

The top 100 cited neurorehabilitation papers

Jeffrey S. Kreutzer^{a,*}, Amma A. Agyemang^a, David Weedon^b, Nathan Zasler^c, Melissa Oliver^d, Aaron A. Sorensen^e, Saskia van Wijngaarden^b and Eileen Leahy^b

^a*Department of Physical Medicine and Rehabilitation, Virginia Commonwealth University Health System, Richmond, VA, USA*

^b*IOS Press, Amsterdam, The Netherlands*

^c*Concussion Care Centre of Virginia Ltd., Tree of Life Services, Inc., Virginia Commonwealth University, University of Virginia, VA, USA*

^d*Physical Medicine and Rehabilitation Service, McGuire VA Medical Center, Richmond, VA, USA*

^e*ÜberResearch – Digital Science, Inc., Cambridge, MA, USA*

Abstract.

BACKGROUND: Neurorehabilitation covers a large range of disorders, assessment approaches and treatment methods. There have been previous citation analyses of rehabilitation and of its subfields. However, there has never been a comprehensive citation analysis in neurorehabilitation.

OBJECTIVE: The present study reports findings from a citation analysis of the top 100 most cited neurorehabilitation papers to describe the research trends in the field.

METHODS: A *de-novo* keyword search of papers indexed in the Web of Science Core Collection database yielded 52,581 papers. A candidate pool of the 200 most-cited papers published between 2005 and 2016 was reviewed by the clinician authors. The papers in the top 100 deemed to be irrelevant were discarded and replaced by the most highly-cited articles in the second tier deemed to be clinically relevant.

RESULTS: The most frequently cited neurorehabilitation papers appeared in *Stroke*, *Movement Disorders*, and *Neurology*. Papers tended to focus on treatments, especially for stroke. Authorship trends suggest that top cited papers result from group endeavors, with 90% of the papers involving a collaboration among 3 or more authors.

CONCLUSION: Treatment studies, often focused on stroke, appear to have the highest impact in the field of neurorehabilitation.

Keywords: Neurorehabilitation, neurosciences, bibliometrics, scientometrics, factual databases, ranking, citation, citation analysis, highly-cited, history of science

1. Introduction

The number of citations a manuscript receives is often considered a measure of impact and merit. Citation analyses, or the systematic study of patterns in publications, have been used to evaluate scientific

activity for many decades (Narin, 1976) and have proliferated in biomedicine in recent years (King, Tam, Fasano, & Lozano, 2016; Sorenson & Weedon, 2011). These analyses are effective for describing the trends in scholarship in a particular area of study.

As a multidisciplinary field, rehabilitation encompasses diverse clinical and research settings. Consequently, results from citation analyses in rehabilitation can be particularly difficult to synthesize, even in the most common areas of practice (Shadgan, Roig, HajGhanbari, & Reid, 2010). Instead, the

*Address for correspondence: Jeffrey S. Kreutzer, PhD, ABPP, FACRM, Department of Physical Medicine and Rehabilitation, Virginia Commonwealth University Health System, 1200 E. Broad St., Richmond, VA 23298, USA. Tel.: +1 804 828 3704; Fax: +1 804 828 2378; E-mail: Jeffrey.kreutzer@vcuhealth.org.

approach has been to focus on specific subfields in rehabilitation. For instance, the first citation analysis in rehabilitation was an examination of research in physical therapy (Michels, 1982). Subsequent published works have similarly focused on the physical therapy literature (Bohannon & Gibson, 1986; Roberts, 1992; Wakiji, 1997), identifying the core journals in physical therapy (Bohannon & Roberts, 2009), and assessing the relative ranking of a specific rehabilitation journal (Kuhlemeier, 1992).

There has been only one published review of the top cited articles in the broader field of rehabilitation (Shadgan et al., 2010). Findings from this analysis focused on manuscripts published between 1959 and 2002 identified neurorehabilitation as the most common field of study in rehabilitation, accounting for 41% of published papers. There has not, however, been a recent analysis of the growing neurorehabilitation research literature to assess, in a comprehensive manner, the trends in this area. The present manuscript aims to characterize the published literature in neurorehabilitation over the last decade to identify the most frequently cited papers, the journals in which they were published, and the number of authors of these works. This review also provides guidance for future neurorehabilitation research and highlights where there are deficiencies in the current literature.

2. Methods

The data used in the tabulation of each article's citations originate from the Web of Science Core Collection database, which includes, but is not limited to all papers indexed by the NIH's MEDLINE® database. To start, a *de-novo* keyword search strategy was developed and applied (see Appendix A). The search strategy yielded 52,581 published papers in 2,781 journals. Manuscripts in 23 languages other than English were excluded. Next, two selection filters were used to determine which papers would be evaluated in the analysis. The first filter applied was temporal. Only papers published and subsequently indexed in Web of Science Core Collection between January 1, 2005 and April 18, 2016 were considered. As shown in Fig. 1, the authors focused on the past decade, characterized by substantial and increasing productivity.

