

Review Article

Top 100 most-cited articles in low back pain: a 22-year survey of publication activity

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Abstract: The field of low back pain research has gained more attentions over these years due to the prevalence of low back pain. The main objective of this article is to report the top 100 cited articles in the field of low back pain research and provide a practical guide and references in evaluating the low back pain literature. The 100 most cited articles were selected and analyzed base on the number of citations in the Science Citation Index Expanded (SCI-E) without any time or study-type restriction. The citation ranged from 300 to 1469 in the top 100 cited articles in the field of low back pain research with an average citation number of 527.95. Notably, 2003 is the most productive year with 12 of top 100 cited articles published. The leading country is United States that published the largest number of articles (n=51). University of Washington is the most productive institution with 17 articles. The journal published the highest number of top 100 cited articles was Spine with 26, followed by Pain with 14. Sixty-three of the 100 most cited articles were original articles and 35 were reviews. Fifty-four articles concerning the subspecialty of Neurosciences Neurology, followed by Orthopedics (n=37). The study provided an insight on the citation rank of low back pain research and identified the top 100 cited articles in this particular field, which may be utilized to guide low back pain-related research and healthcare.

Keywords: Citation analysis, low back pain, publications

Introduction

Low back pain has a negative impact on the well-being of an individual and also escalating health-care cost [1]. A review concerning the prevalence of low back pain has shown that the point prevalence was about 12% in the adult general population, and a lifetime of prevalence was about 40% [2]. The prosperous of the low back pain research have led to the evolvement of surgical technique and management to patients, and thus dramatically improved the care of low back pain [1]. In order to identify studies that have the significant influence, a citation rank list has been established.

Nowadays, the quality of scholarly work is a becoming a parameter for academic achievement to prioritize resources and funds support in academic institutions and funding sectors [3, 4]. The use of particular article by other researchers indicated the contributing effect of a previous work on ongoing study [5-7]. Citation

rate did provide a kind of recognition in the scientific field, although it is not a direct indicator of the impact of scholar articles [8]. To some extent, articles with high citation numbers are of particular impact thus analysis of top-cited articles may demonstrate useful message in a specific research filed [9, 10]. Multiple medical fields had used a rank list to evaluating a paper's impact in particular field [11, 12].

Citation analyses have been performed in orthopaedic surgery [11, 13] and its subspecialties, including pediatric orthopaedics [14], fracture surgery [15], shoulder surgery [16], foot and ankle surgery [17], spine surgery [18], hand surgery [19], joint arthroplasty [20], and arthroscopy [21]. Several articles focused on the bibliometric characteristics of pain-related research were also published recently. Some focused on a specific syndrome, such as neonatal pain [22], headaches [23], and orofacial pain [24]. Some focused on a specific journal including Pain [25, 26] and Clinical Journal of Pain [27]. However, to date, no analysis has

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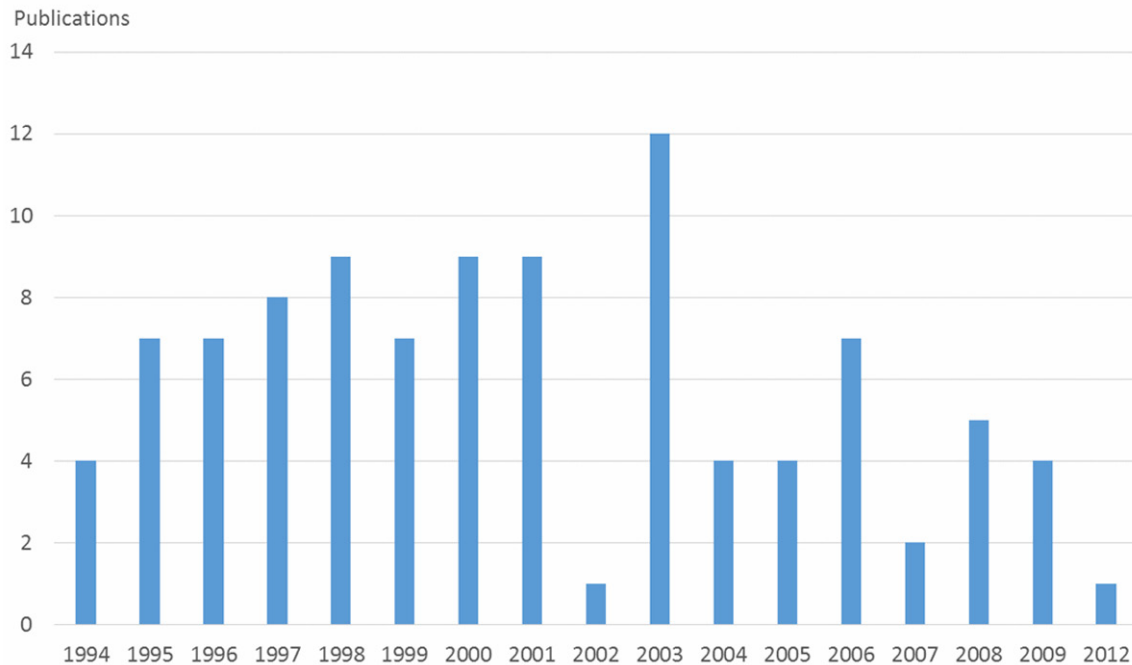


Figure 1. Number of articles per year of publication.

been made for those in the field of low back pain. In light of this, we sought to identify 100 most cited articles and to provide an analysis of their important characteristics in terms of article ranking, publication year, publication journal, authorship, country, and subspecialty in the field of low back pain research.

