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REVIEW

Scientometric evaluation of the global research in spine: an update on the pioneering study by Wei et al.

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Abstract

Purpose Wei et al. evaluated the global research in spine using scientometric methods based on a sample of 13,115 papers published in 5 spine journals from 2004 to 2013. This study builds on this pioneering study and provides up-to-date and thorough information on spine based on a sample of 166,962 papers for the stakeholders.

Method 'Articles' and 'reviews' published in 'English' in the journals indexed by the 'Web of Science' primary databases between 1980 and 2017 were retrieved through the use of an optimal keyword set for titles of both papers and ten spine journals. The information on document types and number of papers, authors, countries, funding bodies, institutions, publication years, journals, 'Web of Science' subject categories, and ten top citation classics were analyzed.

Results A large sample of 166,962 papers were retrieved. The 'reviews' and 'proceedings papers' formed 5.8 and 2.8% of the sample, respectively. 'Fehlings', 'Vaccaro', 'Takahashi', 'Lenke', and 'Gokaslan' were the most-prolific authors. Nearly 0.7% of the papers had group authors besides single authors. The US was the most prolific country publishing 37.3% of the sample whilst Europe contributed to more than 39.8% of the sample. Only, 26.6% of the papers disclosed research funding. Among 40,897 institutions, 'Harvard University' was the most-prolific institution whilst the US institutions dominated the top-institution list. The research output steadily rose from 1375 papers in 1980 to 9357 papers in 2016 whilst 69.2% of the papers were published after 2000. Ten spine journals published only 23.4% of the sample. 'Clinical Neurology', 'Orthopedics', 'Neurosciences', and 'Surgery' was the most prolific subject categories. The top citation classic was a paper by van der Linden et al. on ankylosing spondylitis.

Conclusions The optimal design of research sample made it possible to obtain nearly 13 times the size of the sample in Wei et al. as a true representation of the research in spine through the use of an optimal keyword set for the titles of both papers and 10 spine journals. However, despite the inefficient design of the incentive structures for the relevant stakeholders, the research in spine had expanded 6.8 times since 1980.

Keywords Spine · Back pain · Citation classics · Scientometrics · Research evaluation

Introduction

Wei et al. [1] evaluated the global research in spine using scientometric methods based on a sample of 13,115 papers published in 5 spine journals from 2004 to 2013. This study builds on this pioneering study and provides up-to-date and thorough information on spine based on a sample of 166,962 papers in 5436 journals in 234 Web of Science subject categories by 40,897 institutions between 1980 and 2017 for the stakeholders.

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Materials and methods

A multi-step approach was adapted for the search for the literature on the spine to provide a comprehensive update on Wei et al. [1].

The 'Web of Science Core Collection' (WOSCC) was used for data search. The 'Science Citation Index-Expanded' (SCIE), 'Social Sciences Citation Index' (SSCI), and 'Arts & Humanities Citation Index' (A&HCI) were used from this collection of databases as the social and humanitarian aspect of spine complement the medical aspects of spine [2–4]. The search period extended from 1980 to 2017 (as of October 2017) to provide a relatively large sample. However, this sample was restricted to ‘articles’ and ‘reviews’ published in ‘English’ to focus on the primary publications contributing to the research in spine.

All the located spine journals were selected for the search in the first instance. The keyword set for journals was structured as SO = [(“Clinical Spine Surgery” or “Journal of Spinal Disorders & Techniques” or “Journal of Spinal Disorders”) or “European Spine Journal” or “Journal of Neurosurgery Spine” or “Journal of Spinal Cord Medicine” or (“Spinal Cord” or Paraplegia) or Spine or “Spine Journal”].

The journal ‘Joint Bone Spine’ was not selected as there were papers published in the topical areas other than spine as well. It is notable that two journals ‘Clinical Spine Surgery’ and ‘Spinal Cord’ followed the earlier journal titles of ‘Journal of Spinal Disorders & Techniques’ or ‘Journal of Spinal Disorders’ and ‘Paraplegia’, respectively.

The keywords from the titles and abstracts of these spine journals were collected to carry out a ‘title’ based general topical search.

The successive quality control exercises were carried out by revising continuously the topical keyword list to ensure that the retrieved papers are relevant to spine.

