, clinical lateralization, and regional blood-flow changes in temporal-lobe seizures. *Neurology* 1992;42: 371–377 | Epidemiology |
| 72 | 58d | 161 | Aguiar PD, Sweadner KJ, Penniston JT, et al. Mutations in the Na+/K+-ATPase alpha 3 gene ATP1A3 are associated with rapid-onset dystonia Parkinsonism. *Neuron* 2004; 43:169–175 | Lab: Genetic studies |

**Table 3.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 73 | 58e | 161 | Silberstein P, Kuhn AA, Kupsch A, et al. Patterning of globus pallidus local field potentials differs between Parkinson's disease and dystonia. *Brain* 2003;126:2597–2608 | Lab: Patho-physiology |
| 74 | 59 | 160 | Lew MF, Adornato BT, Duane DD, et al. Botulinum toxin type B: A double-blind, placebo-controlled, safety and efficacy study in cervical dystonia. *Neurology* 1997; 49: 701–707 | Clinical: Medicine |
| 75 | 60 | 159 | Albanese A, Bhatia K, Bressman SB, et al. Phenomenology and classification of dystonia: A consensus update. *Mov Disord* 2013;28:863–873 | Clinical: Classification |
| 76 | 61a | 157 | Abbruzzese G, Marchese R, Buccolieri A; et al. Abnormalities of sensorimotor integration in focal dystonia – A transcranial magnetic stimulation study. *Brain* 2001;124:537–545 | Lab: Patho-physiology |
| 77 | 61b | 157 | Kotagal P, Lüders H, Morris HH, et al. Dystonic posturing in complex partial seizures of temporal-lobe onset: a new lateralizing sign. *Neurology* 1989:39:196–201 | Lab: Patho-physiology |
| 78 | 62a | 155 | Jankovic J, Vuong KD, Ahsan, J. Comparison of efficacy and immunogenicity of original versus current botulinum toxin in cervical dystonia. *Neurology* 2003;60:1186–1188 | Clinical: Medicine |
| 79 | 62b | 155 | Vercueil L, Pollak P, Fraix V, et al. Deep brain stimulation in the treatment of severe dystonia. *J Neurol* 2001;248: 695–700 | Clinical: Surgery |
| 80 | 63a | 154 | Kothary R, Clapoff S, Brown A, Campbell R, Peterson A, Rossant J. A transgene containing lacz inserted into the dystonia locus is expressed in neural tube. *Nature* 1988;335:435–437 | Lab: Genetic studies |
| 81 | 63b | 154 | Byrnes ML, Thickbroom GW, Wilson SA, et al. The corticomotor representation of upper limb muscles in writer's cramp and changes following botulinum toxin injection. *Brain* 1998;121:977–988 | Clinical: Medicine |
| 82 | 64a | 152 | Rajput AH, Gibb WR, Zhong XH, et al. Dopa-responsive dystonia – pathological and biochemical observations in a case. *Ann Neurol* 1994;35:396–402 | Clinical: Medicine |
| 83 | 64b | 152 | Krack P, Pollak P, Limousin P, et al. From off-period dystonia to peak-dose chorea – The clinical spectrum of varying subthalamic nucleus activity. *Brain* 1999; 122:1133–1146 | Clinical: Classification |
| 84 | 64c | 152 | Knappskog PM, Flatmark T, Mallet J, et al. Recessively inherited l-dopa-responsive dystonia caused by a point mutation (q381k) in the tyrosine-hydroxylase gene. *Hum Mol Genet* 1995;4:1209–1212 | Lab: Genetic studies |