Methods and materials

In August 19, 2015, we performed a citation search using the Science Citation Index Expanded (SCI-E) of the ISI Web of Science (WOS) (Thomson Reuters, Philadelphia, PA, USA) without any limitation in publication time or restriction on study types, availability of an abstract and human versus nonhuman research subjects. The results were arranged by using the option “Times cited”, which automatically provided us a rank of all articles in term of citation numbers. The top 100 cited articles were retrieved and reviewed using the methods by Lim et al, [28]. Basic information including publication title, publication year, journal, citation time, author, country and institution of origin, study type and subspecialty were compiled and further analysed by analysis tool in the WOS. The statistical association was evaluated between the impact factor (IF) and the number of articles included in the top 100

cited list. SPSS 16.0 (IBM Corporation, USA) was used for data analysis. Data are presented as medians and interquartile ranges. A statistical level of $P < 0.05$ was considered to be significant.

Results

Citation count and publication year

The Top 100 cited article in the field of low back pain research were published from 1994 to 2009 (**Figure 1**), with number of citations ranging from 300 to 1469 (mean=527.95) (**Table 1**). The year responsible for the most number of articles was 2003 ($n=12$; 12%), followed by 2001 ($n=9$; 9%), 2000 ($n=9$; 9%) and 1998 ($n=9$; 9%). The first article cited more than 1000 times was published in 1994 in New England Journal of Medicine, and the most cited articles were published in 2001 in Pain.

Top-cited articles in low back pain-related journals

In total, there were 14 journals with no less than 2 top cited articles (**Table 2**). There were no significant correlation between publication numbers and impact factors ($P > 0.05$). The most articles were published in Spine ($n=26$; IF=2.297) with the mean citation of 439.2

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Table 1. Top 100 cited articles in the field of low back pain

Rank	Article	Citations
1	Farrar JT, Young JP, LaMoreaux L, Werth JL, Poole RM (2001). Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. <i>Pain</i> 94: 149-158.	1469
2	Lawrence RC, Helmick CG, Arnett FC, Deyo RA, Felson DT, et al. (1998). Estimates of the prevalence of arthritis and selected musculoskeletal disorders in the United States. <i>Arthritis And Rheumatism</i> 41: 778-799.	1447
3	Vlaeyen JWS, Linton SJ (2000). Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. <i>Pain</i> 85: 317-332.	1343
4	Lawrence RC, Felson DT, Helmick CG, Arnold LM, Choi H, et al. (2008). Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. <i>Arthritis And Rheumatism</i> 58: 26-35.	1167
5	Bressler NM, Treatment Age Related Macular D (1999). Photodynamic therapy of subfoveal choroidal neovascularization in age-related macular degeneration with verteporfin-One-year results of 2 randomized clinical trials-TAP report 1. <i>Archives Of Ophthalmology</i> 117: 1329-1345.	1063
6	Jensen MC, Brantzawadzki MN, Obuchowski N, Modic MT, Malkasian D, et al. (1994). Magnetic-resonance-imaging of the lumbar spine in people without back pain. <i>New England Journal Of Medicine</i> 331: 69-73.	1017
7	Fairbank JCT, Pynsent PB (2000). The Oswestry Disability Index. <i>Spine</i> 25: 2940-2952.	979
8	Breivik H, Collett B, Ventafridda V, Cohen R, Gallacher D (2006). Survey of chronic pain in Europe: Prevalence, impact on daily life, and treatment. <i>European Journal Of Pain</i> 10: 287-333.	965
9	Tunis SR, Stryer DB, Clancy CM (2003). Practical clinical trials-Increasing the value of clinical research for decision making in clinical and health policy. <i>Jama-Journal Of the American Medical Association</i> 290: 1624-1632.	882
10	Bair MJ, Robinson RL, Katon W, Kroenke K (2003). Depression and pain comorbidity-A literature review. <i>Archives Of Internal Medicine</i> 163: 2433-2445.	876
11	Andersson GBJ (1999). Epidemiological features of chronic low-back pain. <i>Lancet</i> 354: 581-585.	874
12	Dworkin RH, Turk DC, Farrar JT, Haythornthwaite JA, Jensen MP, et al. (2005). Core outcome measures for chronic pain clinical trials: IMMPACT recommendations. <i>Pain</i> 113: 9-19.	834
13	Woolf AD, Pfleger B (2003). Burden of major musculoskeletal conditions. <i>Bulletin Of the World Health Organization</i> 81: 646-656.	826
14	Sim J, Wright CC (2005). The kappa statistic in reliability studies: Use, interpretation, and sample size requirements. <i>Physical Therapy</i> 85: 257-268.	823
15	Vlaeyen JWS, Kolesnijders AMJ, Boeren RGB, Vaneek H (1995). Fear of movement (re)injury in chronic low-back-pain and its relation to behavioral performance. <i>Pain</i> 62: 363-372.	809
16	Heim C, Ehler U, Hellhammer DH (2000). The potential role of hypocortisolism in the pathophysiology of stress-related bodily disorders. <i>Psychoneuroendocrinology</i> 25: 1-35.	799
17	Kiecolt-Glaser JK, Newton TL (2001). Marriage and health: His and hers. <i>Psychological Bulletin</i> 127: 472-503.	792
18	Sullivan MJL, Thorn B, Haythornthwaite JA, Keefe F, Martin M, et al. (2001). Theoretical perspectives on the relation between catastrophizing and pain. <i>Clinical Journal Of Pain</i> 17: 52-64.	761
19	Hrobjartsson A, Gotzsche PC (2001). Is the placebo powerless? An analysis of clinical trials comparing placebo with no treatment. <i>New England Journal Of Medicine</i> 344: 1594-1602.	750
20	Unruh AM (1996). Gender variations in clinical pain experience. <i>Pain</i> 65: 123-167.	727
21	Vos T, Flaxman AD, Naghavi M, Lozano R, Michaud C, et al. (2012). Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. <i>Lancet</i> 380: 2163-2196.	725
22	Linton SJ (2000). A review of psychological risk factors in back and neck pain. <i>Spine</i> 25: 1148-1156.	711
23	Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M (2003). Reliability of the PEDro scale for rating quality of randomized controlled trials. <i>Physical Therapy</i> 83: 713-721.	690
24	Crombez G, Vlaeyen JWS, Heuts P, Lysens R (1999). Pain-related fear is more disabling than pain itself: evidence on the role of pain-related fear in chronic back pain disability. <i>Pain</i> 80: 329-339.	684
25	Morley S, Eccleston C, Williams A (1999). Systematic review and meta-analysis of randomized controlled trials of cognitive behaviour therapy and behaviour therapy for chronic pain in adults, excluding headache. <i>Pain</i> 80: 1-13.	676
26	Chou R, Qaseem A, Snow V, Casey D, Cross JT, et al. (2007). Diagnosis and treatment of low back pain: A joint clinical practice guideline from the American college of physicians and the American pain society. <i>Annals Of Internal Medicine</i> 147: 478-491.	648
27	Dworkin RH, Turk DC, Wyrwich KW, Beaton D, Cleeland CS, et al. (2008). Interpreting the clinical importance of treatment outcomes in chronic pain clinical trials: IMMPACT recommendations. <i>Journal Of Pain</i> 9: 105-121.	647
28	Chou R, Fanciullo GJ, Fine PG, Adler JA, Ballantyne JC, et al. (2009). Clinical Guidelines for the Use of Chronic Opioid Therapy in Chronic Noncancer Pain. <i>Journal Of Pain</i> 10: 113-130.	637
29	Deyo RA, Battie M, Beurskens A, Bombardier C, Croft P, et al. (1998). Outcome measures for low back pain research-A proposal for standardized use. <i>Spine</i> 23: 2003-2013.	630
30	Deyo RA, Weinstein JN (2001). Primary care-Low back pain. <i>New England Journal Of Medicine</i> 344: 363-370.	625
31	Hodges PW, Richardson CA (1996). Inefficient muscular stabilization of the lumbar spine associated with low back pain-A motor control evaluation of transversus abdominis. <i>Spine</i> 21: 2640-2650.	617
32	DePaulo BM, Lindsay JJ, Malone BE, Muhlenbruck L, Charlton K, et al. (2003). Cues to deception. <i>Psychological Bulletin</i> 129: 74-118.	573