The second filter applied to the search was relevance to neurorehabilitation. A candidate pool of the top 200 most cited was identified. From the top

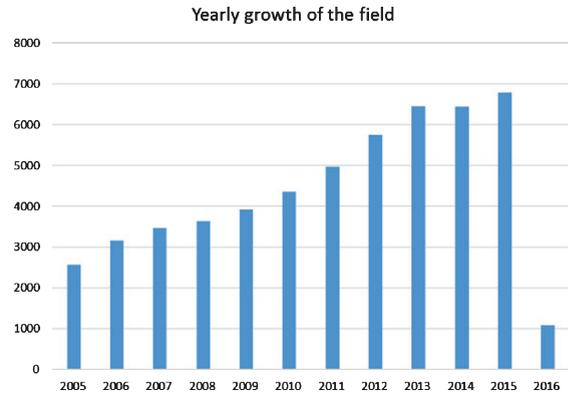


Fig. 1. Number of neurorehabilitation articles published annually since 2005.

100, papers irrelevant to neurorehabilitation were excluded and replaced by the most highly-cited articles in the second tier deemed to be clinically relevant. Relevance to rehabilitation was judged by consensus decisions of the clinician authors NZ, JSK and MO.

After compiling the 100 published papers with the most citations, papers were categorized by content. The type of article (e.g., review or evaluation, treatment study), clinical diagnosis of focus (e.g., Parkinson's disease, stroke), and symptom type (e.g., aphasia, cognitive impairment) were determined by consensus between the clinician authors. These categories were not mutually exclusive, such that one paper could be classified into more than one category (i.e., review paper and stroke).

3. Results

The top 100 most cited papers are presented in Table 1.

3.1. Journals of top 100 neurorehabilitation papers

To identify journals that were the greatest source of scientific information on neurorehabilitation, a list of the journals in which the most neurorehabilitation articles were published was compiled (see Table 2). With more than one thousand relevant articles published, the journals, *Stroke*, *Movement Disorders*, *Neurology*, *Epilepsia*, *European Journal of Neurology*, and *International Journal of Stroke* were most often a source for neurorehabilitation content.

Table 1
Most-cited papers in neurorehabilitation between January 1, 2005 and April 18, 2016

Rank	Year	Authors	Title	Journal	Total Citations
1	2005	Nasreddine, ZS; Phillips, NA; Bedirian, V; et al.	The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment	Journal of the American Geriatrics Society	1,905
2	2006	Spitzer, RL; Kroenke, K; Williams, JBW; et al.	A brief measure for assessing generalized anxiety disorder – The GAD-7	Archives of Internal Medicine	1,196
3	2005	SantaCruz, K; Lewis, J; Spires, T; et al.	Tau suppression in a neurodegenerative mouse model improves memory function	Science	795
4	2010	Lees, KR; Bluhmki, E; von Kummer, R; et al.	Time to treatment with intravenous alteplase and outcome in stroke: an updated pooled analysis of ECASS, ATLANTIS, NINDS, and EPITHEM trials	Lancet	746
5	2005	Keirstead, HS; Nistor, G; Bernal, G; et al.	Human embryonic stem cell-derived oligodendrocyte progenitor cell transplants remyelinate and restore locomotion after spinal cord injury	Journal of Neuroscience	629
6	2006	Albers, GW; Thijs, VN; Wechsle, L; et al.	Magnetic resonance imaging profiles predict clinical response to early reperfusion: The diffusion and perfusion imaging evaluation for understanding stroke evolution (DEFUSE) study	Annals of Neurology	625
7	2007	Rha, JH; Saver, JL	The impact of recanalization on ischemic stroke outcome – A meta-analysis	Stroke	623
8	2008	Avants, BB; Epstein, CL; Grossman, M; et al.	Symmetric diffeomorphic image registration with cross-correlation: Evaluating automated labeling of elderly and neurodegenerative brain	Medical Image Analysis	583
9	2008	Davis, SM; Donnan, GA; Parsons, MW; et al.	Effects of alteplase beyond 3 h after stroke in the Echoplanar Imaging Thrombolytic Evaluation Trial (EPITHEM): a placebo-controlled randomised trial	Lancet Neurology	514
10	2012	Saver, JL; Jahan, R; Levy, EI; et al.	Solitaire flow restoration device versus the Merci Retriever in patients with acute ischaemic stroke (SWIFT): a randomised, parallel-group, non-inferiority trial	Lancet	499
11	2009	Easton, JD; Saver, JL; Albers, GW; et al.	Definition and Evaluation of Transient Ischemic Attack. A Scientific Statement for Healthcare Professionals From the American Heart Association/American Stroke Association Stroke Council; Council on Cardiovascular Surgery and Anesthesia; Council on Cardiovascular Radiology and Intervention; Council on Cardiovascular Nursing; and the Interdisciplinary Council on Peripheral Vascular Disease the American Academy of Neurology affirms the value of this statement as an educational tool for neurologists	Stroke	487
12	2007	Broderick, J; Connolly, S; Feldmann, E; et al.	Guidelines for the management of spontaneous intracerebral Hemorrhage in adults – 2007 update	Stroke	437
13	2005	Hackett, ML; Yapa, C; Parag, V; et al.	Frequency of depression after stroke – A systematic review of observational studies	Stroke	423
14	2008	Kwakkel, G; Kollen, BJ; Krebs, HI	Effects of robot-assisted therapy on upper limb recovery after stroke: A systematic review	Neurorehabilitation and Neural Repair	413

