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Scientific research outputs in orthopedics from China and other top-ranking countries: a ten-year survey of the literature

Yuming Zou[1] MD, Quan Li[1] MD, PhD, Weidong Xu[1] MD, PhD

1 Department of Orthopedics, Changhai hospital, the first affiliated hospital of the Second Military Medical University, Yangpu DIST, Shanghai, P.R. China

Yuming Zou and Quan Li contributed equally to this paper.

Yuming Zou: ymzousmmu@163.com

Quan Li: drliquan@126.com

Corresponding to Weidong Xu:

Postal address: Changhai Hospital of Second Military Medical University,Yangpu DIST, Shanghai, P.R.China

Email: xwdsmmu@163.com

Tel: +86-13901814702

Keywords: Orthopedics, Impact Factor, Citations, Science Citation Index Expanded (SCIE), Publications.

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Abstract

Objectives: Orthopedics related diseases are an important burden for the entire world. In this study we aim to compare research output in the filed of orthopedics from mainland China (MC) United States (USA), (United Kingdom) UK, Japan and Germany in the field of orthopedics.

Setting: USA, UK, Japan, Germany, MC

Participants: The orthopedics journals were selected under the subject category "orthopedics" of the Science Citation Index Expanded (SCIE).

Outcome measures: Data about funding on research and experimental development (R&D), the number of publications, the number of publications in surveyed publication types, impact factors (IF), and citations of the corresponding country from 2005 to 2014 was collected for quantity and quality comparisons.

Results: A total of 128,895 articles were published worldwide in orthopedics related journals, publications from MC (3,389 [2.63%]) was the fewest but was growing rapidly. The annual publications from MC has exceeded that from Germany since 2012. The USA is in the predominant role in all kinds of publication types under investigation, except Meta-analysis. MC was in the last place in cumulative IF, second to the last in average IF. For total and average citations, MC was still lagging behind. When the total number of publications from each nation were adjusted by R&D funding, the gap between MC and the rest four countries was even greater.

Conclusions: Though MC has made great progress in the number of publications in the field

of orthopedics for the last ten years, the quality of publication is far from satisfactory. There is still a long way to go for Chinese orthopedics researchers.

Trial registration: None

Strength and limitations of this study

Only publications published in the journals listed in Science Citation Index Expanded (SCIE) orthopedics category were identified. Some articles published on them may not related closely to orthopedics. Besides, some articles pertaining to orthopedics may have been published on some general journals that were not included in our study. The estimate of the amount of research funding in relation to orthopedic publications is just a crude measure because gross domestic spending on R&D is for all types of R&D, not specific to orthopedic research. The top 10 high-impact journals were selected solely based on IF.

Introduction

Orthopedics related diseases are an important burden for the entire world. Globally, by 2013, two of the five leading causes of disability-adjusted life-years are orthopedics related.[1] In China, musculoskeletal disorders accounted for 25.8% causes of years lived with disability in adults. [2]

Within the last decades, as economy picking up rapidly, Mainland China (MC) has made remarkable progress in the field of medicine. To a certain extent, the quantity and quality of scientific publications are measurable indexes of research impact of an individual[3], and to a larger extent, a nation. As revealed by the Chinese Institute of Scientific and Technical

Information in the *Statistical Data of Chinese S&T Papers 2013*[4], USA, MC, Germany, Japan and UK were the top five regions with most scientific articles published. However, little is known about the publication situation specifically in the field of orthopedics in MC compared with the other top-ranking countries in the last ten years.

In this study, we aim to compare the contributions of mainland Chinese scholars with rest of the top five most published regions in the area of orthopedics between 2005 and 2014, and provide a better yardstick to evaluate the development status of orthopedics in MC. As the funding and regulation system of academic research in Taiwan and Hong Kong is not consistent with mainland China, articles from Taiwan and Hong Kong were not included in our study.

Methods

We included 73 orthopedic journals from the Orthopedics category of the Science Citation Index Expanded (SCIE) designed by Thomson Reuters. The full list of the designed Orthopedics category by Thomson Reuters is shown in the appendix (See Electronic Supplementary Material 1). All of the 73 journals in the Orthopedics category, which could be retrieved by PubMed and Web of Science, covers resources on surgery and medical appliances as means to preserve or restore function or alleviate pain in the musculoskeletal system, particularly the bones and joints. A computerized bibliography retrieval was conducted on 29 September 2015, and the articles published in the 73 journals from USA, UK, Japan, Germany and MC between 1 January 2005 and 31 December 2014 were

identified. As the name of *JBJS Br* was changed to *Bone Joint J* in 2013, articles on the journal with these two names were deliberately pooled together. The whole retrieval and data extraction process was conducted in duplicate by two independent researchers (YM Zou and Q Li), differences were solved though discussion, until concordance was reached.

The publication date (print) and ISSN(print) were used in our research strategy in the PubMed database. The search terms were "USA[Affiliation]", "UK[Affiliation]", "Japan[Affiliation]", "Germany[Affiliation]"," China [Affiliation] NOT Taiwan[Affiliation] NOT (Hong Kong)[Affiliation]" AND "0001-5415 OR 1745-3674 OR 0001-6462 OR 1017-995X OR 1413-7852 OR 0363-5465 OR 0936-8051 OR 0749-8063 OR 1471-2474 OR 2049-4394 OR 2046-3758 OR 1413-3555 OR 1947-6035 OR 1297-3203 OR 0268-0033 OR 1050-64921X OR 0891-8422 OR 0300-8207 OR 1305-8282 OR 0940-6719 OR 1071-1007 OR 1083-7515 OR 1268-7731 OR 0966-6362 OR 0749-0712 OR 1120-7000 OR 0019-5413 OR 0020-1383 OR 0973-6042 OR 0341-2695 OR 0959-3020 OR 0883-5403 OR 1053-8127 OR 0021-9355 OR 1067-2516 OR 1757-1146 OR 0363-5023 OR 1753-1934 OR 0894-1130 OR 1538-8506 OR 0190-6011 OR 0736-0266 OR 0949-2658 OR 1022-5536 OR 1749-799X OR 0890-5339 OR 0271-6798 OR 1060-152X OR 1836-9553 OR 2000-656X OR 1058-2746 OR 1536-0652 OR 1067-151X OR 8750-7315 OR 0968-0160 OR 0942-2056 OR 0934-6694 OR 0085-4530 OR 0744-6020 OR 1757-7853 OR 1877-0568 OR 0030-5898 OR 0147-7447 OR 1063-4584 OR 0031-9023 OR 0091-3847 OR 0309-3646 OR 0364-2348 OR 0362-2436 OR 1529-9430 OR 0932-0555 OR 1864-6697 OR 0301-620X". An article was considered to be output from a region if it was affiliated to the respective region according to the search

result by PubMed. The number of specific types of articles including clinical trial, randomized controlled trials (RCTs), meta-analysis and review were also identified.

Three methods were used to evaluate the quality of articles. Firstly, the cumulative and average impact factors (IF) were calculated according to the journal Citation Reports (JCR) 2014 published by Thomson Reuters. Secondly, citation reports of literatures in each region were collected through Web of Science. Thirdly, the number of articles published in the top 10 high-impact orthopedics journals were counted and 10 most popular orthopedics journals in each region were also identified.

Statistical analysis

Trends of publication were our primary focus but not verifying the hypothesis that differences of contributions exist in these regions. For that reason, only simple descriptive statistics (e.g. sum and average) are conducted in our study.

Results

Total amount and share of publications

A total of 128, 895 articles were published worldwide between 2005 and 2014 in orthopedics related journals. Over all, the USA contributed the largest proportion (31,190 [24.20%]), followed by the UK (6,703 [5.20%], Japan (5,718 [4.41%]), Germany (4,701 [3.66%]) and China (3,389 [2.63%]) (Figure 1).

MC's gross domestic spending on research and experimental development (R&D) had been growing rapidly in recent years, from $78.7 billion to $317.8 billion between 2005 and

2014, and now was only after USA, according to estimates by Organization for Economic Cooperation and Development (OECD)[5] (Figure 2). After the number of publications was adjusted with the amount of money spent on R&D, UK (17.78) had the biggest publications per billion dollars, followed by USA (7.81), Germany (5.54), Japan (3.95) and MC (1.88). The ranking has not changed for a decade, except the value of USA declined in recent two years (Figure 3).

Publication types

The number of different article types including, RCTs, clinical trials, reviews, case reports and meta-analysis published by each region were shown in Figure 4. USA accounted for the largest share and absolute superiority in all types of article except meta-analysis. In the last decade, MC had published the most number of meta-analysis in all five regions. In addition, MC had published more RCTs and Reviews than Japan for the last ten years in total. Apart from the ascending number of RCTs from China, the publication trend of RCTs for rest countries under surveyed was relatively stable (Figure 5).

Impact factors

Based on journal citation report (JCR) 2014, we calculated the cumulative and average IF for each region. During the last decade, cumulative IF was ranked in the following order: USA, Japan, UK, Germany and MC. By average IF calculation, Germany ranked first, followed by USA, MC, UK and Japan. The details of trends in cumulative and average IF were listed in Table 1.