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33	Roland M, Fairbank J (2000). The Roland-Morris Disability Questionnaire and the Oswestry Disability Questionnaire. <i>Spine</i> 25: 3115-3124.	572
34	Gureje O, Von Korff M, Simon GE, Gater R (1998). Persistent pain and well-being-A World Health Organization study in primary care. <i>Jama-Journal Of the American Medical Association</i> 280: 147-151.	563
35	Eccleston C, Crombez G (1999). Pain demands attention: A cognitive-affective model of the interruptive function of pain. <i>Psychological Bulletin</i> 125: 356-366.	534
36	Airaksinen O, Brox JI, Cedraschi C, Hildebrandt J, Klüber-Moffett J, et al. (2006). Chapter 4-European guidelines for the management of chronic nonspecific low back pain. <i>European Spine Journal</i> 15: S192-S300.	524
37	Turner JA, Deyo RA, Loeser JD, Vonkorff M, Fordyce WE (1994). The importance of placebo-effects in pain treatment and research. <i>Jama-Journal Of the American Medical Association</i> 271: 1609-1614.	505
38	Wilke HJ, Neef P, Caimi M, Hoogland T, Claes LE (1999). New in vivo measurements of pressures in the intervertebral disc in daily life. <i>Spine</i> 24: 755-762.	493
39	Bouhassira D, Attal N, Alchaar H, Boureau F, Brochet B, et al. (2005). Comparison of pain syndromes associated with nervous or somatic lesions and development of a new neuropathic pain diagnostic questionnaire (DN4). <i>Pain</i> 114: 29-36.	481
40	Kallmes DF, Comstock BA, Heagerty PJ, Turner JA, Wilson DJ, et al. (2009). A Randomized Trial of Vertebroplasty for Osteoporotic Spinal Fractures. <i>New England Journal Of Medicine</i> 361: 569-579.	466
41	Cholewicki J, McGill SM (1996). Mechanical stability of the in vivo lumbar spine: Implications for injury and chronic low back pain. <i>Clinical Biomechanics</i> 11: 1-15.	462
42	Ramsay DJ, Bowman MA, Greenman PE, Jiang SP, Kushi LH, et al. (1998). Acupuncture. <i>Jama-Journal Of the American Medical Association</i> 280: 1518-1524.	460
43	Fillingim RB, King CD, Ribeiro-Dasilva MC, Rahim-Williams B, Riley JL (2009). Sex, Gender, and Pain: A Review of Recent Clinical and Experimental Findings. <i>Journal Of Pain</i> 10: 447-485.	459
44	vanTulder MW, Koes BW, Bouter LM (1997). Conservative treatment of acute and chronic nonspecific low back pain-A systematic review of randomized controlled trials of the most common interventions. <i>Spine</i> 22: 2128-2156.	458
45	Patrick DL, Deyo RA, Atlas SJ, Singer DE, Chapin A, et al. (1995). Assessing health-related quality-of-life in patients with sciatica. <i>Spine</i> 20: 1899-1908.	451
46	Perquin CW, Hazebroek-Kampschreur A, Hunfeld JAM, Bohnen AM, van Suijlekom-Smit LWA, et al. (2000). Pain in children and adolescents: a common experience. <i>Pain</i> 87: 51-58.	445
47	Fritzell P, Hagg O, Wessberg P, Nordwall A, Swedish Lumbar Spine Study G (2001). 2001 Volvo Award winner in clinical studies: Lumbar fusion versus nonsurgical treatment for chronic low back pain-A multicenter randomized controlled trial from the Swedish Lumbar Spine Study Group. <i>Spine</i> 26: 2521-2532.	436
48	Gatchel RJ, Peng YB, Peters ML, Fuchs PN, Turk DC (2007). The biopsychosocial approach to chronic pain: Scientific advances and future directions. <i>Psychological Bulletin</i> 133: 581-624.	428
49	O'Sullivan PB, Twomey LT, Allison GT (1997). Evaluation of specific stabilizing exercise in the treatment of chronic low back pain with radiologic diagnosis of spondylolysis or spondylolisthesis. <i>Spine</i> 22: 2959-2967.	428
50	Fishbain DA, Cutler R, Rosomoff HL, Rosomoff RS (1997). Chronic pain-associated depression: Antecedent or consequence of chronic pain? A review. <i>Clinical Journal Of Pain</i> 13: 116-137.	428
51	Picavet HSJ, Schouten J (2003). Musculoskeletal pain in the Netherlands: prevalences, consequences and risk groups, the DMC3-study. <i>Pain</i> 102: 167-178.	418
52	Ostelo R, Deyo RA, Stratford P, Waddell G, Croft P, et al. (2008). Interpreting change scores for pain and functional status in low back pain-Towards international consensus regarding minimal important change. <i>Spine</i> 33: 90-94.	413
53	Dagenais S, Caro J, Haldeman S (2008). A systematic review of low back pain cost of illness studies in the United States and internationally. <i>Spine Journal</i> 8: 8-20.	396
54	Fischgrund JS, Mackay M, Herkowitz HN, Brower R, Montgomery DM, et al. (1997). 1997 Volvo Award winner in clinical studies - Degenerative lumbar spondylolisthesis with spinal stenosis: A prospective, randomized study comparing decompressive laminectomy and arthrodesis with and without spinal instrumentation. <i>Spine</i> 22: 2807-2812.	396
55	Guzman J, Esmail R, Karjalainen K, Malmivaara A, Irvin E, et al. (2001). Multidisciplinary rehabilitation for chronic low back pain: systematic review. <i>British Medical Journal</i> 322: 1511-1516.	395
56	Hoogendoorn WE, van Poppel MNM, Bongers PM, Koes BW, Bouter LM (2000). Systematic review of psychosocial factors at work and private life as risk factors for back pain. <i>Spine</i> 25: 2114-2125.	393
57	Cote P, Cassidy JD, Carroll L (1998). The Saskatchewan Health and Back Pain Survey-The prevalence of neck pain and related disability in Saskatchewan adults. <i>Spine</i> 23: 1689-1698.	392
58	Wampold BE, Mondin GW, Moody M, Stich F, Benson K, et al. (1997). A meta-analysis of outcome studies comparing bona fide psychotherapies: Empirically, "all must have prizes". <i>Psychological Bulletin</i> 122: 203-215.	388
59	Hides JA, Richardson CA, Jull GA (1996). Multifidus muscle recovery is not automatic after resolution of acute, first-episode low back pain. <i>Spine</i> 21: 2763-2769.	382
60	Weinstein JN, Tosteson TD, Lurie JD, Tosteson ANA, Hanscom B, et al. (2006). Surgical vs nonoperative treatment for lumbar disk herniation-The Spine Patient Outcomes Research Trial (SPORT): A randomized trial. <i>Jama-Journal Of the American Medical Association</i> 296: 2441-2450.	380
61	Turk DC, Dworkin RH, Allen RR, Bellamy N, Brandenburg N, et al. (2003). Core outcome domains for chronic pain clinical trials: IMMPACT recommendations. <i>Pain</i> 106: 337-345.	374
62	Malmivaara A, Hakkinen U, Aro T, Heinrichs ML, Koskeniemi L, et al. (1995). The treatment of acute low-back-pain-bed rest, exercises, or ordinary activity. <i>New England Journal Of Medicine</i> 332: 351-355.	374