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Table 1
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Rank	Year	Authors	Title	Journal	Total Citations
15	2006	Ownby, RL; Crocco, E; Acevedo, A; et al.	Depression and risk for Alzheimer disease – Systematic review, meta-analysis, and metaregression analysis	Archives of General Psychiatry	410
16	2005	Swaab, DF; Bao, AM; Lucassen, PJ	The stress system in the human brain in depression and neurodegeneration	Ageing Research Reviews	402
17	2007	Chalela, JA; Kidwell, CS; Nentwich, LM; et al.	Magnetic resonance imaging and computed tomography in emergency assessment of patients with suspected acute stroke: a prospective comparison	Lancet	383
18	2005	Remy, P; Doder, M; Lees, A; et al.	Depression in Parkinson's disease: loss of dopamine and noradrenaline innervation in the limbic system	Brain	375
19	2005	Harper, SQ; Staber, PD; He, XH; et al.	RNA interference improves motor and neuropathological abnormalities in a Huntington's disease mouse model	Proceedings of the National Academy of Sciences of the United States of America	354
20	2009	Langhorne, P; Coupar, F; Pollock, A	Motor recovery after stroke: a systematic review	Lancet Neurology	351
21	2005	Tellez-Zenteno, JF; Dhar, R; Wiebe, S	Long-term seizure outcomes following epilepsy surgery: a systematic review and meta-analysis	Brain	342
22	2015	Goyal, M; Demchuk, AM; Menon, BK; et al.	Randomized Assessment of Rapid Endovascular Treatment of Ischemic Stroke	New England Journal of Medicine	323
22	2008	Adlard, PA; Cherny, RA; Finkelstein, DI; et al.	Rapid restoration of cognition in Alzheimer's transgenic mice with 8-hydroxy quinoline analogs is associated with decreased interstitial A beta	Neuron	323
24	2006	Krakauer, JW	Motor learning: its relevance to stroke recovery and neurorehabilitation	Current Opinion in Neurology	321
24	2010	van Asch, CJJ; Luitse, MJA; Rinkel, GE; et al.	Incidence, case fatality, and functional outcome of intracerebral haemorrhage overtime, according to age, sex, and ethnic origin: a systematic review and meta-analysis	Lancet Neurology	321
26	2007	Schiff, ND; Giacino, JT; Kalmar, K; et al.	Behavioural improvements with thalamic stimulation after severe traumatic brain injury	Nature	320
27	2006	Kauvar, DS; Lefering, R; Wade, CE	Impact of hemorrhage on trauma outcome: an overview of epidemiology, clinical presentations, and therapeutic considerations	Journal of Trauma-Injury Infection and Critical Care	309
28	2006	Hummel, FC; Cohen, LG	Non-invasive brain stimulation: a new strategy to improve neurorehabilitation after stroke?	Lancet Neurology	305
29	2007	Nieuwboer, A; Kwakkel, G; Rochester, L; et al.	Cueing training in the home improves gait-related mobility in Parkinson's disease: the RESCUE trial	Journal of Neurology Neurosurgery and Psychiatry	299
30	2009	Blurton-Jones, M; Kitazawa, M; Martinez-Coria, H; et al.	Neural stem cells improve cognition via BDNF in a transgenic model of Alzheimer's disease	Proceedings of the National Academy of Sciences of the United States Of America	296
31	2013	Titulaer, MJ; McCracken, L; Gabilondo, I; et al.	Treatment and prognostic factors for long-term outcome in patients with anti-NMDA receptor encephalitis: an observational cohort study	Lancet Neurology	295
32	2010	Lo, AC; Guarino, PD; Richards, LG; et al.	Robot-Assisted Therapy for Long-Term Upper-Limb Impairment after Stroke	New England Journal of Medicine	290