Table 1. Cumulative and average IFs of articles from the five regions

Year	Cumulative IFs					Average IFs				
	USA	UK	Japan	Germany	MC	USA	UK	Japan	Germany	MC
2005	5865.896	1056.832	1089.882	634.944	78.716	2.047	1.929	2.112	2.116	2.385
2006	6425.466	1045.266	1120.177	831.133	140.899	2.061	1.883	2.114	2.199	2.168
2007	6482.460	1195.260	1103.435	848.391	222.186	2.094	1.853	2.138	2.215	2.314
2008	6262.057	1094.861	1072.712	893.142	303.679	2.024	1.777	2.039	2.142	2.266
2009	7880.583	1135.516	1154.643	910.234	506.102	2.447	1.769	2.073	2.073	1.763
2010	6636.580	1035.284	1123.844	1084.724	561.488	2.126	1.681	2.025	2.135	1.707
2011	8127.619	1136.579	1178.769	1071.755	852.724	2.339	1.645	2.072	2.144	1.814
2012	7885.948	1311.986	1279.197	1089.660	997.298	2.087	1.676	2.508	2.137	1.885
2013	7716.064	1359.962	1308.423	1275.919	1279.832	2.387	1.828	2.035	2.137	1.888
2014	5048.107	1708.500	1637.344	1524.299	1555.280	2.305	1.980	2.057	2.278	2.025
Total	68330.780	12080.046	12068.426	10164.201	6498.204	2.191	1.802	2.111	2.162	1.917

Citation reports

As shown in Table 2, MC was lagged behind by other 4 countries in total or average citations. But the gap narrowed in terms of annual citations of each region in recent years, and MC approached quite close to Germany. Moreover, MC had exceeded Japan in annual citations since 2011.

Table 2. Total and average citations of articles from the five regions

	USA	**UK**	**Japan**	**Germany**	**MC**
Year	**39840 articles**	**9667 articles**	**6390 articles**	**8083 articles**	**3548 articles**
2005	79575	13760	9455	9386	1348
2006	78313	12996	8943	11592	1483
2007	71782	13202	7624	9287	1987
2008	62347	13924	6089	9619	2536
2009	54476	10722	5989	8886	3487
2010	45068	9683	4892	8150	3275
2011	36709	9954	4135	6303	4147
2012	27476	7898	3380	4414	3683
2013	17455	7447	2011	3234	2598
2014	8162	4913	1226	1405	1243
Total citations	481363	104499	53744	72276	25787

Average citations	27.63	35.52	11.68	18.76	2.49

Top 10 high-impact orthopedics journals

Top 10 high-impact journals were selected according to the IF in 2014. Articles from each region published in these journals from 2005 to 2014 were counted. Again, USA (8820 articles) had the biggest share, far more than the combination of other four regions. However, when the numbers were divided by total article volume of each region, the difference was not that obvious (Table 3), and MC did slightly higher than UK.

Table 3. Articles in top 10 high-impact orthopedic journals from the five regions

Rank	Journal Title	2014IF	USA	UK	Japan	Germany	MC
1	J Bone Joint Surg Am	5.280	1729	98	126	102	33
2	Am J Sports Med	4.362	1424	54	154	155	33
3	Osteoarthritis Cartilage	4.165	600	186	119	93	64
4	J Physiother	3.708	107	8	1	0	0
5	Arthroscopy	3.206	902	41	165	136	70
6	Knee Surg Sports Traumatol Arthrosc	3.053	309	195	267	351	88
7	J Orthop Sports Phys Ther	3.011	345	19	16	10	0
8	J Orthop Res	2.986	546	59	200	174	88
9	Acta Orthop	2.771	51	65	45	80	11
10	Clin Orthop Relat Res	2.765	2789	134	182	129	75
Total			8802	859	1230	1275	462
Divided by total article volume of each country (%)			28.40	14.88	22.06	27.54	13.76

Most popular orthopedics journals

The details of top 10 most popular journals in each region were listed in Table 4. Four popular orthopedics journals in USA (*J Clin Orthop Relat Res, J Bone Joint Surg Am, Am J Sports Med, Arthroscopy*) were listed in the top 10 high-impact journals. Meanwhile, three

journals in Germany *(Knee Surg Sports Traumatol Arthrosc, J Orthop Res, Arthroscopy)* and Japan *(Knee Surg Sports Traumatol Arthrosc, J Orthop Res, Clin Orthop Relat Res*), and one journal in MC *(J Orthop Res)*, but none in the UK was ranked in the top 10 high-impact journals. Besides, *Spine, Eur Spine J, Arch Orthop Trauma Surg, Injury* and *Int Orthop* were widely popular among these regions.

Table 4. Top 10 most popular orthopedic journals in the five regions

	USA	N	UK	N	Japan		Germany	N	MC	N
1	CORR	2789	BJR	981	JOC	856	AOTS	555	Spine	390
2	Spine	2088	Injury	547	Spine	677	KSSTA	351	ESJ	318
3	JBJS	1729	JHS-E	271	ESJ	269	ESJ	335	Int Orthop	283
4	Orthopedics	1657	HIP INT	263	KSSTA	267	Int Orthop	294	Orthopade	238
5	AJSM	1424	Knee	260	JA	228	Injury	240	Orthopedics	176
6	JFAR	1420	ESJ	237	JHS-A	213	Spine	205	AOTS	175
7	SPINE J	1166	SR	234	AOTS	206	BMD	186	Injury	152
8	JHT	1086	BMD	226	JOR	200	JOR	174	JSDT	124
9	JAAOS	914	BJJ	216	CORR	182	AJSM	155	BMD	113
10	Arthroscopy	902	Int Orthop	208	JSDT	177	Arthroscopy	136	JOR	88

AJSM, Am J Sports Med, IF=4.362; AOTS, Arch Orthop Trauma Surg, IF=1.597; Arthroscopy, IF=3.206; BJJ, Bone Joint J, IF=1.961; BJR, Bone Joint Res, IF=1.64; BMD, BMC Musculoskelet Disord; IF=1.717; CORR, Clin Orthop Relat Res, IF=2.765; ESJ, Eur Spine J, IF=2.066; Hip Int, IF=0.756; Injury, IF=2.137; Int Orthop, IF=2.11; JA, J Arthroplasty, IF=2.666; JAAOS, J Am Acad Orthop Surg, IF=2.527; JBJS, J Bone Joint Surg Am, IF=5.28; JFAR, J Foot Ankle Res, IF=1.462; JHS-A, J Hand Surg Am, IF=1.667; JHS-E, J Hand Surg Eur Vol, IF=2.037; JHT, J Hand Ther, IF=2; JOC,J Orthop Sci, IF=0.941; JOR, J Orthop Res, IF=2.986; JSDT, J Spinal Disord Tech, IF=2.202; Knee, IF=1.936; KSSTA, Knee Surg Sports Traumatol Arthrosc, IF=3.053; Arthrosc, IF=3.053; Orthopade, IF=0.359; Orthopedics, IF=0.962; Spine, IF=2.297; SPINE J, IF=2.426; SR, Skeletal Radiol, IF=1.51.

Discussion

Our study compared the quantity and quality of scientific publications in the field of orthopedics from MC with USA, UK, Japan and Germany. These five regions had biggest scientific output in the world and were also top five areas with highest GDP.

In 2005 only 31 articles in orthopedics journals were from MC, and rapid growth in both absolute number and share of publications were observed from 2005 to 2014. Articles from MC in 2014 was almost 25 times the amount in 2005, and the number had exceeded Germany and Japan since 2011, and now quite close to UK. Increasing R&D funding accompany with improving economic status was undoubtedly the main reason for such progression on scientific reports output. Besides, the availability of increased journal space in which to publish may also helped. Further we adjusted the absolute number of publications with gross domestic spending on R&D, and found that though the number of articles published per billion US dollars kept increasing in the last decade, MC was still on the bottom of the list in 2014, while UK seems to be doing very well in this regard (Figure 2). It was indicated that the funding efficiency on general quantity of articles from MC might be not as good as the others.

RCTs were considered as the best evidence for clinical practice.[6] It is noteworthy that the number of RCTs from China exceeded Japan in the last decade, meaning more original work are coming out of China. But our results also revealed that MC published more meta-analysis than other four countries. It should be pointed out that meta-analysis is not really original research. Several reasons may contribute to this quite abnormal phenomenon.

First, the relatively low doorsill to perform meta-analysis; Second, many RCTs performed by scientists are available, and the fact that well-performed meta-analyses are the highest evidence in the hierarchy of clinical evidence and; Thirdly, the need of Chinese scholars to publish in peer-reviewed academic journals also contributed.

IF of an academic journal is frequently used for measuring and comparing the influence of the journal. Journals with higher IF are generally rendered to be more important and more influential.[7-8] We took IF as an objective parameter evaluating the quality of publications from each region. However, it is possible that articles published in journals with low IF may be an excellent work, and the opposite situation could happen. Thus we further compared average citations of articles from each region. The data on cumulative and average IF is interesting in that it makes the point that more publications coming out of MC in recent years did not change the average IF, which actually went down (Table 1). The data on total and average citations is actually also quite telling, as it shows that although MC has increased its publications by many folds, the average citation is extremely low compared to the other countries (Table 2). The same result was found in publication status in the top 10 high-impact orthopedics journals. All these indicates that orthopedic researchers from MC should be looking at improving the quality of the publications.