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63	Hides JA, Stokes MJ, Saide M, Jull GA, Cooper DH (1994). Evidence of lumbar multifidus muscle wasting ipsilateral to symptoms in patients with acute subacute low-back-pain. <i>Spine</i> 19: 165-172.	367
64	Burton AK, Tillotson KM, Main CJ, Hollis S (1995). Psychosocial predictors of outcome in acute and subchronic low-back trouble. <i>Spine</i> 20: 722-728.	366
65	Kingery WS (1997). A critical review of controlled clinical trials for peripheral neuropathic pain and complex regional pain syndromes. <i>Pain</i> 73: 123-139.	364
66	Boden SD, Kang J, Sandhu H, Heller JG (2002). Use of recombinant human bone morphogenetic protein-2 to achieve posterolateral lumbar spine fusion in humans-A prospective, randomized clinical pilot trial-2002 Volvo Award in clinical studies. <i>Spine</i> 27: 2662-2673.	356
67	Croft PR, Macfarlane GJ, Papageorgiou AC, Thomas E, Silman AJ (1998). Outcome of low back pain in general practice: a prospective study. <i>British Medical Journal</i> 316: 1356-1359.	354
68	Carey TS, Garrett J, Jackman A, McLaughlin C, Fryer J, et al. (1995). The outcomes and costs of care for acute low-back-pain among patients seen by primary-care practitioners, chiropractors, and orthopedic surgeons. <i>New England Journal Of Medicine</i> 333: 913-917.	354
69	Alfredson H, Pietila T, Jonsson P, Lorentzon P (1998). Heavy-load eccentric calf muscle training for the treatment of chronic Achilles tendinosis. <i>American Journal Of Sports Medicine</i> 26: 360-366.	351
70	Banks SM, Kerns RD (1996). Explaining high rates of depression in chronic pain: A diathesis-stress framework. <i>Psychological Bulletin</i> 119: 95-110.	348
71	Han JS (2003). Acupuncture: neuropeptide release produced by electrical stimulation of different frequencies. <i>Trends In Neurosciences</i> 26: 17-22.	342
72	Keefe FJ, Rumble ME, Scipio CD, Giordano LA, Perri LM (2004). Psychological aspects of persistent pain: Current state of the science. <i>Journal Of Pain</i> 5: 195-211.	340
73	Green CR, Anderson KO, Baker TA, Campbell LC, Decker S, et al. (2003). The unequal burden of pain: Confronting racial and ethnic disparities in pain. <i>Pain Medicine</i> 4: 277-294.	338
74	Koes BW, van Tulder MW, Ostelo R, Burton AK, Waddell G (2001). Clinical guidelines for the management of low back pain in primary care - An international comparison. <i>Spine</i> 26: 2504-2513.	338
75	Freemont AJ, Peacock TE, Goupille P, Hoyland JA, O'Brien J, et al. (1997). Nerve ingrowth into diseased intervertebral disc in chronic back pain. <i>Lancet</i> 350: 178-181.	338
76	Klenerman L, Slade PD, Stanley IM, Pennie B, Reilly JP, et al. (1995). The prediction of chronicity in patients with an acute attack of low-back-pain in a general-practice setting. <i>Spine</i> 20: 478-484.	338
77	Childs JD, Fritz JM, Flynn TW, Irrgang JJ, Johnson KK, et al. (2004). A clinical prediction rule to identify patients with low back pain most likely to benefit from spinal manipulation: A validation study. <i>Annals Of Internal Medicine</i> 141: 920-928.	337
78	Kang JD, Georgescu HI, McIntyreLarkin L, StefanovicRacic M, Donaldson WF, et al. (1996). Herniated lumbar intervertebral discs spontaneously produce matrix metalloproteinases, nitric oxide, interleukin-6, and prostaglandin E(2). <i>Spine</i> 21: 271-277.	337
79	Urwin M, Symmons D, Allison T, Brammah T, Busby H, et al. (1998). Estimating the burden of musculoskeletal disorders in the community: the comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. <i>Annals Of the Rheumatic Diseases</i> 57: 649-655.	335
80	Burdorf A, Sorock G (1997). Positive and negative evidence of risk factors for back disorders. <i>Scandinavian Journal Of Work Environment & Health</i> 23: 243-256.	325
81	Hart LG, Deyo RA, Cherkin DC (1995). Physician office visits for low-back-pain-frequency, clinical-evaluation, and treatment patterns from an us national survey. <i>Spine</i> 20: 11-19.	325
82	Beurskens A, deVet HCW, Koke AJA (1996). Responsiveness of functional status in low back pain: A comparison of different instruments. <i>Pain</i> 65: 71-76.	324
83	Freyenhagen R, Baron R, Gockel U, Tolle TR (2006). Pain DETECT: a new screening questionnaire to identify neuropathic components in patients with back pain. <i>Current Medical Research And Opinion</i> 22: 1911-1920.	318
84	Cherkin DC, Deyo RA, Battie M, Street J, Barlow W (1998). A comparison of physical therapy, chiropractic manipulation, and provision of an educational booklet for the treatment of patients with low back pain. <i>New England Journal Of Medicine</i> 339: 1021-1029.	318
85	Gracely RH, Geisser ME, Giesecke T, Grant MAB, Petzke F, et al. (2004). Pain catastrophizing and neural responses to pain among persons with fibromyalgia. <i>Brain</i> 127: 835-843.	315
86	Hagg O, Fritzell P, Nordwall A (2003). The clinical importance of changes in outcome scores after treatment for chronic low back pain. <i>European Spine Journal</i> 12: 12-20.	314
87	Fritz JM, Irrgang JJ (2001). A comparison of a modified Oswestry Low Back Pain Disability Questionnaire and the Quebec Back Pain Disability Scale. <i>Physical Therapy</i> 81: 776-788.	314
88	Frebürger JK, Holmes GM, Agans RP, Jackman AM, Darter JD, et al. (2009). The Rising Prevalence of Chronic Low Back Pain. <i>Archives Of Internal Medicine</i> 169: 251-258.	313
89	Luoma K, Riihimäki H, Luukkonen R, Raininko R, Viikari-Juntura E, et al. (2000). Low back pain in relation to lumbar disc degeneration. <i>Spine</i> 25: 487-492.	311
90	Walker BF (2000). The prevalence of low back pain: A systematic review of the literature from 1966 to 1998. <i>Journal Of Spinal Disorders</i> 13: 205-217.	308
91	Binkley JM, Stratford PW, Lott SA, Riddle DL (1999). The lower extremity functional scale (LEFS): Scale development, measurement properties, and clinical application. <i>Physical Therapy</i> 79: 371-383.	308