**Table 3.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 85 | 65 | 151 | Kessler KR, Skutta M, Benecke R. Long-term treatment of cervical dystonia with botulinum toxin A: efficacy, safety, and antibody frequency. *J Neurol* 1999;246:265–274 | Clinical: Medicine |
| 86 | 66a | 150 | Ceballos-Baumann AO, Sheean G, Passingham RE, et al. Botulinum toxin does not reverse the cortical dysfunction associated with writer's cramp . A PET study. *Brain* 1997;120:571–582 | Lab: Patho-physiology |
| 87 | 66b | 150 | Nygaard TG, Wilhelmsen KC, Risch NJ, et al. Linkage mapping of dopa-responsive dystonia (drd) to chromosome 14q. *Nat Genet* 1993;5:386–391 | Lab: Genetic studies |
| 88 | 65a | 149 | Tempel LW, Perlmutter JS. Abnormal cortical responses in patients with writer's cramp. *Neurology* 1993;43: 2252–2257 | Lab: Patho-physiology |
| 89 | 65b | 149 | Agostino R, Berardelli A, Formica A, et al. Sequential arm movements in patients with Parkinson's disease, Huntington's disease and dystonia. *Brain* 1992;115: 1481–1495 | Clinical: Classification |
| 90 | 66a | 146 | Blackie JD, Lees AJ. Botulinum toxin treatment in spasmodic torticollis. *J Neurol Neurosurg Psychiatry* 1990;53:640–643 | Clinical: Medicine |
| 91 | 66b | 146 | Lugaresi E, Cirignotta F. Hypnogenic paroxysmal dystonia: epileptic seizure or a new syndrome? *Sleep* 1981;4:129–138 | Clinical: Classification |
| 92 | 67 | 143 | Leube B, Rudnicki D, Ratzlaff T, et al. Idiopathic torsion dystonia: Assignment of a gene to chromosome 18p in a German family with adult onset, autosomal dominant inheritance and purely focal distribution. *Hum Mol Genet* 1996;5:1673–1677 | Lab: Genetic studies |
| 93 | 68a | 142 | Fahn S. High dosage anticholinergic therapy in dystonia. *Neurology* 1983;33:1255–1261 | Clinical: Medicine |
| 94 | 68b | 142 | Cohen LG, Hallett M, Geller, BD, et al. Treatment of focal dystonias of the hand with botulinum toxin injections. *J Neurol Neurosurg Psychiatry* 1989;52:355–363 | Clinical: Medicine |
| 95 | 69a | 141 | Chen R, Wassermann EM, Canos M, et al. Impaired inhibition in writer's cramp during voluntary muscle activation. *Neurology* 1997;49:1054–1059 | Clinical: Medicine |
| 96 | 69b | 141 | Goodchild RE, Dauer WT. Mislocalization to the nuclear envelope: An effect of the dystonia-causing torsinA mutation. *Proc Natl Acad Sci U S A* 2004;101:847–852 | Lab: Genetic studies |

**Table 3.** Continued

| Absolute Number | Rank | Citations | Paper | Category |
|---|---|---|---|---|
| 97 | 70 | 140 | Paisan-Ruiz C, Bhatia KP, Li A, et al. Characterization of PLA2G6 as a locus for dystonia-parkinsonism. *Ann Neurol* 2009; 65:19–23 | Lab: Genetic studies |
| 98 | 71 | 138 | Ondo WG, Desaloms JM, Jankovic J, et al. Pallidotomy for generalized dystonia. *Mov Disord* 1998;13:693–698 | Clinical: Surgery |
| 99 | 72a | 137 | Quartarone A, Siebner HR, Rothwell JC. Task-specific hand dystonia: can too much plasticity be bad for you? *Trends Neurosci* 2006;29:192–199 | Review |
| 100 | 72b | 137 | DeVries DD, Went LN, Bruyn GW, et al. Genetic and biochemical impairment of mitochondrial complex I activity in a family with Leber hereditary optic neuropathy and hereditary spastic dystonia. *Am J Hum Genet* 1996;58:703–771 | Lab: Patho-physiology |