Some of the limitations in this articles should be addressed. Firstly, we focused publications only in the journals listed in SCIE database orthopedics category. Some published articles on them may not related closely to orthopedics, while, some articles

pertaining to orthopedics may have been published on some general journals that were not included in our study; Secondly, as gross domestic spending on R&D is for all types of R&D, and not specific to orthopedic research, thus, the estimate of the amount of research funding in relation to orthopedic publications is a crude measure; Last but not the least, the top 10 high-impact journals were selected based on IF in 2014, some highly influential journals in the orthopedics field, such as Spine (IF=2.297) , J Arthroplasty (IF=2.666) were not included.

Conclusion

The number and share of articles from Chinese authors are ascending every year, and is now comparable with the UK, Japan and Germany. But the general quality of publications is dissatisfying. The efficiency of R&D funding in MC was on the lowest level in the field of orthopedics, which suggest some deficiency in the system of funding management and use in the field of orthopedics. It was interesting and worth mentioning that articles from UK had the highest average citations and the greatest funding efficiency, despite lowest average IF.

As the second largest economy in the world with a population of 1.3 billion, MC has a great potential in the field of orthopedics and there is still a long way for MC academics to go, the world could expect better performances from China.

Contributorship statement X-WD planned the study. Z-YM and L-Q researched and analyzed data and wrote the manuscript. X-WD is the guarantor of this work and had full access to all the data in this study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Competing interests None

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Data sharing statement No additional unpublished data are available.

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Figure Legends

Fig 1A-B. The number (A) and share (B) of papers published in orthopedic journals from the top five most published regions

Fig 2. R&D spending from each region

Fig 3. Number of publications adjusted by R&D spending from each region

Fig 4. The number of papers of different publication types (including RCTs, clinical trial, review, case report and meta-analysis) from different regions.

Fig 5. Cumulative IF adjusted by R&D spending of the top five most published countries (2005-2014)

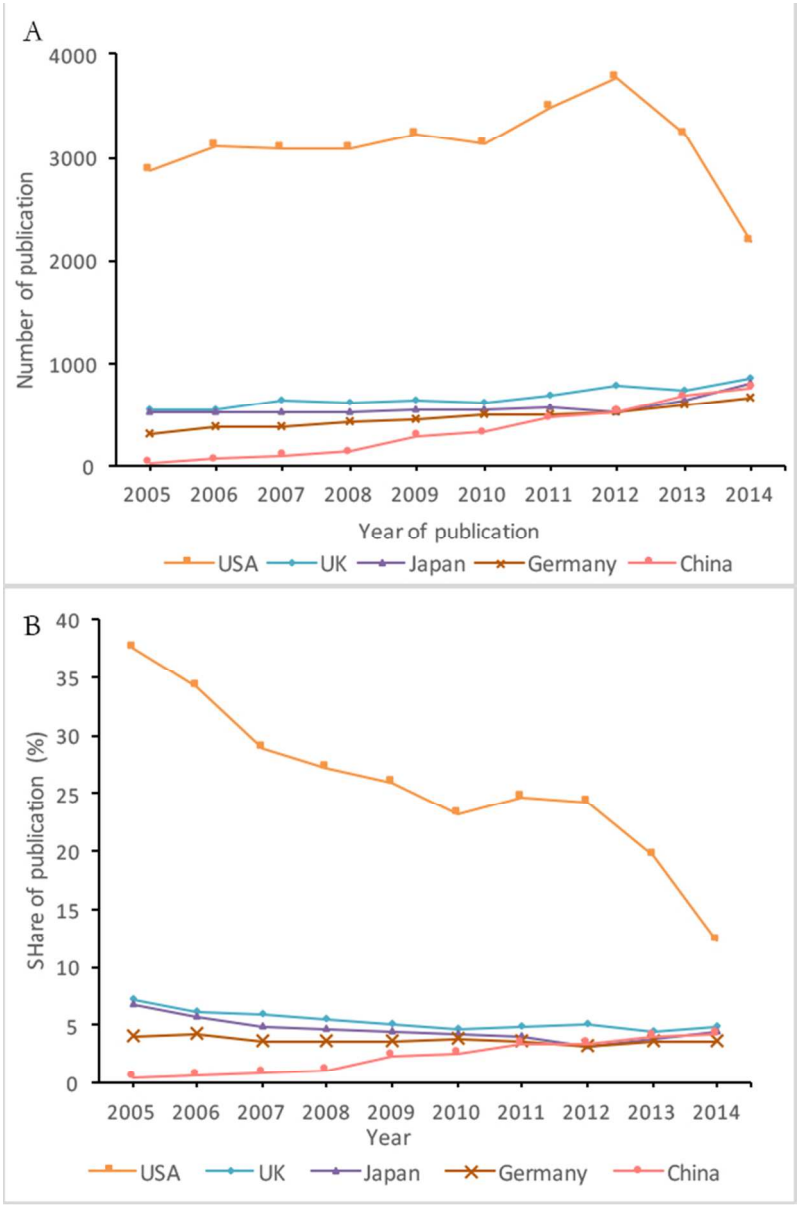

Fig 1A-B. The number (A) and share (B) of papers published in orthopedic journals from the top five most published regions

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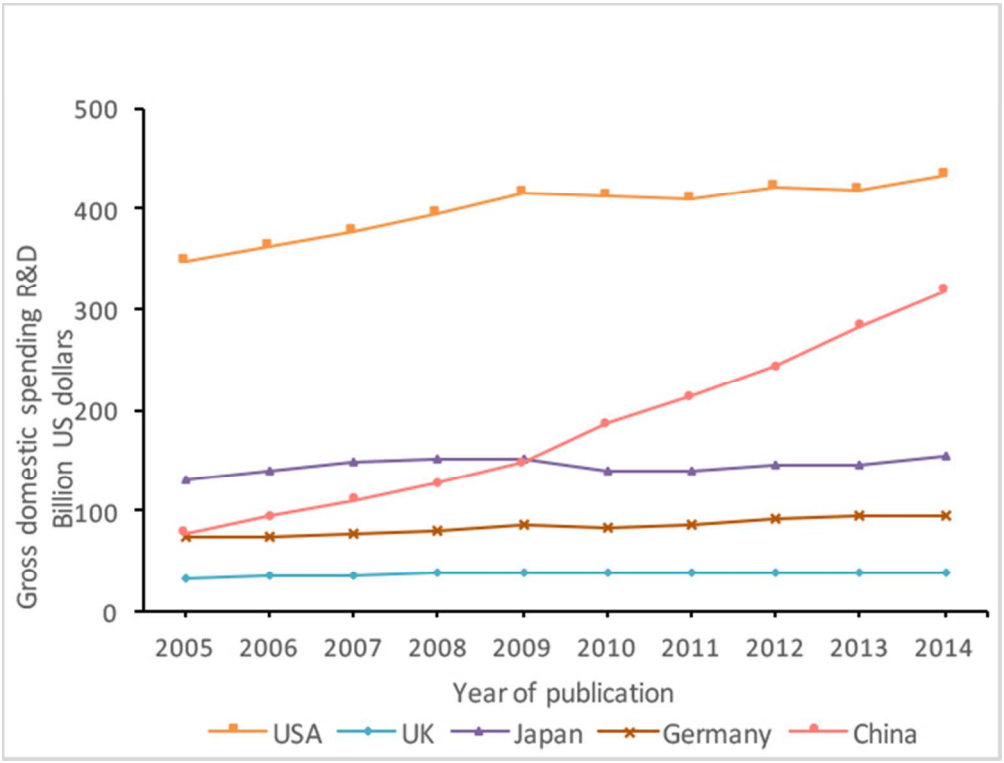