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32	2009	Barone, P; Antonini, A; Colosimo, C; et al.	The Priamo Study: a Multicenter Assessment of Nonmotor Symptoms and Their Impact on Quality of Life in Parkinson's Disease	Movement Disorders	290
34	2007	Banks, JL; Marotta, CA	Outcomes validity and reliability of the modified Rankin scale: implications for stroke clinical trials – A literature review and synthesis	Stroke	288
35	2005	Duncan, PW; Zorowitz, R; Bates, B; et al.	Management of adult stroke rehabilitation care – A clinical practice guideline	Stroke	280
35	2005	Flansbjerg, UB; Holmback, AM; Downham, D; et al.	Reliability of gait performance tests in men and women with hemiparesis after stroke	Journal of Rehabilitation Medicine	280
37	2009	Schnakers, C; Vanhaudenhuyse, A; Giacino, J; et al.	Diagnostic accuracy of the vegetative and minimally conscious state: clinical consensus versus standardized neurobehavioral assessment	BMC Neurology	278
38	2005	Marini, C; De Santis, F; Sacco, S; et al.	Contribution of atrial fibrillation to incidence and outcome of ischemic stroke – Results from a population-based study	Stroke	276
39	2008	Reijnders, JSAM; Ehrt, U; Weber, WEJ; et al.	A systematic review of prevalence studies of depression in Parkinson's disease	Movement Disorders	274
39	2005	Naeser, MA; Martin, PI; Nicholas, M; et al.	Improved picture naming in chronic aphasia after TMS to part of right Broca's area: An open-protocol study	Brain and Language	274
41	2005	Fregni, F; Boggio, PS; Mansur, CG; et al.	Transcranial direct current stimulation of the unaffected hemisphere in stroke patients	Neuroreport	269
42	2005	Takeuchi, N; Chuma, T; Matsuo, Y; et al.	Repetitive Transcranial magnetic stimulation of contralesional primary motor cortex improves hand function after stroke	Stroke	263
42	2007	Birbaumer, N; Cohen, LG	Brain-computer interfaces: communication and restoration of movement in paralysis	Journal of Physiology-London	263
44	2006	Bourke, SC; Tomlinson, M; Williams, TL; et al.	Effects of non-invasive ventilation on survival and quality of life in patients with amyotrophic lateral sclerosis	Lancet Neurology	261
45	2006	Zandbergen, EGJ; Hijdra, A; Koelman, JHTM; et al.	Prediction of poor outcome within the first 3 days of postanoxic coma	Neurology	257
46	2005	Slevin, JT; Gerhardt, GA; Smith, CD; et al.	Improvement of bilateral motor functions in patients with Parkinson disease through the unilateral intraputaminial infusion of glial cell line-derived neurotrophic factor	Journal of Neurosurgery	256
47	2006	Fregni, F; Boggio, PS; Lima, MC; et al.	A sham-controlled, phase II trial of transcranial direct current stimulation for the treatment of central pain in traumatic spinal cord injury	Pain	254
48	2005	Edwards, P; Arango, M; Balica, L; et al.	Final results of MRC CRASH, a randomised placebo-controlled trial of intravenous corticosteroid in adults with head injury – outcomes at 6 months	Lancet	253
49	2005	Belanger, HG; Curtiss, G; Demery, JA; et al.	Factors moderating neuropsychological outcomes following mild traumatic brain injury: A meta-analysis	Journal of the International Neuropsychological Society	252

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Table 1
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Rank	Year	Authors	Title	Journal	Total Citations
50	2006	Aarabi, B; Hesdorffer, DC; Ahn, ES; et al.	Outcome following decompressive craniectomy for malignant swelling due to severe head injury	Journal of Neurosurgery	250
51	2005	Geurts, JIG; Pouwels, PJW; Uitdehaag, BMJ; et al.	Intracortical lesions in multiple sclerosis: improved detection with 3D double inversion-recovery MR imaging	Radiology	249
51	2008	Steyerberg, EW; Mushkudiani, N; Perel, P; et al.	Predicting outcome after traumatic brain injury: Development and international validation of prognostic scores based on admission characteristics	PLoS Medicine	249
53	2008	Perel, P; Arango, M; Clayton, T; et al.	Predicting outcome after traumatic brain injury: practical prognostic models based on large cohort of international patients	British Medical Journal	248
54	2007	Schrag, A; Barone, P; Brown, RG; et al.	Depression rating scales in Parkinson's disease: Critique and recommendations	Movement Disorders	247
54	2006	Belle, SH; Burgio, L; Burns, R; et al.	Enhancing the quality of life of dementia caregivers from different ethnic or racial groups - A randomized, controlled trial	Annals of Internal Medicine	247
54	2005	Thompson, HJ; Lifshitz, J; Marklund, N; et al.	Lateral fluid percussion brain injury: a 15-year review and evaluation	Journal of Neurotrauma	247
57	2007	Kennedy, J; Hill, MD; Ryckborst, KJ; et al.	Fast assessment of stroke and transient ischaemic attack to prevent early recurrence (FASTER): a randomised controlled pilot trial	Lancet Neurology	246
58	2007	Guskiewicz, KM; Marshall, SW; Bailes, J; et al.	Recurrent concussion and risk of depression in retired professional football players	Medicine and Science in Sports And Exercise	244
59	2008	Reeves, MJ; Bushnell, CD; Howard, G; et al.	Sex differences in stroke: epidemiology, clinical presentation, medical care, and outcomes	Lancet Neurology	241
60	2008	Spencer, S; Huh, L	Outcomes of epilepsy surgery in adults and children	Lancet Neurology	239
61	2011	Langhorne, P; Bernhardt, J; Kwakkel, G	Stroke Care 2 Stroke rehabilitation	Lancet	238
61	2007	Garcia-Alloza, M; Borrelli, LA; Rozkalne, A; et al.	Curcumin labels amyloid pathology <i>in vivo</i> , disrupts existing plaques, and partially restores distorted neurites in an Alzheimer mouse model	Journal of Neurochemistry	238
63	2006	Moser, DK; Alberts, MJ; Kimble, LP; et al.	Reducing delay in seeking treatment by patients with acute coronary syndrome and stroke - A scientific statement from the American Heart Association Council on Cardiovascular Nursing and Stroke Council	Circulation	236
64	2005	Yogev, G; Giladi, N; Peretz, C; et al.	Dual tasking, gait rhythmicity, and Parkinson's disease: Which aspects of gait are attention demanding?	European Journal of Neuroscience	234
65	2009	Khatri, P; Abruzzo, T; Yeatts, SD; et al.	Good clinical outcome after ischemic stroke with successful revascularization is time-dependent	Neurology	231
66	2006	Fregni, F; Boggio, PS; Valle, AC; et al.	A sham-controlled trial of a 5-day course of repetitive transcranial magnetic stimulation of the unaffected hemisphere in stroke patients	Stroke	229
66	2008	Bao, AM; Meynen, G; Swaab, DF	The stress system in depression and neurodegeneration: Focus on the human hypothalamus	Brain Research Reviews	229