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92	Bouhassira D, Lanteri-Minet M, Attal N, Laurent B, Touboul C (2008). Prevalence of chronic pain with neuropathic characteristics in the general population. <i>Pain</i> 136: 380-387.	307
93	Katz JN (2006). Lumbar disc disorders and low-back pain: Socioeconomic factors and consequences. <i>Journal Of Bone And Joint Surgery-American Volume</i> 88A: 21-24.	307
94	Gomes B, Higginson IJ (2006). Factors influencing death at home in terminally ill patients with cancer: systematic review. <i>British Medical Journal</i> 332: 515-518A.	306
95	Urban JPG, Smith S, Fairbank JCT (2004). Nutrition of the intervertebral disc. <i>Spine</i> 29: 2700-2709.	306
96	Jackson RP, McManus AC (1994). Radiographic analysis of sagittal plane alignment and balance in standing volunteers and patients with low-back-pain matched for age, sex, and size-a prospective controlled clinical-study. <i>Spine</i> 19: 1611-1618.	306
97	Goetzel RZ, Hawkins K, Ozminkowski RJ, Wang SH (2003). The health and productivity cost burden of the "top 10" physical and mental health conditions affecting six large US employers in 1999. <i>Journal Of Occupational And Environmental Medicine</i> 45: 5-14.	304
98	Furlan AD, Sandoval JA, Mailis-Gagnon A, Tunks E (2006). Opioids for chronic noncancer pain: a meta-analysis of effectiveness and side effects. <i>Canadian Medical Association Journal</i> 174: 1589-1594.	302
99	Pengel LHM, Herbert RD, Maher CG, Refshauge KM (2003). Acute low back pain: systematic review of its prognosis. <i>British Medical Journal</i> 327: 323-325.	301
100	Deyo RA, Gray DT, Kreuter W, Mirza S, Martin BI (2005). United States trends in lumbar fusion surgery for degenerative conditions. <i>Spine</i> 30: 1441-1445.	300