Fig 2. R&D spending from each region

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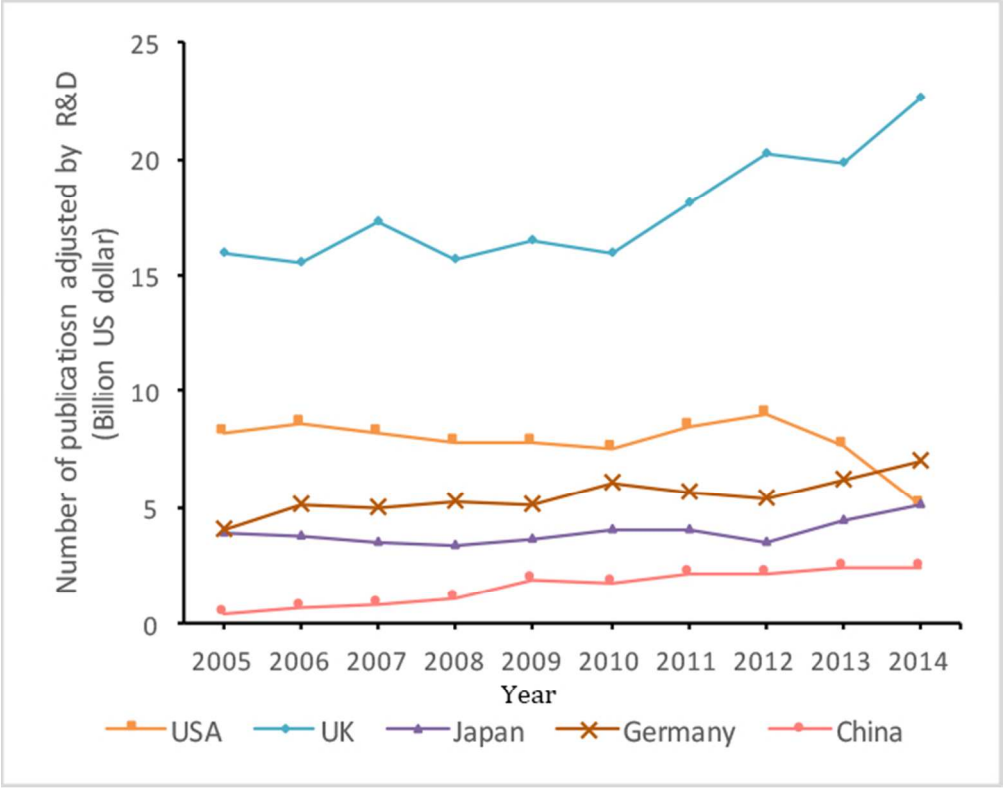

Fig 3. Number of publications adjusted by R&D spending from each region

125x98mm (144 x 144 DPI)

Fig 4. The number of papers of different publication types (including RCT, clinical trial, review, case report and meta-analysis) from different regions.

100x42mm (300 x 300 DPI)

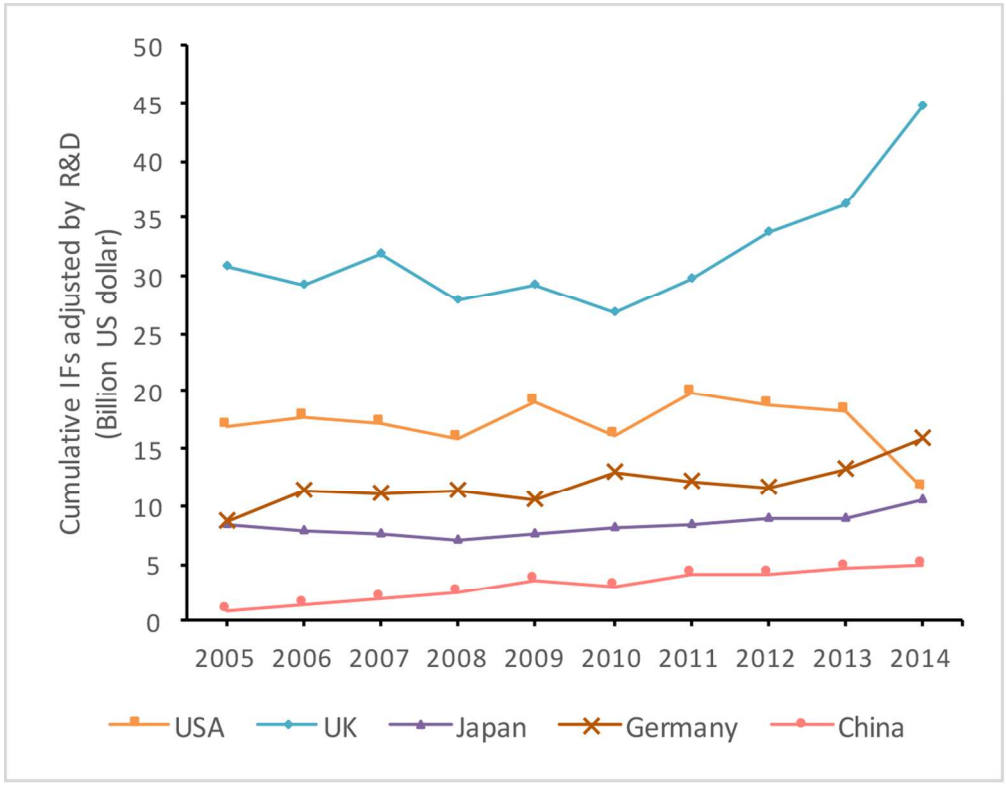

Fig 5. Cumulative IF adjusted by R&D spending of the top five most published countries (2005-2014)

114x88mm (300 x 300 DPI)

	ISSN	Full Name	Abbreviated Journal Title	IF
1	0021-9355	JOURNAL OF BONE AND JOINT SURGERY-AMERICAN VOLUME	J BONE JOINT SURG AM	5.28
2	0363-5465	AMERICAN JOURNAL OF SPORTS MEDICINE	AM J SPORT MED	4.362
3	1063-4584	OSTEOARTHRITIS AND CARTILAGE	OSTEOARTHR CARTILAGE	4.165
4	1836-9553	JOURNAL OF PHYSIOTHERAPY	J PHYSIOTHER	3.708
5	0749-8063	ARTHROSCOPY-THE JOURNAL OF ARTHROSCOPIC AND RELATED SURGERY	ARTHROSCOPY	3.206
6	0942-2056	KNEE SURGERY SPORTS TRAUMATOLOGY ARTHROSCOPY	KNEE SURG SPORT TR A	3.053
7	0190-6011	JOURNAL OF ORTHOPAEDIC & SPORTS PHYSICAL THERAPY	J ORTHOP SPORT PHYS	3.011
8	0736-0266	JOURNAL OF ORTHOPAEDIC RESEARCH	J ORTHOP RES	2.986
9	1745-3674	ACTA ORTHOPAEDICA	ACTA ORTHOP	2.771
10	0009-921X	CLINICAL ORTHOPAEDICS AND RELATED RESEARCH	CLIN ORTHOP RELAT R	2.765
11	0966-6362	GAIT & POSTURE	GAIT POSTURE	2.752
12	0883-5403	JOURNAL OF ARTHROPLASTY	J ARTHROPLASTY	2.666
13	1067-151X	JOURNAL OF THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS	J AM ACAD ORTHOP SUR	2.527
14	0031-9023	PHYSICAL THERAPY	PHYS THER	2.526
15	1529-9430	SPINE JOURNAL	SPINE J	2.426
16	0362-2436	SPINE	SPINE	2.297
17	1058-2746	JOURNAL OF SHOULDER AND ELBOW SURGERY	J SHOULDER ELB SURG	2.289
18	1050-642X	CLINICAL JOURNAL OF SPORT MEDICINE	CLIN J SPORT MED	2.268
19	1536-0652	JOURNAL OF SPINAL DISORDERS & TECHNIQUES	J SPINAL DISORD TECH	2.202
20	0020-1383	INJURY-INTERNATIONAL JOURNAL OF THE CARE OF THE INJURED	INJURY	2.137
21	0341-2695	INTERNATIONAL ORTHOPAEDICS	INT ORTHOP	2.11
22	0940-6719	EUROPEAN SPINE JOURNAL	EUR SPINE J	2.066
23	1753-1934	JOURNAL OF HAND SURGERY-EUROPEAN VOLUME	J HAND SURG-EUR VOL	2.037
24	0894-1130	JOURNAL OF HAND THERAPY	J HAND THER	2
25	0268-0033	CLINICAL BIOMECHANICS	CLIN BIOMECH	1.97
26	2049-4394	BONE & JOINT JOURNAL	BONE JOINT J	1.961
27	0968-0160	KNEE	KNEE	1.936
28	0890-5339	JOURNAL OF ORTHOPAEDIC TRAUMA	J ORTHOP TRAUMA	1.803
29	1471-2474	BMC MUSCULOSKELETAL DISORDERS	BMC MUSCULOSKEL DIS	1.717
30	0363-5023	JOURNAL OF HAND SURGERY-AMERICAN VOLUME	J HAND SURG-AM	1.667
31	2046-3758	BONE & JOINT RESEARCH	BONE JOINT RES	1.64
32	0300-8207	CONNECTIVE TISSUE RESEARCH	CONNECT TISSUE RES	1.607