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68	2005	Khedr, EM; Ahmed, MA; Fathy, N; et al.	Therapeutic trial of repetitive transcranial magnetic stimulation after acute ischemic stroke	Neurology	228
69	2006	Jicha, GA; Parisi, JE; Dickson, DW; et al.	Neuropathologic outcome of mild cognitive impairment following progression to clinical dementia	Archives of Neurology	226
70	2005	Brambilla, R; Bracchi-Ricard, V; Hu, WH; et al.	Inhibition of astroglial nuclear factor kappa B reduces inflammation and improves functional recovery after spinal cord injury	Journal of Experimental Medicine	225
71	2011	Chollet, F; Tardy, J; Albucher, JF; et al.	Fluoxetine for motor recovery after acute ischaemic stroke (FLAME): a randomised placebo-controlled trial	Lancet Neurology	222
71	2006	Benedict, RHB; Cookfair, D; Gavett, R; et al.	Validity of the minimal assessment of cognitive function in multiple sclerosis (MACHMS)	Journal of the International Neuropsychological Society	222
73	2010	Tsuji, O; Miura, K; Okada, Y; et al.	Therapeutic potential of appropriately evaluated safe-induced pluripotent stem cells for spinal cord injury	Proceedings of the National Academy of Sciences of the United States of America	218
74	2005	Siegert, RJ; Abernethy, DA	Depression in multiple sclerosis: a review	Journal of Neurology Neurosurgery and Psychiatry	217
75	2006	Pinquart, M; Sorensen, S	Helping caregivers of persons with dementia: which interventions work and how large are their effects?	International Psychogeriatrics	216
75	2006	Mittelman, MS; Haley, WE; Clay, OJ; et al.	Improving caregiver well-being delays nursing home placement of patients with Alzheimer disease	Neurology	216
75	2009	Schwamm, LH; Fonarow, GC; Reeves, MJ; et al.	Get With the Guidelines-Stroke Is Associated With Sustained Improvement in Care for Patients Hospitalized with Acute Stroke or Transient Ischemic Attack	Circulation	216
78	2007	Boggio, PS; Nunes, A; Rigonatti, SP; et al.	Repeated sessions of noninvasive brain DC stimulation is associated with motor function improvement in stroke patients	Restorative Neurology and Neuroscience	215
78	2007	Rolland, Y; Pillard, F; Klapouszczak, A; et al.	Exercise program for nursing home residents with Alzheimer's disease: A 1-year randomized, controlled trial	Journal of the American Geriatrics Society	215
80	2005	Hackett, ML; Anderson, CS	Predictors of depression after stroke – A systematic review of observational studies	Stroke	212
81	2006	Dyet, LE; Kennea, N; Counsell, SJ; et al.	Natural history of brain lesions in extremely preterm infants studied with serial magnetic resonance imaging from birth and neurodevelopmental assessment	Pediatrics	211
82	2005	Macko, RF; Ivey, FM; Forrester, LW; et al.	Treadmill exercise rehabilitation improves ambulatory function and cardiovascular fitness in patients with chronic stroke – A randomized, controlled trial	Stroke	210
82	2005	Garshick, E; Kelley, A; Cohen, S; et al.	A prospective assessment of mortality in chronic spinal cord injury	Spinal Cord	210
84	2006	Barnes, DE; Alexopoulos, GS; Lopez, OL; et al.	Depressive symptoms, vascular disease, and mild cognitive impairment – Findings from the cardiovascular health study	Archives of General Psychiatry	208
85	2007	Steeves, JD; Lammertse, D; Curt, A; et al.	Guidelines for the conduct of clinical trials for spinal cord injury (SCI) as developed by the ICCP panel: clinical trial outcome measures	Spinal Cord	207

(Continued)