The general topical title keyword set was constructed as follows: TI = (*discectomy or *discotomy or *diskectomy or *intervertebral or *lumbar or *parapleg* or *spondyl* or “anulus fibrosus” or “articular process*” or “artificial disc” or “artificial disk” or “atlanto-axial” or “atlanto-occipital” or “back disabilit*” or “back disorder*” or “back injur*” or “back pain” or “back problem*” or “back review*” or “back surgery” or “back syndrome” or “back trouble*” or “backache*” or “back-ache” or “back-injur*” or “back-pain” or “basilar invagination” or “C2 fixation” or “cauda equina” or “cervical arthrodesis” or “cervical arthroplasty*” or “cervical decompression” or “cervical disc*” or “cervical discectom*” or “cervical disk*” or “cervical disorder*” or “cervical facet” or “cervical fixation” or “cervical fusion” or “cervical injur*” or “cervical myelopathy” or “cervical pain” or “cervical pedicle*” or “cervical spine trauma” or “cervical spine” or “cervical spondylosis” or “cervical trauma” or “cervical vertebra*” or “cervical-spine” or “coronal imbalance” or “coronal plane deformity” or “cortico-spinal” or “cranio-cervical” or “cranio-vertebral” or “c-spine” or “degenerated disc*” or “degenerative disc” or “degenerative disk*” or “dens fracture*” or “disc arthroplasty” or “disc cell*” or “disc degeneration” or “disc disease*” or “disc disorder*” or “disc disruption” or “disc herniation” or “disc prolapse” or “disc protrusion” or “disc regeneration” or “disc replacement*” or “disk arthroplasty” or “disk cell*” or “disk degeneration” or “disk disease*” or “disk disorder*” or “disk disruption” or “disk herniation” or “disk prolapse” or “disk protrusion” or “disk regeneration” or “disk replacement*” or “facet denervation” or “facet joint*” or “facet syndrome” or “foraminal stenosis” or “fusion surgery” or “hangman’s fracture” or “herniated disc*” or “herniated disk*” or “iliac crest bone graft” or “iliac screw*” or “interbody fusion” or “klippel-feil” or “lateral interbody fusion” or “lateral mass screw*” or “longitudinal ligament*” or “low back” or “low-back” or “lower back” or “lumbar spine fusion” or “neck disabilit*” or “neck disorder*” or “neck injur*” or “neck pain” or “nerve root compression” or “occipito-cervical” or “odontoid fracture*” or “optic-spinal” or “pars defect*” or “pedicle fixation” or “pedicle screw*” or “pedicle subtraction osteotomy” or “prodisc* c” or “raphe-spinal” or “sacral giant cell*” or “sagittal alignment” or “sagittal balance” or “sagittal deformity” or “sagittal imbalance “or “sagittal plane alignment” or “sagittal plane deformity” or “transarticular screw fixation” or “transverse process” or aospine or atlantoaxial or atlantooccipital or cervicogenic or chondrosarcoma or chordoma* or corpectomy or corticospinal or craniocervical or craniovertebral or discitis or discogenic or discogram* or discography or diskitis or diskogenic or diskography or dorsalgia or ependymoma* or hemivertebra* or interspinal or intradiscal or intraspinal or kyphoplasty or kyphoscoliosis or kyphosis or laminectom* or laminoplasty or lordosis or lumbago or lumbosacral or myelopathy or myeloradiculopathy or nucleotomy or occipitocervical or oswestry or paraspinal or quadripleg* or radiculopathy or raphespinal or sacroiliac or sacrum or sciatic* or scoliosis or spinal or spine or spinopelvic or spondylitis or syringomyelia or tetrapleg* or thoracolumbar or vertebral or vertebrectomy or vertebrobasilar or vertebroplasty or whiplash or zygapophyseal or zygapophysial) NOT TI = (spinel or threespine* or “three-spine*” or supraspinal or “cross-beta spine*” or “dendritic spine*” or (spine* and (dendrit* or urchin* or fluid*)) or cerebrospinal or “low-background” or “spine density”)

It was found that title (TI)-based general topical search was more efficient in relation to the topic (TS)-based general topical search where the abstracts, author keywords, and WOSCC keywords of the papers were screened. It was also noted that the pre-1991–1992 papers had no abstracts, making the keyword design more important for the literature search as most of the citation classics were published in the 1980s.

The information on the document types, authors, group authors, countries, institutions, funding bodies, languages, publication years, journals, and WOSCC subject categories were collected from the WOSCC. Additionally, the information relating to the 10 citation classics were presented.