33	0936-8051	ARCHIVES OF ORTHOPAEDIC AND TRAUMA SURGERY	ARCH ORTHOP TRAUM SU	1.597
34	0364-2348	SKELETAL RADIOLOGY	SKELETAL RADIOL	1.51
35	1071-1007	FOOT & ANKLE INTERNATIONAL	FOOT ANKLE INT	1.506
36	0271-6798	JOURNAL OF PEDIATRIC ORTHOPAEDICS	J PEDIATR ORTHOPED	1.474
37	1757-1146	JOURNAL OF FOOT AND ANKLE RESEARCH	J FOOT ANKLE RES	1.462
38	1538-8506	JOURNAL OF KNEE SURGERY	J KNEE SURG	1.442
39	1749-799X	JOURNAL OF ORTHOPAEDIC SURGERY AND RESEARCH	J ORTHOP SURG RES	1.386
40	0749-0712	HAND CLINICS	HAND CLIN	1.259
41	1877-0568	ORTHOPAEDICS TRAUMATOLOGY SURGERY RESEARCH	ORTHOP TRAUMATOL-SUR	1.256
42	0030-5898	ORTHOPEDIC CLINICS OF NORTH AMERICA	ORTHOP CLIN N AM	1.252
43	0091-3847	PHYSICIAN AND SPORTSMEDICINE	PHYSICIAN SPORTSMED	1.085
44	0309-3646	PROSTHETICS AND ORTHOTICS INTERNATIONAL	PROSTHET ORTHOT INT	1.041
45	0147-7447	ORTHOPEDICS	ORTHOPEDICS	0.962
46	1413-3555	BRAZILIAN JOURNAL OF PHYSICAL THERAPY	BRAZ J PHYS THER	0.944
47	1305-8282	EKLEM HASTALIKLARI VE CERRAHISI-JOINT DISEASES AND RELATED SURGERY	EKLEM HAST CERRAHISI	0.944
48	0949-2658	JOURNAL OF ORTHOPAEDIC SCIENCE	J ORTHOP SCI	0.941
49	1067-2516	JOURNAL OF FOOT & ANKLE SURGERY	J FOOT ANKLE SURG	0.845
50	1120-7000	HIP INTERNATIONAL	HIP INT	0.756
51	1083-7515	FOOT AND ANKLE CLINICS	FOOT ANKLE CLIN	0.755
52	0934-6694	OPERATIVE ORTHOPADIE UND TRAUMATOLOGIE	OPER ORTHOP TRAUMATO	0.719
53	1053-8127	JOURNAL OF BACK AND MUSCULOSKELETAL REHABILITATION	J BACK MUSCULOSKELET	0.705
54	1022-5536	JOURNAL OF ORTHOPAEDIC SURGERY	J ORTHOP SURG-HONG K	0.701
55	2000-656X	JOURNAL OF PLASTIC SURGERY AND HAND SURGERY	J PLAST SURG HAND SU	0.695
56	1947-6035	CARTILAGE	CARTILAGE	0.694
57	0001-6462	ACTA ORTHOPAEDICA BELGICA	ACTA ORTHOP BELG	0.654
58	8750-7315	JOURNAL OF THE AMERICAN PODIATRIC MEDICAL ASSOCIATION	J AM PODIAT MED ASSN	0.654
59	0973-6042	INTERNATIONAL JOURNAL OF SHOULDER SURGERY	INT J SHOULDER SURG	0.647
60	0019-5413	INDIAN JOURNAL OF ORTHOPAEDICS	INDIAN J ORTHOP	0.64
61	1017-995X	ACTA ORTHOPAEDICA ET TRAUMATOLOGICA TURCICA	ACTA ORTHOP TRAUMATO	0.614
62	1060-152X	JOURNAL OF PEDIATRIC ORTHOPAEDICS-PART B	J PEDIATR ORTHOP B	0.594
63	0891-8422	CLINICS IN PODIATRIC MEDICINE AND SURGERY	CLIN PODIATR MED SUR	0.561
64	0744-6020	ORTHOPAEDIC NURSING	ORTHOP NURS	0.561
65	1864-6697	ZEITSCHRIFT FUR ORTHOPADIE UND UNFALLCHIRURGIE	Z ORTHOP UNFALLCHIR	0.494

66	0959-3020	ISOKINETICS AND EXERCISE SCIENCE	ISOKINET EXERC SCI	0.488
67	0001-5415	ACTA CHIRURGIAE ORTHOPAEDICAE ET TRAUMATOLOGIAE CECHOSLOVACA	ACTA CHIR ORTHOP TR	0.388
68	0085-4530	ORTHOPADE	ORTHOPADE	0.359
69	0932-0555	SPORTVERLETZUNG SPORTSCHADEN	SPORTVERLETZ SPORTSC	0.333
70	1297-3203	CHIRURGIE DE LA MAIN	CHIR MAIN	0.287
71	1413-7852	ACTA ORTOPEDICA BRASILEIRA	ACTA ORTOP BRAS	0.19
72	1268-7731	FOOT AND ANKLE SURGERY	FOOT AND ANKLE SURGERY	0
73	1757-7853	ORTHOPAEDIC SURGERY	ORTHOPAEDIC SURGERY	0

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Scientific research output in orthopedics from China and other top-ranking countries: A 10-year survey of the literature

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Scientific research output in orthopedics from China and other top-ranking countries: A 10-year survey of the literature

Yuming Zou[1] MD, Quan Li[1] MD, PhD, Weidong Xu[1] MD, PhD

1 Department of Orthopedics, Changhai hospital: The first affiliated hospital of the Second Military Medical University, Yangpu DIST, Shanghai, P.R. China

Yuming Zou and Quan Li contributed equally to this paper.

Yuming Zou: ymzousmmu@163.com

Quan Li: drliquan@126.com

Corresponding to Weidong Xu:

Postal address: Changhai Hospital of Second Military Medical University, Yangpu DIST, Shanghai, P.R. China

Email: xwdsmmu@163.com

Tel: +86-13901814702

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Abstract

Objectives: Orthopedics-related diseases and conditions are a significant burden worldwide. In this study we aim to compare the quantity and quality of research output in the field of orthopedics from mainland China (MC), United States (USA), UK (United Kingdom), Japan, and Germany.

Setting: USA, UK, Japan, Germany, and MC

Participants: We selected orthopedics journals from the subject category "orthopedics" from the Science Citation Index Expanded (SCIE).

Outcome measures: The number of publications, the number of publications in the surveyed publication types, impact factor (IF), and citations from the corresponding country from 2005 to 2014 were collected for quantity and quality comparisons.

Results: A total of 128,895 articles were published worldwide in orthopedics-related journals from 2005 to 2014. The United States contributed the largest proportion (31,190 [24.20%]), followed by the United Kingdom (6703 [5.20%], Japan (5718 [4.41%]), Germany (4701 [3.66%]), and mainland China (3389 [2.63%]). Publications from MC represented the fewest but this quantity is rapidly increasing. The quantity of annual publications from MC has exceeded that of Germany since 2012. The USA occupies a predominant role in all kinds of publication types under investigation in the study, except in the category of meta-analysis. MC was in the last place for cumulative IFs, and the average IF actually decreased from the beginning of the study. For total and average citations, MC still lags behind the other countries in the study.

Conclusions: The USA has occupied the dominant place in orthopedics-related research for the last ten years. Although MC has made great progress in the number of published works in the field of orthopedics over the last ten years, the quality of these publishing efforts needs improvement.

Trial registration: None

Strength and limitations of this study

1. Only journals listed in the Science Citation Index Expanded (SCIE) orthopedics category

were identified. Some other orthopedics-related journals not included in SCIE were not collected for this study.

2. Some articles pertaining to orthopedics that were published in some general journals were not included in our study.
3. The country of origin of an article was classified according to the affiliation of the first author, but some of the articles were efforts of international collaboration.
4. The top 10 high-impact journals were selected solely based on IF.

Introduction

Orthopedic diseases and conditions represent a significant burden worldwide. Globally, by 2013, two of the five leading causes of disability-adjusted life years were orthopedics related[1]. In China, musculoskeletal disorders accounted for 25.8% of the causes for which adults live with disability [2].

Over the last few decades, due to rapid improvement in the economy, MC's gross domestic spending on research and experimental development (R&D) has grown from $78.7 billion in 2005 to $317.8 billion in 2014, and now this spending is second only after the USA, according to estimates made by the Organization for Economic Cooperation and Development (OECD)[3]. Mainland China (MC) has made remarkable progress in the field of medicine. To a certain extent, the quantity and quality of scientific publications are measurable indexes of the research impact of an individual [4], and to a larger extent, a nation. As revealed by the Chinese Institute of Scientific and Technical Information in the *Statistical Data of Chinese S&T Papers 2013*[5], the USA, MC, Germany, Japan, and UK were the top five countries with the most scientific articles published. Articles have compared publications between MC, Hong Kong, and Taiwan in the field of orthopedics[6, 7]. However, little is known about the situation with regard to publication of scientific articles specifically in the field of orthopedics in MC compared with the other top-ranking countries for the period covering the last ten years.

In this study, we aim to compare the contributions of mainland Chinese researchers with

contributions from the other top five most published countries in the field of orthopedics between the years 2005 and 2014, and provide a more accurate measure to evaluate the development status of orthopedics in MC.

Methods

We included 73 orthopedics journals from the Orthopedics category of the Science Citation Index Expanded (SCIE) designed by Thomson Reuters[8].The full list of the journals, including the ISSN, full title, abbreviated journal title, and impact factors (IF) from 2014 included in our study is shown in the appendix. (See Electronic Supplementary Material 1.) All of the 73 journals in the orthopedics category, which could be retrieved by PubMed and Web of Science, cover resources on surgery and medical appliances as a means to preserve or restore function or alleviate pain in the musculoskeletal system, particularly the bones and joints. A computerized bibliographic retrieval was conducted on September 29, 2015 and the articles published in the 73 journals from the USA, UK, Japan, Germany, and MC between January 1, 2005 and December 31, 2014 were identified. Because the name of the *JBJS Br* journal was changed to *Bone Joint J* in 2013, articles from the journals with these two names were pooled together for this study. The entire retrieval and data extraction process was conducted in duplicate by two independent researchers (YM Zou and Q Li). Differences of opinion were solved though discussion, until agreement was reached. The full search strategy was included in the supplementary file. (See Electronic Supplementary Material 2.) Articles that showed the first author's affiliation (AD) with these five countries were considered as research outputs from the countries. The numbers of each specific type of article such as clinical trials, randomized controlled trials (RCTs), meta-analysis, reviews, and case reports were also identified according to the publication types generated by PubMed.