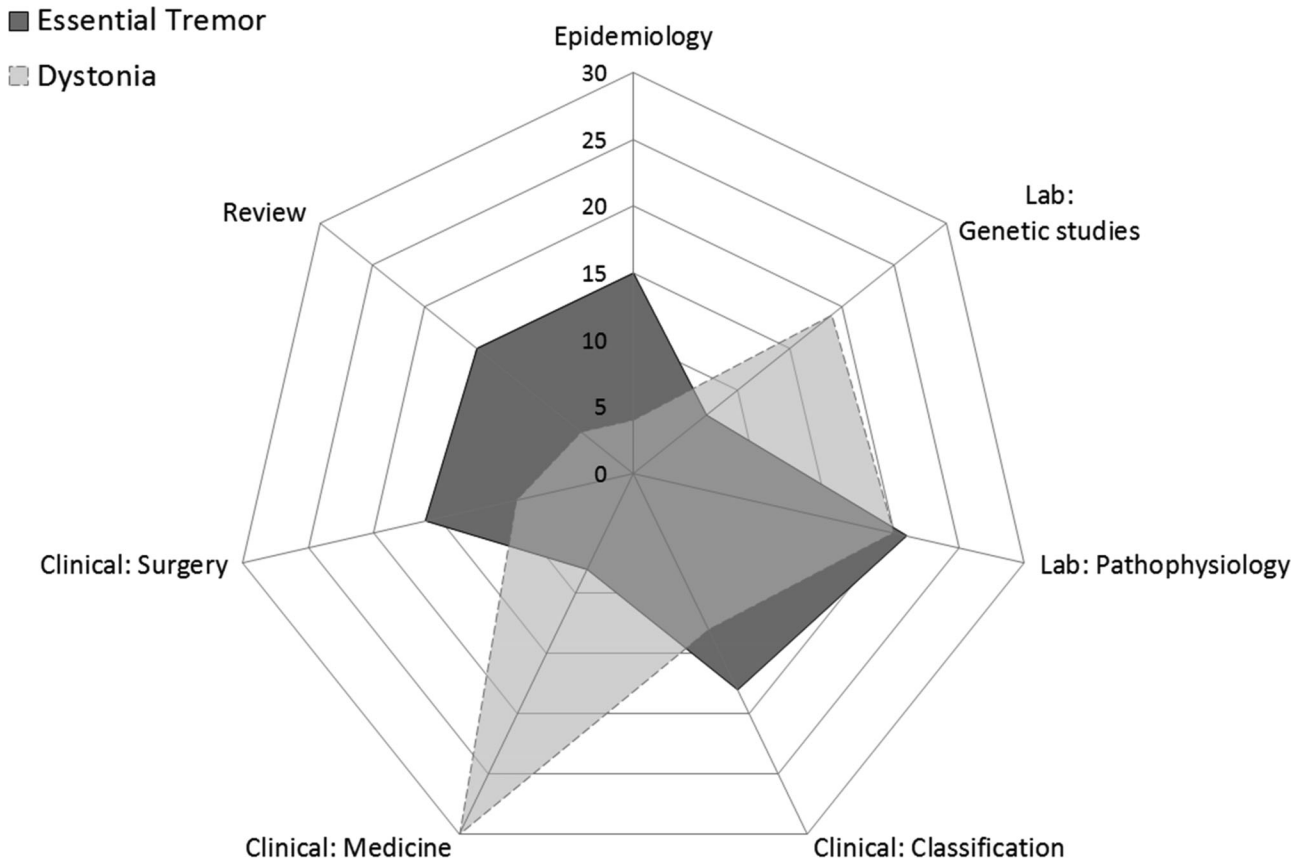


Figure 1. **Plot Showing the Number of Articles by Category.** Essential Tremor (shaded grey) and dystonia (hatched lines).