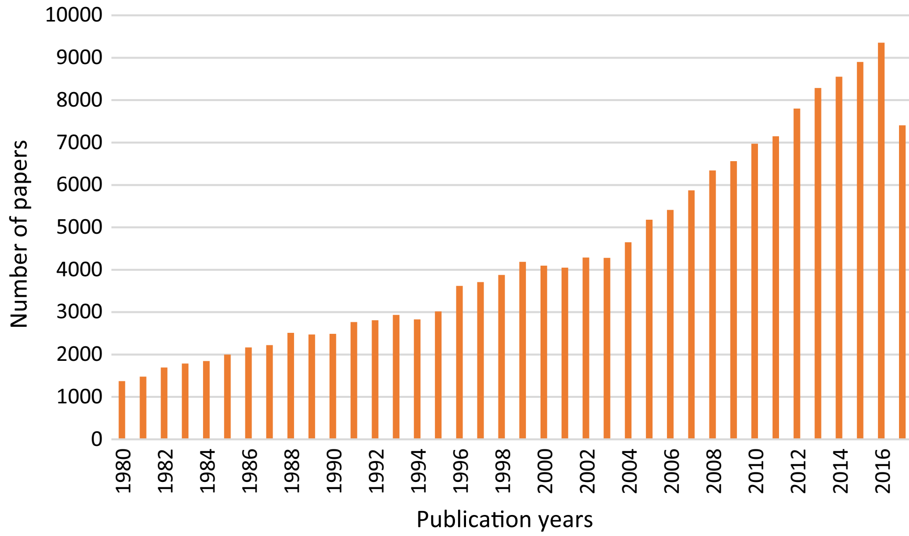

Fig. 1 Research output in spine between 1980 and 2017

Results and discussion

Document analysis

There were 166,962 'articles' and 'reviews' published in 'English' forming the working sample for this paper. It is notable that 'reviews' and 'proceedings papers' formed 5.8 and 2.8% of the final sample. It is further notable that there were 41 'retracted publications'.

Nearly, 98.8% of this sample were indexed by the SCIE whilst, 5.1 and 0.3% of the sample was indexed by the SSCI and A&HCI, respectively. Thus, 4.2% of the sample was indexed by more than one index. Additionally, 2.8% of the sample was indexed by the 'Conference Proceedings Citation Index-Science' (CPCI-S) since these papers were also presented as 'proceedings papers'.

It is notable that since 13,115 papers formed the sample for Wei et al. [1], 166,962 papers provide a larger sample as nearly 13 times larger than the sample of Wei et al. for the key stakeholders to consider [1].

Author analysis

'Michael G Fehlings' was the most prolific author with 481 papers. The other top authors were 'Alexander R Vaccaro', 'Kazuhisa Takahashi', 'Lawrence G Lenke', and 'Ziya L Gokaslan' with 477, 349, 330, and 282 papers, respectively. There was serious 'gender gap' in the top author list as only one of 18 top authors was female. Nearly 0.7% of the papers had group authors besides single authors. The top group author was 'International Spine Study Group' with 84 papers.

Country analysis

The most-prolific country was the US with 62,261 papers forming 37.3% of the sample. The other most-prolific countries were Japan, England, China, and Canada with 8.2, 7.1, 6.9, and 6.4% of the sample, respectively. On the other hand, Europe contributed as a regional power to more than 39.8% of the sample. These findings confirm the results of Ding et al. [5] and Koutras et al. [6] that developed countries produced more than 84% of papers on spine.

Although China was the fourth most-prolific country for the period from 1980 to 2017, it became second most-prolific country publishing 14.7% of the sample for the 2010s with a further potential for rise [1, 7].

Funding body analysis

It appears that 26.6% of the papers disclosed research funding in the acknowledgement part of the papers. There were 32,971 such funding bodies disclosed. The various branches of National Health Institutes of the US topped the funding body list. It is notable that the rate of funding was too low indicating the presence of inefficiencies in the incentive structures for the key stakeholders engaged in the spine research at a global basis.

Institution analysis

In total, 40,897 institutions contributed to the research in spine. The most-prolific single institution was 'Harvard University' with 3189 papers. The other most prolific

Table 1 Ten citation classics in spine

Rank	Paper ref.	Year	Doc.	Affil.	Country	N. auths.	M/F	Lead author	N. pgs.	N. refs.	Journal	Subject	Topics I	Topics II	No cits
1	Van der Linden et al. [8]	1984	A	Erasmus Univ., Leiden State Univ. + 1	Netherlands, Switzerland	3	M	Van der Linden	8	27	Arthritis Rheum	Rheum	Evaluation of diagnostic criteria for ankylosing spondylitis	Ankylosing spondylitis	2848
2	Black et al. [9]	1995	A	Univ. Pittsburgh, Stanford Univ. + 7	US	12	M	Marcus	7	30	Lancet	Med Gen Int	Effect of alendronate on risk of fracture	Vertebral fractures	2480
3	Mayer et al. [10]	1984	A	NICHD + 1	US, England	3	M	Mayer	3	18	Nature	Mult Sci	NMDA responses in spinal cord neurones	Spinal neurol-ogy	2208
4	Kim and Chung [11]	1992	A	Univ. Texas	US	2	M	Kim	9	27	Pain	Anesth, Clin Neur +1	Peripheral neuropathy	Spinal neurol-ogy	2160
5	Beaton et al. [12]	2000	A	Univ. Toronto + 4	Canada, France + 1	4	F	Bombardier F	6	27	Spine	Clin Neur, Orthoped	Cross-cultural adaptation of self-report measures	Spinal epidemi-ology	2143
6	Ettinger et al. [13]	1999	A	Univ. Calif San Francisco, Univ. Kiel + 9	US, France + 4	18	M	Christiansen	9	25	JAMA-J Am Med Assoc	Med Gen Int	Reduction of vertebral frac-ture risk with raloxifene	Vertebral fractures	2055
7	Lefebvre et al. [14]	1995	A	Genethon + 2	France	16	F	Munnich	11	36	Cell	Bioch Mol Biol, Cell Biol	Spinal muscular atrophy-determining gene	Spinal muscu-lar atrophy	1893
8	Roland and Morris [15]	1983	A	St Thomas Hosp. and Med. Sch.	England	2	M	Morris	4	0	Spine	Clin Neur, Orthoped	Natural history of back pain	Back injury	1875
9	Rossini et al. [16]	1994	A	Osped Fate-benefratelli Oftalmico.	Italy	16	M	Rossini	14	101	Electroen Clin Neuro	Eng Biomed, Clin Neur	Non-invasive stimulation of the brain, spinal cord and roots:	Spinal neurol-ogy	1799
10	Hunt et al. [17]	1987	A	Univ. Cam-bridge + 2	England	3	M	Evan	3	30	Nature	Mult Sci	Induction of *c-fos*-like protein in spinal cord neurons	Spinal neurol-ogy	1637