Table 1
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Rank	Year	Authors	Title	Journal	Total Citations
85	2012	Friberg, L; Rosenqvist, M; Lip, GYH	Evaluation of risk stratification schemes for ischaemic stroke and bleeding in 182 678 patients with atrial fibrillation: the Swedish Atrial Fibrillation cohort study	European Heart Journal	207
85	2008	Kuhn, AA; Kempf, F; Brucke, C; et al.	High-frequency stimulation of the subthalamic nucleus suppresses oscillatory beta activity in patients with Parkinson's disease in parallel with improvement in motor performance	Journal of Neuroscience	207
88	2008	Sidaros, A; Engberg, A; Sidaros, K; et al.	Diffusion tensor imaging during recovery from severe traumatic brain injury and relation to clinical outcome: a longitudinal study	Brain	206
89	2006	Wartenberg, KE; Schmidt, JM; Claassen, J; et al.	Impact of medical complications on outcome after subarachnoid hemorrhage	Critical Care Medicine	203
90	2005	Dobkin, BH	Rehabilitation after stroke	New England Journal of Medicine	202
91	2006	Kuhn, AA; Kupsch, A; Schneider, GH; et al.	Reduction in subthalamic 8–35 Hz oscillatory activity correlates with clinical improvement in Parkinson's disease	European Journal of Neuroscience	201
92	2006	Kim, YH; You, SH; Ko, MH; et al.	Repetitive transcranial magnetic stimulation-induced corticomotor excitability and associated motor skill acquisition in chronic stroke	Stroke	199
92	2006	Boggio, PS; Ferrucci, R; Rigonatti, SP; et al.	Effects of transcranial direct current stimulation on working memory in patients with Parkinson's disease	Journal of the Neurological Sciences	199
94	2008	Etters, L; Goodall, D; Harrison, BE	Caregiver burden among dementia patient caregivers: a review of the literature	Journal of the American Academy of Nurse Practitioners	198
95	2005	Raina, P; O'Donnell, M; Rosenbaum, P; et al.	The health and well-being of caregivers of children with cerebral palsy	Pediatrics	197
95	2006	Yang, QH; Botto, LD; Erickson, JD; et al.	Improvement in stroke mortality in Canada and the United States, 1990 to 2002	Circulation	197
95	2008	Xiao, GM; Wei, J; Yan, WQ; et al.	Improved outcomes from the administration of progesterone for patients with acute severe traumatic brain injury: a randomized controlled trial	Critical Care	197
98	2005	Benedict, RHB; Wahlig, E; Bakshi, R; et al.	Predicting quality of life in multiple sclerosis: accounting for physical disability, fatigue, cognition, mood disorder, personality, and behavior change	Journal of the Neurological Sciences	196
98	2008	Wahlgren, N; Ahmed, N; Eriksson, N; et al.	Multivariable Analysis of Outcome Predictors and Adjustment of Main Outcome Results to Baseline Data Profile in Randomized Controlled Trials Safe Implementation of Thrombolysis in Stroke-MONitoring STudy (SITS-MOST)	Stroke	196
98	2006	Miyasaki, JM; Shannon, K; Voon, V; et al.	Practice Parameter: evaluation and treatment of depression, psychosis, and dementia in Parkinson disease (an evidence-based review) Report of the Quality Standards Subcommittee of the American Academy of Neurology	Neurology	196

Table 2
Article counts of top 50 journals in which the most
neurorehabilitation articles were published

#	Journal	Article Count
1	Stroke	2360
2	Movement Disorders	2181
3	Neurology	1732
4	Epilepsia	1552
5	European Journal of Neurology	1130
6	International Journal of Stroke	1119
7	Brain Injury	954
8	Journal of Neurotrauma	876
9	Multiple Sclerosis Journal	831
10	Journal of Neurology	823
11	Archives of Physical Medicine and Rehabilitation	733
12	Cerebrovascular Diseases	624
13	International Psychogeriatrics	594
14	Journal of the Neurological Sciences	549
15	PLoS One	519
16	Epilepsy & Behavior	487
17	Journal of Neurology Neurosurgery and Psychiatry	473
18	Multiple Sclerosis	450
19	Disability and Rehabilitation	412
20	Annals of Neurology	397
21	Journal of the American Geriatrics Society	392
22	International Journal of Geriatric Psychiatry	345
23	Spinal Cord	340
24	Parkinsonism & Related Disorders	339
25	Value in Health	334
26	Neurosurgery	333
27	Journal of Neurosurgery	287
28	Journal of Rehabilitation Medicine	283
29	American Journal of Geriatric Psychiatry	282
30	Archives of Clinical Neuropsychology	282
31	Neurorehabilitation and Neural Repair	280
32	Clinical Rehabilitation	275
33	Journal of Stroke & Cerebrovascular Diseases	265
34	Journal of Head Trauma Rehabilitation	259
35	Gait & Posture	242
36	European Psychiatry	234
37	Topics in Stroke Rehabilitation	216
38	NeuroRehabilitation	209
39	Journal of Physical Therapy Science	208
40	BMC Neurology	196
41	Clinical Neuropsychologist	196
42	Developmental Medicine and Child Neurology	193
43	Journal of Alzheimers Disease	187
44	Critical Care Medicine	184
45	Circulation	179
46	Neuromuscular Disorders	179
47	Quality of Life Research	179
48	Aging & Mental Health	175
49	American Journal of Physical Medicine & Rehabilitation	175
50	Dementia and Geriatric Cognitive Disorders	174

3.2. Most common focus of neurorehabilitation papers

Among the 100 most cited papers in neurorehabilitation, treatment studies emerged as the most common type of article (38% of the papers). Treatments evaluated in these papers included devices for stroke patients, basic studies using animal models, and surgical interventions for neurological conditions. With the exception of a few papers (4%), all treatment studies cited involved human subjects. There was a significant minority of published papers (9%) testing the efficacy of transcranial magnetic stimulation (TMS) as an intervention for various neurological conditions such as stroke and spinal cord injury.