Table 2. Journals with no less than 2 Top-cited articles in the field of low back pain

Journals	Articles	IF (2014)	5-year IF	Total citation	Median No. of Citations (Range)
Spine	26	2.297	3.003	11418	439.2 (330, 982)
Pain	14	5.213	6.341	9271	662.2 (308, 1472)
New England Journal of Medicine	7	55.873	52.426	3908	558.3 (318, 1017)
Psychological Bulletin	6	14.756	21.197	3069	511.5 (348, 793)
Jama Journal of The American Medical Association	5	35.289	29.914	2794	558.8 (381, 882)
British Medical Journal	4	17.445	16.122	1356	339 (301, 395)
Journal of Pain	4	4.01	5.007	2087	521.8 (340, 648)
Physical Therapy	4	2.526	3.896	2142	535.5 (308, 826)
Lancet	3	45.217	39.315	1913	637.7 (338, 875)
Annals of Internal Medicine	2	17.81	16.482	987	493.5 (338, 648)
Archives of Internal Medicine	2	13.116	N/A	1191	595.5 (313, 878)
Arthritis and Rheumatism	2	7.764	7.987	1309	654.5 (1171, 1447)
Clinical Journal of Pain	2	2.527	3.148	1191	595.5 (430, 761)
European Spine Journal	2	2.066	2.658	841	420.5 (316, 525)

Table 3. Top 3 authors with 4 or more articles in the top 100 articles

Author	Articles	Total citations	Authorship Position			Author affiliations
			First	Second	Other	
Deyo RA	11	6575	3	4	4	Univ Washington, Div Gen Internal Med, Ctr Cost & Outcomes Res, Box 356429, Seattle, WA 98195 USA.
Farrar JT	4	3334	1	0	3	Univ Penn, Sch Med, Dept Biostat & Epidemiol, Blockley Hall, Room 816.423 Guardian Dr, Philadelphia, PA 19104 USA.
Turk DC	4	2292	1	1	2	Univ Washington, Dept Anesthesiol, Seattle, WA 98195 USA.

(330, 982), followed by Pain (n=14; IF=5.213) with the mean citation of 662.2 (308, 1472) and New England Journal of Medicine (n=7; IF=55.873) with the mean citation of 558.3 (318, 1017). Another general medical journals with extremely high impact was Lancet (n=3; IF=45.271) with mean citation of 637.7 (338,875). Three authors accounted for 19 of the 100 papers (19%), the top author was DEYO

RA in University of Washington with 11 publication one the list (**Table 3**), followed by FARRAR JT (n=4) and TURK DC (n=4).

Origin countries and institutions

United States (**Table 4**) published the largest number of articles on the list (n=51), followed by England (n=22) and Canada (n=16). Re-

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Table 4. Country of Origin of the 100 Top-Cited Articles in low back pain

Rank	Country or Origin	No. of Articles
1	USA	51
2	England	22
3	Canada	16
4	Netherlands	14
5	Australia	11
6	Germany	8
7	Sweden	8
8	Finland	5
9	France	5
10	Scotland	5
11	Switzerland	4
12	Denmark	3
13	Italy	3
14	Norway	3
15	Spain	3
16	Belgium	2
17	Israel	2
18	Nigeria	2
19	Peoples R China	2
20	Wales	2

Table 5. Institution of Origin of the 100 Top-Cited Articles in low back pain

Rank	Institution	Articles
1	Univ Washington	17
2	Univ Toronto	6
3	Duke Univ	5
4	Johns Hopkins Univ	5
5	Maastricht Univ	5
6	Univ Manchester	5
7	Univ Penn	5
8	Univ Queensland	5
9	Yale Univ	5
10	Boston Univ	4

Table 6. Type of manuscripts for 100 top-cited articles in low back pain

Rank	Article type	Articles
1	Article	63
2	Review	35
3	Proceedings Paper	5
4	Editorial Material	2

searchers from University of Washington (**Table 5**) authored 17 of the top 100 articles while

University of Toronto published 6 of articles on the list.