Three methods were used to evaluate the quality of articles. First, the cumulative and average IF were calculated according to *Journal Citation Reports* (JCR) 2014 published by Thomson Reuters[9]. Second, citation reports for the literature from each region were collected through Web of Science[10]. Third, the number of articles published in the top 10 high-impact

orthopedics journals (based on IF) were counted and the 10 most published orthopedics journals for each region (based on the number of publications) were also identified.

Statistical analysis

The non-parametric test for trend and time series analysis was performed using SPSS Version 13.0 (SPSS Inc., Chicago, IL, USA) to determine any significant change over the study period. The Kruskal–Wallis test was used to detect the differences among the five countries, and to rank-sum test between two countries if necessary. The test for significance was two-tailed and the value of $p < 0.05$ was considered significant.

Results

Total amount and share of publications

A total of 128, 895 articles were published worldwide between 2005 and 2014 in orthopedics-related journals. Overall, the USA contributed the largest proportion (31,190 [24.20%]), followed by the UK (6703 [5.20%], Japan (5718 [4.41%]), Germany (4701 [3.66%]), and China (3389 [2.63%]) (Figure 1). Despite such large publication numbers, the share of publication numbers attributed to the USA has been in decline for the last 10 years. However, the total number and share of publications from MC increased significantly from 2005 to 2014 (31 to 768, respectively, $P < 0.01$, Figure 1A and 0.43% to 4.26%, respectively, $p < 0.01$, Figure 1B). From 2012 forward, the number of articles from MC has exceeded that of Germany.

Publication types

The number of different article types, which include RCTs, clinical trials, reviews, case reports, and meta-analysis published by each region, are shown in Figure 2. The USA accounts for the largest share and highest quality in all types of articles except meta-analysis. In the last decade, MC has published the largest number of meta-analysis among all five countries. In addition, MC had published more RCTs and reviews than Japan for the last 10 years in total.

Impact factors

Based on the *Journal Citation Reports* (JCR) 2014, we calculated the cumulative and average IF for each region in each year from 2005 to 2014. During the last decade, the total cumulative IFs were ranked in the following order: USA, Japan, UK, Germany, and MC; MC was listed in the last place ($p < 0.01$). According to the average IF calculation, the UK was lower than the USA （$p < 0.001$, Germany ($p < 0.001$), Japan ($p = 0.003$), and MC ($p = 0.018$) for the past 10 years. No statistical differences were detected between MC and the USA ($p = 0.119$), Germany ($p = 0.055$), and Japan ($p = 0.534$). The details of cumulative and average IFs each year from each country are listed in Table 1.

Table 1. Cumulative and average IFs for articles from the five countries

Year	Cumulative IF					Average IF				
	USA	UK	Japan	Germany	MC	USA	UK	Japan	Germany	MC
2005	5865.896	1056.832	1089.882	634.944	78.716	2.047	1.929	2.112	2.116	2.385
2006	6425.466	1045.266	1120.177	831.133	140.899	2.061	1.883	2.114	2.199	2.168
2007	6482.460	1195.260	1103.435	848.391	222.186	2.094	1.853	2.138	2.215	2.314
2008	6262.057	1094.861	1072.712	893.142	303.679	2.024	1.777	2.039	2.142	2.266
2009	7880.583	1135.516	1154.643	910.234	506.102	2.447	1.769	2.073	2.073	1.763
2010	6636.580	1035.284	1123.844	1084.724	561.488	2.126	1.681	2.025	2.135	1.707
2011	8127.619	1136.579	1178.769	1071.755	852.724	2.339	1.645	2.072	2.144	1.814
2012	7885.948	1311.986	1279.197	1089.660	997.298	2.087	1.676	2.508	2.137	1.885
2013	7716.064	1359.962	1308.423	1275.919	1279.832	2.387	1.828	2.035	2.137	1.888
2014	5048.107	1708.500	1637.344	1524.299	1555.280	2.305	1.980	2.057	2.278	2.025
Total	68,330.780	12,080.046	12,068.426	10,164.201	6498.204	2.191	1.802	2.111	2.162	1.917

Citation reports

As shown in Table 2, the USA had the highest total citations and the UK had the highest average number of citations per article over the 10 years, while MC had the lowest total or average number of citations. However, citations to articles from MC grew rapidly from 2005

to 2011. By 2014, the gap between Japan, Germany, and MC was quite narrow. In fact, MC has exceeded Japan in annual citations since 2011.

Table 2. Total and average citations of articles from the five countries

Year	USA	UK	Japan	Germany	MC
2005	79,575	13,760	9455	9386	1348
2006	78,313	12,996	8943	11,592	1483
2007	71,782	13,202	7624	9287	1987
2008	62,347	13,924	6089	9619	2536
2009	54,476	10,722	5989	8886	3187
2010	45,068	9683	4892	8150	3275
2011	36,709	9954	4135	6303	4147
2012	27,476	7898	3380	4414	3683
2013	17,455	7447	2011	3234	2598
2014	8162	4913	1226	1405	1243
Total citations	481,363	104,499	53,744	72,276	25,487
Average citations	27.63	35.52	11.68	18.76	2.49

Top 10 high-impact orthopedics journals

The top 10 high-impact journals were selected according to their IFs in 2014. Articles from each region published in these journals from 2005 to 2014 were counted. Again, the USA (8820 articles) had the biggest share, far more than the combination of the other four countries. In addition, 28.4% of the articles from the USA were published in the top 10 high-impact journals, while only 13.7% from MC were published in those journals (Table 3). If journals that were closely related to physical therapy and with a small volume of publication (J Physiother and J Orthop Sports Phys Ther) were excluded and Spine (IF = 2.297) and J Arthroplasty (IF = 2.666), two highly influential journals, were included in the

analysis, the percentage would have been 27.4% for MC, much higher than the previous result.

Table 3. Articles in the top 10 high-impact orthopedics journals from the five countries

Rank	Journal Title	2014 IF	USA	UK	Japan	Germany	MC
1	*J Bone Joint Surg Am*	5.280	1729	98	126	102	33
2	*Am J Sports Med*	4.362	1424	54	154	155	33
3	*Osteoarthritis Cartilage*	4.165	600	186	119	93	64
4	*J Physiother*	3.708	107	8	1	0	0
5	*Arthroscopy*	3.206	902	41	165	136	70
6	*Knee Surg Sports Traumatol Arthrosc*	3.053	309	195	267	351	88
7	*J Orthop Sports Phys Ther*	3.011	345	19	16	10	0
8	*J Orthop Res*	2.986	546	59	200	174	88
9	*Acta Orthop*	2.771	51	65	45	80	11
10	*Clin Orthop Relat Res*	2.765	2789	134	182	129	75
Total			8802	859	1230	1275	462
Divided by total article volume of each country (%)			28.40	14.88	22.06	27.54	13.76

Most published orthopedics journals

The details for the top 10 most published journals in each region were listed in Table 4. Four of the top 10 most published orthopedics journals in the USA (*J Clin Orthop Relat Res, J Bone Joint Surg Am, Am J Sports Med, Arthroscopy*) were listed in the top 10 high-impact journals. Meanwhile, three journals in Germany *(Knee Surg Sports Traumatol Arthrosc, J Orthop Res, Arthroscopy)* and three journals in Japan *(Knee Surg Sports Traumatol Arthrosc, J Orthop Res, Clin Orthop Relat Res*), and one journal in MC *(J Orthop Res)*, but none in the UK were ranked in the top 10 high-impact journals.