As would be expected, a number of the most frequently cited papers had to do with approaches to neurorehabilitation. Nine percent of the top 100 papers dealt with advanced treatment guidelines from key governing bodies within the field including the American Heart Association. Another 16% of the papers describe assessment tools for measuring critical outcomes in neurorehabilitation including psychological functioning and cognitive impairment. The relevance of these two outcomes in the literature over the past 10 years is further reflected in the findings that 14% of the top 100 most cited papers focused on psychological symptoms, most frequently depression and anxiety, while another 5% covered cognitive functioning. Another indicator of consensus, review papers, which summarize accumulated evidence on specific areas within neurorehabilitation, also made up 16% of the most frequently cited works.

A look at the most frequently studied disease state among the top 100 cited published papers shed some light on the disease attributes that shape research in this area of the rehabilitation. Stroke was the most commonly studied neurological condition, appearing in 39% of the top 100 cited papers. The high number may speak to the high prevalence of stroke and its widespread global impact. It may also be related to the great potential for rehab gains in cerebrovascular disease. In contrast, Huntington's disease is a rare and terminal condition, making up only 1% of the top 100 papers. After stroke, the next conditions are considerably less common in the reviewed literature, ranging from 10–12% compared to a 39% for stroke. These conditions

included degenerative (Parkinson's Disease—11%; Alzheimers/dementia—10%) and other chronic diseases (TBI—11%; epilepsy—12%). Multiple sclerosis, a neurodegenerative disease, accounted for only 4% of the top 100 cited papers. Notably, although spinal cord injury can often co-occur with brain injury, the former appeared in only 6% of the top 100 most cited papers in neurorehabilitation, compared to 11% for TBI.

As with other disorders that compromise functioning, caregivers play a central role in caring for individuals with neurological conditions. This was captured in the 4% of the top 100 papers that focused on caregivers. Most of these papers (75%) focused on the caregivers of individuals with dementia.

3.3. Number of authors of top 100 neurorehabilitation papers

Authorship patterns for each paper were examined. The number of authors ranged from a low of 1 (2%) to a high of 44 (1%). One quarter of the papers (25%) had 4 authors or less. Nearly half (46%) of the papers had between 5 and 10 authors. Nearly one quarter (23%) had between 11 and 20 authors. Six percent had between 21 and 44 authors.

4. Discussion

Neurorehabilitation is the most common field of study in rehabilitation (Shadgan et al., 2010), yet there have been no citation analyses of neurorehabilitation papers to describe the research trends. The most recent comprehensive citation analysis in the broader rehabilitation field was published over five years ago and only included papers through 2002. The present study updates findings from the 2010 publication by focusing on neurorehabilitation papers appearing in print between 2005 and 2015.

First, findings from this citation analysis of the top 100 most cited neurorehabilitation papers show that over the last decade, the field has been dominated by the study of stroke. Shadagan et al. (2010) similarly found from analyzing rehabilitation papers published more than a decade earlier that 41% of neurorehabilitation articles were on stroke and spinal cord rehabilitation. Very likely, substantial resources in neurorehabilitation have been dedicated to the study of stroke because stroke continues to be the leading cause of adult acquired disability in the United States and worldwide (Brenner, Burke, & Skolarus, 2016).

Second, much of the scientific inquiry in neurorehabilitation has been focused on advancing treatments for neurological disorders. Neurorehabilitation in its most fundamental sense is aimed at improving functioning for individuals affected by neurological disorders. For example, this represents a contrast with the related fields of essential tremor and dystonia, where much of the work up till 2015 has been focused on describing the pathophysiology of the conditions (King et al., 2016).

Included among the dozen most often cited journals were *Stroke*, *Movement Disorders*, *Neurology*, *Epilepsia*, *European Journal of Neurology*, *International Journal of Stroke*, *Brain Injury*, and *Journal of Neurotrauma*. Seven of the top 30 journals found in the 2010 citation analysis continue to produce frequently cited manuscripts according to these more recent results.

Lastly, as in all of biomedical literature, the authorship trends show that collaboration continues to be common in top cited manuscripts in neurorehabilitation. Shadagan and colleagues (2010) found that only 7% of the most cited papers were written by a single author, the current findings show an even smaller proportion—2%.

Given the high incidence of neurotrauma and neurological disorders, the field of neurorehabilitation remains an important research area. Increased research productivity is clearly indicated on numerous fronts given the often complex, and long-term needs of this patient population and the dearth of adequate literature in many areas of this subspecialty area of rehabilitation.

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Conflict of interest

None.