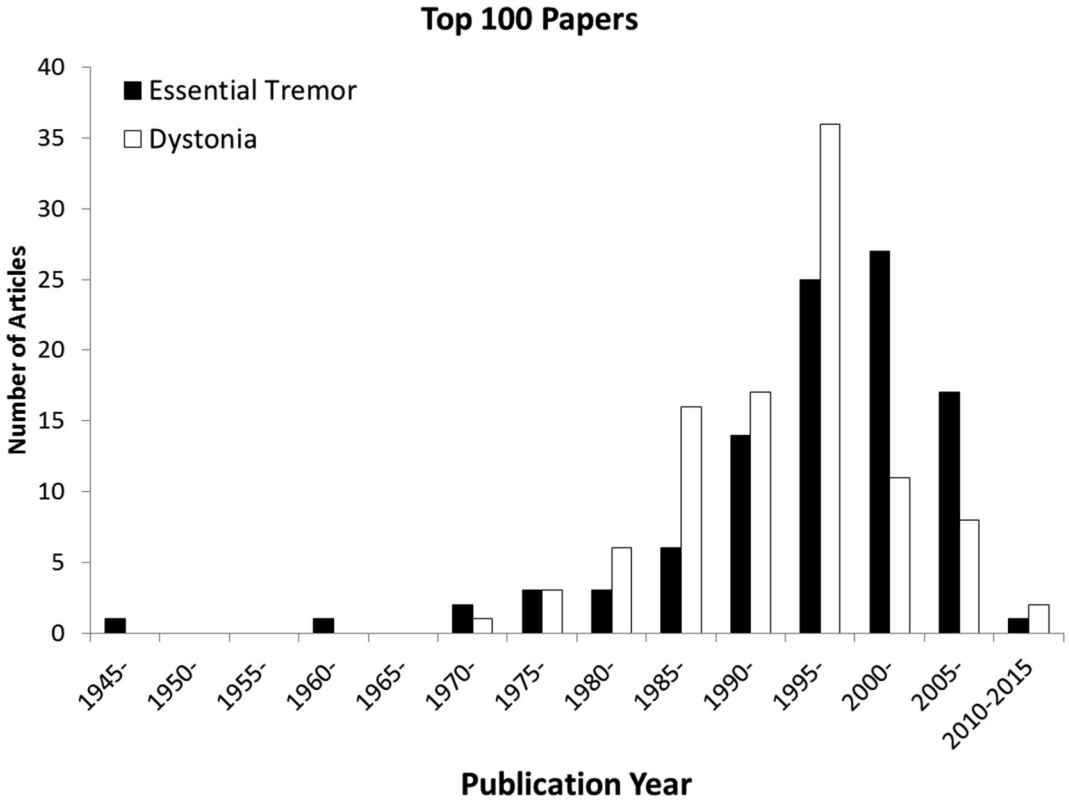


Figure 2. **Number of Most Cited Articles in 5-Year Time Periods.**

classification, genetic studies, surgical treatments, review articles, and epidemiology studies.

Comparing ET and dystonia, there are very similar proportions of articles in the most cited on pathophysiology and clinical classification categories. Nevertheless, the two fields diverge in other subfields because ET is characterized by a larger number of studies describing the epidemiology of the condition, whereas dystonia has a much higher representation of genetic studies. This is likely an indication of the greater understanding and contribution of genetic factors to dystonia compared to ET, which is—by contrast—a much more common condition but probably characterized by a wide spectrum of possible etiologies, making genetic studies very difficult. Moreover, there is a predominance of surgical treatment for ET, whereas medical treatment predominates for dystonia.

Trends over time showed that the peak period of when the most cited papers were published was between 1995 and 2005, with dystonia peaking 5 years before ET. This is in line with our previous work looking at the most cited papers in the functional neurosurgery literature, which showed a similar peak in the 1990s.[6] The proposed reasons for the peak during this time are likely similar, namely that this period was particular active and productive with significant success in elucidating the causes and diagnosis of these conditions, and effective treatments such as deep brain stimulation or botulinum toxin were developed for dystonia. Another possible reason for the proposed peak may be a fundamental feature of contemporary research whereby older publications are no longer cited because they have been replaced by new studies that have replicated the findings and superseded them.[6] At the same time, more recent studies have not had time to become established as a most cited article, for example the more recent discovery of the *DYT6* gene.[20]

The majority of the most cited articles were generally published in specialized journals such as *Neurology*, *Annals of Neurology*, *Movement Disorders*, *Brain*, *Journal of Neurology*, *Neurosurgery*, *and Psychiatry*, among others (Figure 3). However, articles published in the more general medical journals such as the *New England Journal of Medicine* or *Lancet* tend to receive more citations per article published. This also corresponded to their higher overall journal impact factor (Figure 3). An exception were articles published in the *Journal of Neurosurgery*, which received on average 356 citations per articles, more than would be expected by the journal's impact factor. These were attributable to contributions from three studies on deep brain stimulation.[12,21,22] This suggests that the publication of important clinical therapeutic studies in a specialized journal is also able to achieve significant impact.

### *Limitations*

The choice of ISI Web of Science, which indexes over 15,000 journals, over Google Scholar, which indexes a wider range of academic documents may also have had an effect on our findings. However, our previous reviews in other fields yielded very similar results using these two search engines when the study field was small.[6,9]