Table 4. Top 10 most published orthopedics journals in the five countries

	USA	N	UK	N	Japan		Germany	N	MC	N
1	*CORR*	2789	*BJR*	981	*JOC*	856	*AOTS*	555	*Spine*	390
2	*Spine*	2088	*Injury*	547	*Spine*	677	*KSSTA*	351	*ESJ*	318
3	*JBJS*	1729	*JHS-E*	271	*ESJ*	269	*ESJ*	335	*Int Orthop*	283
4	*Orthopedics*	1657	*HIP INT*	263	*KSSTA*	267	*Int Orthop*	294	*Orthopade*	238
5	*AJSM*	1424	*Knee*	260	*JA*	228	*Injury*	240	*Orthopedics*	176
6	*JFAR*	1420	*ESJ*	237	*JHS-A*	213	*Spine*	205	*AOTS*	175
7	*SPINE J*	1166	*SR*	234	*AOTS*	206	*BMD*	186	*Injury*	152
8	*JHT*	1086	*BMD*	226	*JOR*	200	*JOR*	174	*JSDT*	124
9	*JAAOS*	914	*BJJ*	216	*CORR*	182	*AJSM*	155	*BMD*	113
10	*Arthroscopy*	902	*Int Orthop*	208	*JSDT*	177	*Arthroscopy*	136	*JOR*	88

AJSM, Am J Sports Med, IF = 4.362; AOTS, Arch Orthop Trauma Surg, IF = 1.597; Arthroscopy, IF = 3.206; BJJ, Bone Joint J, IF = 1.961; BJR, Bone Joint Res, IF = 1.64; BMD, BMC Musculoskelet Disord; IF = 1.717; CORR, Clin Orthop Relat Res, IF = 2.765; ESJ, Eur Spine J, IF = 2.066; Hip Int, IF = 0.756; Injury, IF = 2.137; Int Orthop, IF = 2.11; JA, J Arthroplasty, IF = 2.666; JAAOS, J Am Acad Orthop Surg, IF = 2.527; JBJS, J Bone Joint Surg Am, IF = 5.28; JFAR, J Foot Ankle Res, IF = 1.462; JHS-A, J Hand Surg Am, IF = 1.667; JHS-E, J Hand Surg Eur Vol, IF = 2.037; JHT, J Hand Ther, IF = 2; JOC, J Orthop Sci, IF = 0.941; JOR, J Orthop Res, IF = 2.986; JSDT, J Spinal Disord Tech, IF = 2.202; Knee, IF = 1.936; KSSTA, Knee Surg Sports Traumatol Arthrosc, IF = 3.053; Arthrosc, IF = 3.053; Orthopade, IF = 0.359; Orthopedics, IF = 0.962; Spine, IF = 2.297; SPINE J, IF = 2.426; SR, Skeletal Radiol, IF = 1.51.

Discussion

Our study compared the quantity and quality of scientific publications in the field of orthopedics from MC with the USA, UK, Japan, and Germany. These five countries had the largest scientific output in the world and were also the top five areas with the highest GDP.

In 2005, only 31 articles in orthopedics journals were from MC, and rapid growth in both absolute number and share of publications was observed from 2005 to 2014. The number of articles from MC in 2014 reached almost 25 times the quantity of 2005, and that number has

exceeded Germany and Japan since 2011, and is now quite close to that of the UK. An increase in R&D funding in addition to improved economic status has undoubtedly been the main reason for such progress in MC's output in scientific reports.

Well-designed, conducted, and reported RCTs represent the gold standard in evaluating healthcare intervention[11]. It is noteworthy that the number of RCTs from China has exceeded that of Japan in the last decade, indicating that a greater quantity of original work is coming out of China. Furthermore, our results also revealed that MC published more meta-analysis than the other four countries. In fact, a 10-fold increase in the number of orthopedic systematic reviews and/or meta-analysis was observed in the past ten years[12]. It is worth mentioning that though meta-analysis are secondary research, they provide one of the best tools for quality clinical evidence on very specific topics, and well-performed meta-analysis are the best evidence in the hierarchy of clinical evidence.

The IF for an academic journal is frequently used for measuring and comparing the influence of the journal. Journals with higher IF are generally considered to be more important and more influential[13,14]. We took IF as an objective parameter evaluating the quality of publications from each region. However, it is possible that articles published in journals with low IF may be excellent work, and the opposite situation could also happen. Thus, we further compared average number of citations of articles from each country. The data on cumulative and average IF is interesting in that it makes the point that while more publications came out of MC in recent years, this quantity did not change the average IF, which actually went down (Table 1). The data on total and average citations is actually also quite telling, as it shows that although MC has greatly increased its number of publications, the average number of citations per article is extremely low compared to the other countries (Table 2). The same result was found in publication status in the top 10 high-impact orthopedics journals. All this data indicates that orthopedics researchers from MC should be looking at improving the quality of their publications. Nevertheless, the very recent nature of the boom in publications from MC might also contribute to the low average number of citations from MC.

Some of the limitations with these articles should be addressed. First, we focused on publications only in the journals listed in the SCIE database "orthopedics" category; there may be some good orthopedics journals that were not included by SCIE. Second, some published articles in the journals included in our analysis may not be related closely to orthopedics, while some articles pertaining to orthopedics may have been published in some general journals that were not included in our study. Finally, we decided on the country of origin of a paper based on the affiliation of the first author, which was consistent with similar studies in other fields[15, 16], however, some of the articles may be international collaborative efforts. Therefore, the contributions of other countries were ignored.

Conclusion

The number and share of scientific research articles from Chinese authors are increasing every year. These numbers are now comparable to the UK, Japan, and Germany. However, the general quality of publications from MC is still in need of improvement. Of note and worth mentioning is the fact that articles from the UK, despite having the lowest average IF, have the highest average number of citations.

As the second largest economy in the world with a population of 1.3 billion, MC has great potential in the field of orthopedics. However, there is still room for considerable improvement on the part of researchers in MC to achieve their potential. The world will benefit from even better performance in the field of orthopedics research from China

Contributorship statement X-WD planned the study. Z-YM and L-Q researched and analyzed the data and wrote the manuscript. X-WD is the guarantor of this work and had full access to all the data in this study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Competing interests None.

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Figure Legends

Fig. 1A–B. The number (A) and share (B) of papers published in orthopedics journals from the top five most published countries.

Fig. 2. The number of papers of each different publication type (including RCTs, clinical trials, reviews, case reports, and meta-analysis) from different countries.

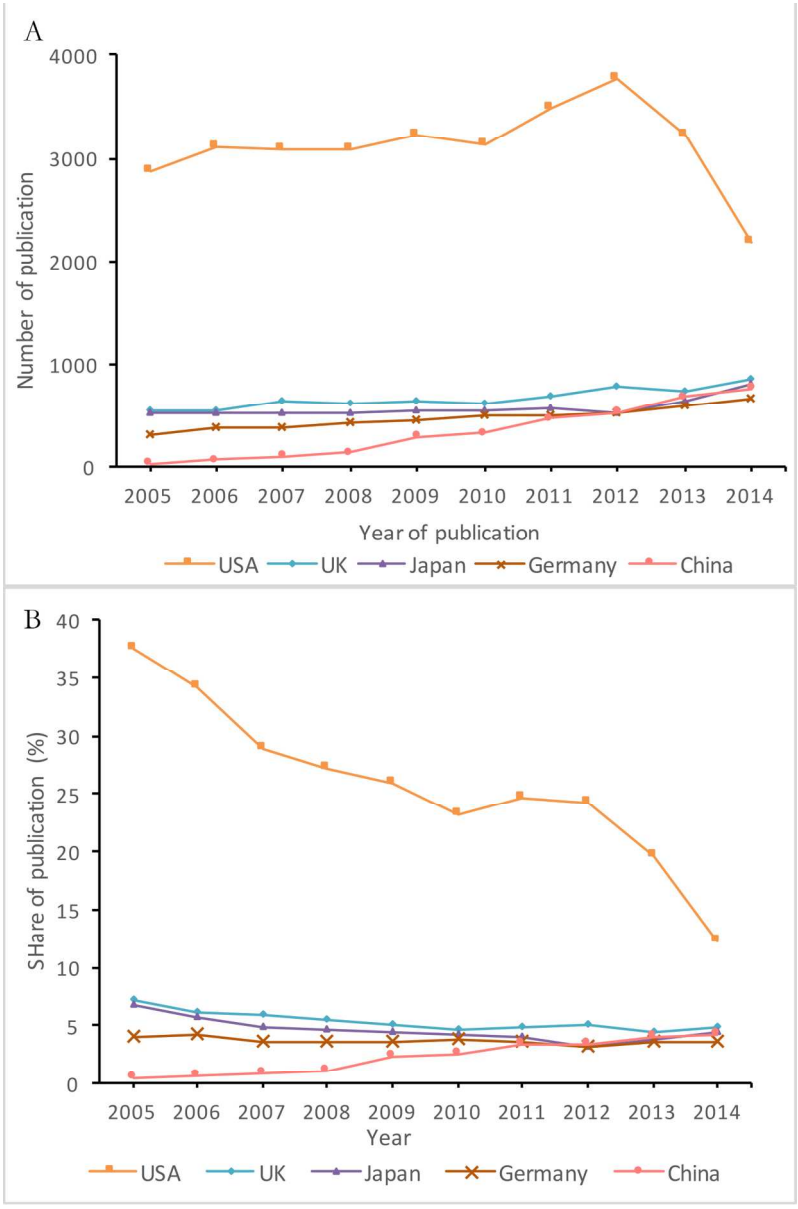

Fig. 1A–B. The number (A) and share (B) of papers published in orthopedics journals from the top five most published countries.

173x262mm (300 x 300 DPI)

Fig. 2. The number of papers of each different publication type (including RCTs, clinical trials, reviews, case reports, and meta-analysis) from different countries.