Areas of study and publication type

Of the 100 most cited articles, 63 were original articles, 35 were review, 5 were proceedings paper and 2 were editorial materials (**Table 6**). The leading subspecialty (**Table 7**) were Neuroscience Neurology (n=54), Orthopedics (n=37) and General Internal Medicine (26). The top WOS categories were Clinical Neurology (n=52), Orthopedics (n=37) and Medicine General Internal (n=26).

Discussion

Low back pain care was evolved due to the ideas and researches from multiple subspecialties. Landmark contributions helped to shape modern treatment protocols thus the recognition of these work was helpful for investigators to understand and design future research. For example, in 1987, a new treatment for low back pain indicated that the patients benefits from the controlled activity, not the prolonged bed rest [29]. Both types of articles, that is, clinical research and basic science study, have contributed to the field of low back pain research. Original clinical studies reported the procedures and outcomes of an intervention and basic studies provide necessary ideas and tools needed in other investigations. Article of high quality naturally received more attention and thus received more citations and advanced the field of low back pain research. To our knowledge, this is the first report of the top cited articles in the field of low back pain research.

The present study demonstrated that Spine (n=26; IF=2.297) is the most productive journal on the list. Journals like New England Journal of Medicine (n=7; IF=55.837) and The Lancet (n=3; IF=45.217) with extremely high IF only publish 10 articles in total. Furthermore, the 3 most cited articles were published in a relatively low IF journal (Pain, Arthritis and Rheumatism). This indicated that there was a growing trend in publishing highly cited articles in specialty journals compared journals with high IF. This revealed that authors may not be motivated only by the IF when submitting their manuscripts, they may considered other factors such as topical interest, the journal's interest [11,

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Table 7. Ranking articles of subspecialty

Rank	Subspecialty	Articles	
1	Neurosciences Neurology	54	0.54
2	Orthopedics	37	0.37
3	General Internal Medicine	26	0.26
4	Anesthesiology	17	0.17
5	Psychology	6	0.06
6	Rehabilitation	4	0.04
7	Public Environmental Occupational Health	3	0.03
8	Rheumatology	3	0.03
9	Sport Sciences	2	0.02

13, 16, 18]. There were 14 journals on the list in all and 40% articles on the list were published in Spine and Pain, which were of a particular subspecialty. Our research supported the application of a bibliometric concept called Bradford's law [30, 31]. The law revealed that the most researchers obtained their citations from some main journals in their field of expertise respectively and their citation frequency weakened when they deviated from these main journals. This tendency led to a large amount of citations from a few core journals. What's more, like many other citation analyses, most of the researches on the top 100 list were from the United States [12, 13, 32]. However, it is important to take multiple factors into consideration when evaluating the contribution of different journals. One of the factors is the frequency of publication since journals published more frequently will publish a greater number of articles and therefore received more citations. Another factor is the time that each journal takes in circulation. Articles have been in circulation for a longer time will have more opportunity to be cited.

Overall, it demonstrated that more than a half of the most cited articles in the field of low back pain focused on the Neurosciences Neurology. This can be an important indicator for the journal editors in selecting and evaluating scientific studies in the field of low back pain research. Thus, understanding the features of highly cited work may help young research to publish more effectively.

Limitations should be noted in this study. Firstly, we only searched a single electronic medical database, this might result in omission of articles published before 1994 since the SCI-E did not track citations prior to 1994.

Regarding the prominent differences between different databases, our top cited list might be different if Google Scholar or PubMed were used. Moreover, although we tried to search all the relevant articles in the field of low back pain, it was impossible that all the relevant articles ever published were traced. General medical journals such as *The New England Journal of Medicine* and *The Lancet* were included to avoid missing highly

cited articles. Finally, the intrinsic controversies of citation analysis were also involved. Some researchers opined that citation counts an article received were not necessarily a reflection of the quality of research, [5, 33] thus, the highly cited articles did not always mean they were of high quality. What's more, self-citation bias was not taken into account in our study. Similarly, author tended to cite articles from journals they hoped to submit their manuscript to thus journal bias was not to be neglected [34]. Finally, "the obliteration by incorporation" effect [35] was involved in older publications, which means the phenomenon that older articles were not cited with the same frequency as their researches became incorporated into the current body of knowledge [18]. In light of this effect, our analysis ranked the articles on the basis of total citation counts, not the citations received in the current year alone. Despite these limitations, citation analysis did provide a quantitative measure of the importance of article on its field. The top 100 cited articles recognized the landmark advanced and put an insight into the low back pain field.