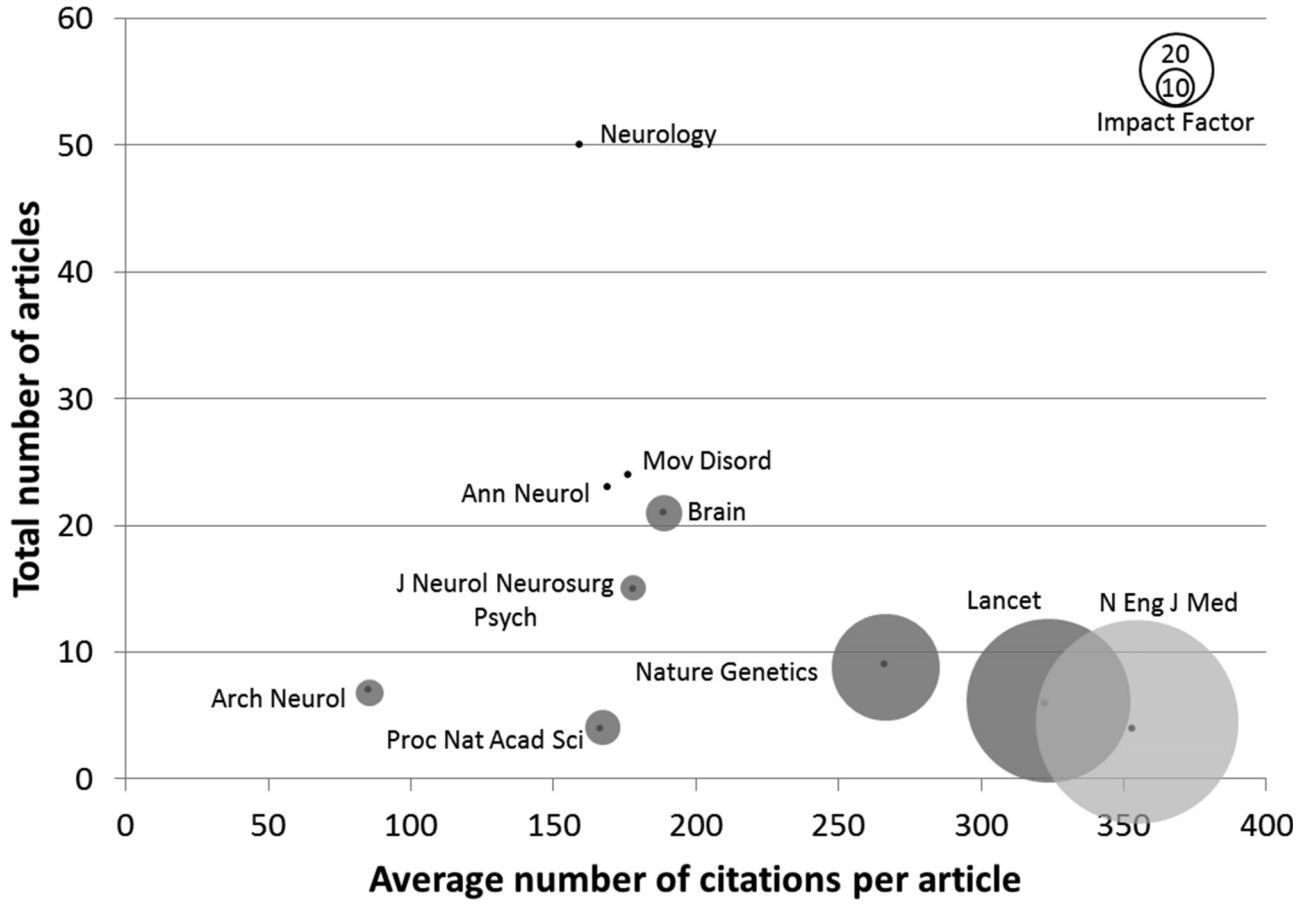


Figure 3. **Top 10 Journals with the Highest Numbers of Most Cited Articles for Essential Tremor and Dystonia.** The size of the bubble represents the 5-year journal impact factor for 2015.

Another limitation is that the search terms may not have yielded all possible results despite our inclusion of broad terms. For the ISI Web of Science search engine, it is possible to perform either a title- or topic-based search. The former would only search for the search term in the title of the article, whereas a topic-based search would also include the abstract. Given the small size of the ET and dystonia fields, a topic-based search was selected to retrieve all possible results as described in the methods section. This is particularly important for ET, as many of the studies would also include patients with parkinsonian tremor. By contrast, a citation analysis study on ET using a title-based search would yield fewer results.[8] Finally, the list of most cited papers changes with time and is therefore a snapshot of the current state of research.

## Conclusions

We performed an analysis to identify the most cited ET and dystonia papers. There are fewer citation classics compared to PD, confirming that this is a smaller field of research. Compared to dystonia, areas of research in ET such as genetics, neurophysiology, and medical treatment are underrepresented. The peak of citations for ET is also lagging by about 5 years. These findings suggest that further work remains to be carried out to improve our understanding of the basic science of ET.

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