A article, *Affil.* affiliations, *N auths.* number of authors, *M* male, *F* female, *N. pgs.* number of pages, *N. refs.* number of references, *No cits* total number of citations received in web of Science Core Collection as of October 2017 institutions were 'University of Toronto', 'University of California San Francisco', 'Johns Hopkins University', and 'University College London'. It appears that top institutions were from the US, Europe, and Canada. On the other hand, the most-prolific national institution was 'Institut National de la Sante et de la Recherche Medicale' with 1383 papers.

Publication year analysis

The research output in spine steadily increased from 1375 papers in 1980–9357 papers in 2016 and 7408 papers in 2017 as of October 2017. Corresponding to the steep rise in the 2000s and 2010s, the research output in these decades formed 30.4 and 38.6% of the sample, respectively (Fig. 1). Additionally, the papers published in the 1980s and 1990s formed 10.9 and 19.3% of the sample, respectively. It is envisaged that the research output in spine would continue to rise.

Journal analysis

In total, 5436 journals published papers on spine. The most-prolific journal was 'Spine' with 14,622 papers forming 8.8% of the sample. The other most-prolific journals with more than 1500 papers were 'European Spine Journal', Spinal Cord', 'Journal of Neurosurgery Spine', and 'Spine Journal' with 4030, 3000, 2625, and 2089, respectively.

It is notable 7 journals related to spine joined the top journal list. Furthermore, in total 10 spine journals published 39,122 papers forming only 23.4% of the sample. Thus, it is necessary to search these other 5426 journals for the papers related to spine with an optimally designed keyword set as it was done in this paper, in addition to the search of all the journals related to spine.

Web of Science subject category analysis

In total, 234 subject categories indexed the papers on spine. The most-prolific subject category of 'Web of Science Core Collection' was 'Clinical Neurology' indexing 59,542 papers, 35.7% of the sample. The other three most-prolific subject categories were 'Orthopedics', 'Neurosciences', and 'Surgery' indexing 23.1, 17.3, and 14.5% of the sample, respectively. These 4 subject categories were the primary research areas of spine. It appears that it is necessary to search all of 234 subject categories for the scientometric and literature review studies on the spine rather than a couple of prolific subjects such as 'Clinical Neurology' or 'Orthopedics'.

Citation classics in spine

This section presents 10 citation classics in spine with more than 1637 citations in the order of decreasing number of citations in Table 1 [8–17]. The publication years of these citation classics ranged from 1983 to 2000. 'Nature' and 'Spine' were the most-prolific journals with 2 papers each whilst only 2 papers were published in spine journals. Similarly, it is notable that this top citation classic list differed entirely from the corresponding list of Wei et al. [1] (pp. 981).

The top citation classics was a paper by van der Linden et al. on the evaluation of diagnostic criteria for ankylosing spondylitis (AS) with 2848 citations and 86 citations per year [8]. They evaluated the 'New York' and the 'Rome diagnostic criteria' for AS and the clinical history screening test for AS in relatives of AS patients and in population control subjects.

Conclusions

Whilst the pioneering study by Wei et al. [1] evaluated the global research in spine using scientometric methods based on a sample of 13,115 papers published in 5 spine journals from 2004 to 2013, this study built on this pioneering study and provided information for the stakeholders on spine based on a sample of 166,962 papers, located through the optimal keyword set in the titles of both papers and 10 spine journals, in 5436 journals in 234 Web of Science subject categories by 40,897 institutions between 1980 and 2017.

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Compliance with ethical standards

Conflict of interest The author does not have any potential conflict of interest.

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