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Appendix A

TI=neurorehabil* OR ((TI=PTSD OR TI="Post-Traumatic Stress Disorder" OR TI="disturbed sleep" OR TI="sleep disruption" OR TI="functional electrical stimulation" OR TI=evaluat* OR TI="sleep problems" OR TI=carer* OR TI=nurse* OR TI=nursing OR TI="quality of life" OR TI=gait* OR TI=employment OR TI=outcome* OR TI="family intervention" OR TI="return to work" OR TI="neurobehavioral disability" OR TI="family needs" OR TI="community integration" OR TI="Community Reintegration" OR TI="Driver's Rehabilitation" OR TI="Life expectancy" OR TI="Postural imbalance" OR TI="Suicid*" OR TI=Aggression OR TI=agitation OR TI=depress* OR TI=rehabil* OR TI=restor* OR TI=improve* OR TI=assess* OR TI="Social Support" OR TI="Transcranial Direct Current Stimulation" OR TI=tDCS OR TI="Transcranial Magnetic Stimulation" OR TI=TMS OR TI="Virtual Reality" OR TI=Psychoeducation OR TI=Psychopathology OR TI=Psychotherapy OR TI="Resistance Training" OR TI="Response Bias" OR TI="Robot Assisted Therapy" OR TI="Gait Training" OR TI="Secondary Gain" OR TI="Self Management" OR TI="Outcome Assessment" OR TI="Physical Therapy" OR TI="Physiotherapy" OR TI="Motor Learning" OR TI="Motor Performance" OR TI="Motor Recovery" OR TI="Assisted Living" OR TI="Assistive Technology" OR TI="Avocational Rehabilitation" OR TI=Caregiver* OR TI="Independent living" OR TI="Group Therapy" OR TI="Family Intervention" OR TI="Family Therapy" OR TI="Functional assessment*" OR TI="Behavior Therapy" OR TI="Effortless learning") AND (TI=stroke OR TI=paralys* OR TI=paralyz* OR TI=hemorrhage OR TI=haemorrhage OR TI="Multiple sclerosis" OR TI=Alzheimer* OR TI=Parkinson* OR TI=Huntington* OR TI=dystonia OR TI="amyotrophic lateral sclerosis" OR TI="motor neuron disease" OR TI="motor neurone disease" OR TI=ALS OR TI="motor deficit*" OR TI=neurodegenerat* OR TI=dementia OR TI=neurodegenerat* OR TI=neuropathy OR TI=paraplegi* OR TI=hemisect* OR TI="axon damage" OR TI="axonal damage"

OR TI="damaged axon*" OR TI="axon injur*" OR TI="injured axon*" OR TI="axon lesion*" OR TI="axonal lesion*" OR TI="brain damage" OR TI="damaged brain" OR TI="brain injur*" OR TI="injured brain" OR TI="brain lesion*" OR TI="CNS injur*" OR TI="CNS damage" OR TI="CNS trauma" OR TI="CNS lesion*" OR TI="head trauma" OR TI="head injur*" OR TI="nerve damage" OR TI="nerve injur*" OR TI="damaged nerve*" OR TI="nerve lesion*" OR TI="injured nerve*" OR TI="nervous system injur*" OR TI="nervous system disease*" OR TI="nervous system damage" OR TI="nervous system lesion*" OR TI="damaged nervous system" OR TI="injured nervous system" OR TI="neural disease*" OR TI="neural injur*" OR TI="neural damage" OR TI="neural lesion*" OR TI="spinal cord injur*" OR TI="injured spinal cord" OR TI="spinal cord damage" OR TI="spinal cord transect*" OR TI="transected spinal cord" OR TI="damaged spinal cord" OR TI="spinal cord lesion*" OR TI=dystrophy OR TI=myasthenia OR TI=Spasticity OR TI="Subdural hematoma" OR TI="Subdural haematoma" OR TI="Substance Abuse" OR TI=Tetraplegi* OR TI="Vegetative State" OR TI=Vertigo OR TI=anoxi* OR TI=Polytrauma OR TI="Post-concussive Disorder" OR TI="Post-Polio Myelitis" OR TI="Neuroendocrine disorder" OR TI="Neurogenic bladder" OR TI="Neurogenic bowel" OR TI=Neuropathy OR TI="Motor Impairment" OR TI="Adjustment Disorder" OR TI=Agnosia OR TI="Akinetic mutism" OR TI=Amnesia OR TI=Aphasia OR TI=Apraxia OR TI="Axonal Pathology" OR TI="Brain Trauma" OR TI="Cerebral Palsy" OR TI="Ischemic Infarct" OR TI="Minimally Conscious State" OR TI="Intellectual Disability" OR TI=Hemianopia OR TI=Hemiparesis OR TI=Hydrocephalus OR TI=Dysphagia OR TI=Dysphasia OR TI=Dysphonia OR TI=Dysphoria OR TI="Epidural Hematoma" OR TI=Epilepsy OR TI=Coma OR TI="Complex regional pain syndrome" OR TI=concussion OR TI=iplopia OR TI="Cerebrovascular Disease" OR TI="Cognitive Impairment" OR TI="Post-Traumatic vestibulopathy" OR TI="Anxiety disorder*" OR TI="vestibular disorder*" OR TI="vestibular dysfunct*" OR TI="encephalit*" OR TI="TBI").