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References

- [1] Manchikanti L, Singh V, Falco FJ, Benyamin RM and Hirsch JA. Epidemiology of low back pain in adults. *Neuromodulation* 2014; 17 Suppl 2: 3-10.
- [2] Hoy D, Bain C, Williams G, March L, Brooks P, Blyth F, Woolf A, Vos T and Buchbinder R. A systematic review of the global prevalence of low back pain. *Arthritis Rheum* 2012; 64: 2028-2037.
- [3] Adams AB and Simonson D. Publication, citations, and impact factors of leading investigators in critical care medicine. *Respir Care* 2004; 49: 276-281.
- [4] Taubes G. Measure for measure in science. *Science* 1993; 260: 884-886.
- [5] Cheek J, Garnham B and Quan J. What's in a number? Issues in providing evidence of impact and quality of research(ers). *Qual Health Res* 2006; 16: 423-435.
- [6] Garfield E. Citation analysis as a tool in journal evaluation. *Science* 1972; 178: 471-479.
- [7] Gisvold SE. Citation analysis and journal impact factors—is the tail wagging the dog? *Acta Anaesthesiol Scand* 1999; 43: 971-973.
- [8] Shadgan B, Roig M, Hajghanbari B and Reid WD. Top-cited articles in rehabilitation. *Arch Phys Med Rehabil* 2010; 91: 806-815.
- [9] Wohlin C, Elbaum S and Shepperd M. Most cited journal articles in software engineering. *Information And Software Technology* 2007; 49: 1-1.
- [10] Fardi A, Kodonas K, Gogos C and Economides N. Top-cited articles in endodontic journals. *J Endod* 2011; 37: 1183-1190.
- [11] Kelly JC, Glynn RW, O'Briain DE, Felle P and McCabe JP. The 100 classic papers of orthopaedic surgery: a bibliometric analysis. *J Bone Joint Surg Br* 2010; 92: 1338-1343.
- [12] Paladugu R, Schein M, Gardezi S and Wise L. One hundred citation classics in general surgical journals. *World J Surg* 2002; 26: 1099-1105.
- [13] Lefavre KA, Shadgan B and O'Brien PJ. 100 most cited articles in orthopaedic surgery. *Clin Orthop Relat Res* 2011; 469: 1487-1497.
- [14] Kavanagh RG, Kelly JC, Kelly PM and Moore DP. The 100 classic papers of pediatric orthopaedic surgery: a bibliometric analysis. *J Bone Joint Surg Am* 2013; 95: e134.
- [15] Baldwin K, Namdari S, Donegan D, Kovatch K, Ahn J and Mehta S. 100 most cited articles in fracture surgery. *Am J Orthop (Belle Mead NJ)* 2013; 42: 547-552.
- [16] Namdari S, Baldwin K, Kovatch K, Huffman GR and Glaser D. Fifty most cited articles in orthopedic shoulder surgery. *J Shoulder Elbow Surg* 2012; 21: 1796-1802.
- [17] Bayley M, Brooks F, Tong A and Hariharan K. The 100 most cited papers in foot and ankle surgery. *Foot (Edinb)* 2014; 24: 11-16.
- [18] Murray MR, Wang T, Schroeder GD and Hsu WK. The 100 most cited spine articles. *Eur Spine J* 2012; 21: 2059-2069.
- [19] Joyce CW, Kelly JC and Carroll SM. The 100 top-cited classic papers in hand surgery. *J Plast Surg Hand Surg* 2014; 48: 227-233.
- [20] Holzer LA and Holzer G. The 50 highest cited papers in hip and knee arthroplasty. *J Arthroplasty* 2014; 29: 1878.
- [21] Cassar Gheiti AJ, Downey RE, Byrne DP, Molony DC and Mulhall KJ. The 25 most cited articles in arthroscopic orthopaedic surgery. *Arthroscopy* 2012; 28: 548-564.
- [22] Banos JE, Ruiz G and Guardiola E. An analysis of articles on neonatal pain published from 1965 to 1999. *Pain Res Manag* 2001; 6: 45-50.
- [23] Norton PJ, Asmundson GJ, Norton GR and Craig KD. Growing pain: 10-year research trends in the study of chronic pain and headache. *Pain* 1999; 79: 59-65.
- [24] Robert C, Caillieux N, Wilson CS, Gaudy JF and Arreto CD. World orofacial pain research production: a bibliometric study (2004-2005). *J Orofac Pain* 2008; 22: 181-189.
- [25] Dubner R. A bibliometric analysis of the Pain journal as a representation of progress and trends in the field. *Pain* 2009; 142: 9-10.
- [26] Mogil JS, Simmonds K and Simmonds MJ. Pain research from 1975 to 2007: a categorical and bibliometric meta-trend analysis of every Research Paper published in the journal, Pain. *Pain* 2009; 142: 48-58.
- [27] Turk DC. Impact of articles published in the Clinical Journal of Pain: most frequently cited papers published from 2002 to 2009. *Clin J Pain* 2010; 26: 173-174.
- [28] Lim KJ, Yoon DY, Yun EJ, Seo YL, Baek S, Gu DH, Yoon SJ, Han A, Ku YJ and Kim SS. Characteristics and trends of radiology research: a survey of original articles published in AJR and Radiology between 2001 and 2010. *Radiology* 2012; 264: 796-802.
- [29] Waddell G. 1987 Volvo award in clinical sciences. A new clinical model for the treatment of low-back pain. *Spine (Phila Pa 1976)* 1987; 12: 632-644.
- [30] Siegelman SS. The cat's meow: the most frequently cited papers in Radiology 1955-1986. *Radiology* 1988; 168: 414-420.

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- [31] Brookes BC. Bradford's law and the bibliography of science. *Nature* 1969; 224: 953-956.
- [32] Baltussen A and Kindler CH. Citation classics in anesthetic journals. *Anesth Analg* 2004; 98: 443-451, table of contents.
- [33] Smith R. Beware the tyranny of impact factors. *J Bone Joint Surg Br* 2008; 90: 125-126.
- [34] Seglen PO. Why the impact factor of journals should not be used for evaluating research. *BMJ* 1997; 314: 498-502.
- [35] Garfield E. 100 citation classics from the *Journal of the American Medical Association*. *JAMA* 1987; 257: 52-59.