42x17mm (600 x 600 DPI)

	ISSN	Full Name	Abbreviated Journal Title	IF
1	0021-9355	JOURNAL OF BONE AND JOINT SURGERY-AMERICAN VOLUME	J BONE JOINT SURG AM	5.28
2	0363-5465	AMERICAN JOURNAL OF SPORTS MEDICINE	AM J SPORT MED	4.362
3	1063-4584	OSTEOARTHRITIS AND CARTILAGE	OSTEOARTHR CARTILAGE	4.165
4	1836-9553	JOURNAL OF PHYSIOTHERAPY	J PHYSIOTHER	3.708
5	0749-8063	ARTHROSCOPY-THE JOURNAL OF ARTHROSCOPIC AND RELATED SURGERY	ARTHROSCOPY	3.206
6	0942-2056	KNEE SURGERY SPORTS TRAUMATOLOGY ARTHROSCOPY	KNEE SURG SPORT TR A	3.053
7	0190-6011	JOURNAL OF ORTHOPAEDIC & SPORTS PHYSICAL THERAPY	J ORTHOP SPORT PHYS	3.011
8	0736-0266	JOURNAL OF ORTHOPAEDIC RESEARCH	J ORTHOP RES	2.986
9	1745-3674	ACTA ORTHOPAEDICA	ACTA ORTHOP	2.771
10	0009-921X	CLINICAL ORTHOPAEDICS AND RELATED RESEARCH	CLIN ORTHOP RELAT R	2.765
11	0966-6362	GAIT & POSTURE	GAIT POSTURE	2.752
12	0883-5403	JOURNAL OF ARTHROPLASTY	J ARTHROPLASTY	2.666
13	1067-151X	JOURNAL OF THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS	J AM ACAD ORTHOP SUR	2.527
14	0031-9023	PHYSICAL THERAPY	PHYS THER	2.526
15	1529-9430	SPINE JOURNAL	SPINE J	2.426
16	0362-2436	SPINE	SPINE	2.297
17	1058-2746	JOURNAL OF SHOULDER AND ELBOW SURGERY	J SHOULDER ELB SURG	2.289
18	1050-642X	CLINICAL JOURNAL OF SPORT MEDICINE	CLIN J SPORT MED	2.268
19	1536-0652	JOURNAL OF SPINAL DISORDERS & TECHNIQUES	J SPINAL DISORD TECH	2.202
20	0020-1383	INJURY-INTERNATIONAL JOURNAL OF THE CARE OF THE INJURED	INJURY	2.137
21	0341-2695	INTERNATIONAL ORTHOPAEDICS	INT ORTHOP	2.11
22	0940-6719	EUROPEAN SPINE JOURNAL	EUR SPINE J	2.066
23	1753-1934	JOURNAL OF HAND SURGERY-EUROPEAN VOLUME	J HAND SURG-EUR VOL	2.037
24	0894-1130	JOURNAL OF HAND THERAPY	J HAND THER	2
25	0268-0033	CLINICAL BIOMECHANICS	CLIN BIOMECH	1.97
26	2049-4394	BONE & JOINT JOURNAL	BONE JOINT J	1.961
27	0968-0160	KNEE	KNEE	1.936
28	0890-5339	JOURNAL OF ORTHOPAEDIC TRAUMA	J ORTHOP TRAUMA	1.803
29	1471-2474	BMC MUSCULOSKELETAL DISORDERS	BMC MUSCULOSKEL DIS	1.717
30	0363-5023	JOURNAL OF HAND SURGERY-AMERICAN VOLUME	J HAND SURG-AM	1.667
31	2046-3758	BONE & JOINT RESEARCH	BONE JOINT RES	1.64
32	0300-8207	CONNECTIVE TISSUE RESEARCH	CONNECT TISSUE RES	1.607

33	0936-8051	ARCHIVES OF ORTHOPAEDIC AND TRAUMA SURGERY	ARCH ORTHOP TRAUM SU	1.597
34	0364-2348	SKELETAL RADIOLOGY	SKELETAL RADIOL	1.51
35	1071-1007	FOOT & ANKLE INTERNATIONAL	FOOT ANKLE INT	1.506
36	0271-6798	JOURNAL OF PEDIATRIC ORTHOPAEDICS	J PEDIATR ORTHOPED	1.474
37	1757-1146	JOURNAL OF FOOT AND ANKLE RESEARCH	J FOOT ANKLE RES	1.462
38	1538-8506	JOURNAL OF KNEE SURGERY	J KNEE SURG	1.442
39	1749-799X	JOURNAL OF ORTHOPAEDIC SURGERY AND RESEARCH	J ORTHOP SURG RES	1.386
40	0749-0712	HAND CLINICS	HAND CLIN	1.259
41	1877-0568	ORTHOPAEDICS TRAUMATOLOGY SURGERY RESEARCH	ORTHOP TRAUMATOL-SUR	1.256
42	0030-5898	ORTHOPEDIC CLINICS OF NORTH AMERICA	ORTHOP CLIN N AM	1.252
43	0091-3847	PHYSICIAN AND SPORTSMEDICINE	PHYSICIAN SPORTSMED	1.085
44	0309-3646	PROSTHETICS AND ORTHOTICS INTERNATIONAL	PROSTHET ORTHOT INT	1.041
45	0147-7447	ORTHOPEDICS	ORTHOPEDICS	0.962
46	1413-3555	BRAZILIAN JOURNAL OF PHYSICAL THERAPY	BRAZ J PHYS THER	0.944
47	1305-8282	EKLEM HASTALIKLARI VE CERRAHISI-JOINT DISEASES AND RELATED SURGERY	EKLEM HAST CERRAHISI	0.944
48	0949-2658	JOURNAL OF ORTHOPAEDIC SCIENCE	J ORTHOP SCI	0.941
49	1067-2516	JOURNAL OF FOOT & ANKLE SURGERY	J FOOT ANKLE SURG	0.845
50	1120-7000	HIP INTERNATIONAL	HIP INT	0.756
51	1083-7515	FOOT AND ANKLE CLINICS	FOOT ANKLE CLIN	0.755
52	0934-6694	OPERATIVE ORTHOPADIE UND TRAUMATOLOGIE	OPER ORTHOP TRAUMATO	0.719
53	1053-8127	JOURNAL OF BACK AND MUSCULOSKELETAL REHABILITATION	J BACK MUSCULOSKELET	0.705
54	1022-5536	JOURNAL OF ORTHOPAEDIC SURGERY	J ORTHOP SURG-HONG K	0.701
55	2000-656X	JOURNAL OF PLASTIC SURGERY AND HAND SURGERY	J PLAST SURG HAND SU	0.695
56	1947-6035	CARTILAGE	CARTILAGE	0.694
57	0001-6462	ACTA ORTHOPAEDICA BELGICA	ACTA ORTHOP BELG	0.654
58	8750-7315	JOURNAL OF THE AMERICAN PODIATRIC MEDICAL ASSOCIATION	J AM PODIAT MED ASSN	0.654
59	0973-6042	INTERNATIONAL JOURNAL OF SHOULDER SURGERY	INT J SHOULDER SURG	0.647
60	0019-5413	INDIAN JOURNAL OF ORTHOPAEDICS	INDIAN J ORTHOP	0.64
61	1017-995X	ACTA ORTHOPAEDICA ET TRAUMATOLOGICA TURCICA	ACTA ORTHOP TRAUMATO	0.614
62	1060-152X	JOURNAL OF PEDIATRIC ORTHOPAEDICS-PART B	J PEDIATR ORTHOP B	0.594
63	0891-8422	CLINICS IN PODIATRIC MEDICINE AND SURGERY	CLIN PODIATR MED SUR	0.561
64	0744-6020	ORTHOPAEDIC NURSING	ORTHOP NURS	0.561
65	1864-6697	ZEITSCHRIFT FUR ORTHOPADIE UND UNFALLCHIRURGIE	Z ORTHOP UNFALLCHIR	0.494

66	0959-3020	ISOKINETICS AND EXERCISE SCIENCE	ISOKINET EXERC SCI	0.488
67	0001-5415	ACTA CHIRURGIAE ORTHOPAEDICAE ET TRAUMATOLOGIAE CECHOSLOVACA	ACTA CHIR ORTHOP TR	0.388
68	0085-4530	ORTHOPADE	ORTHOPADE	0.359
69	0932-0555	SPORTVERLETZUNG SPORTSCHADEN	SPORTVERLETZ SPORTSC	0.333
70	1297-3203	CHIRURGIE DE LA MAIN	CHIR MAIN	0.287
71	1413-7852	ACTA ORTOPEDICA BRASILEIRA	ACTA ORTOP BRAS	0.19
72	1268-7731	FOOT AND ANKLE SURGERY	FOOT AND ANKLE SURGERY	0
73	1757-7853	ORTHOPAEDIC SURGERY	ORTHOPAEDIC SURGERY	0

The publication date (print) and ISSN(print) were used in our search strategy in the PubMed database. The search terms were “USA[ad]”, “UK[ad]”, “Japan[ad]”, “Germany[ad]”,“ China [ad] NOT Taiwan[ad] NOT (Hong Kong)[ad]” AND “0001-5415 OR 1745-3674 OR 0001-6462 OR 1017-995X OR 1413-7852 OR 0363-5465 OR 0936-8051 OR 0749-8063 OR 1471-2474 OR 2049-4394 OR 2046-3758 OR 1413-3555 OR 1947-6035 OR 1297-3203 OR 0268-0033 OR 1050-64921X OR 0891-8422 OR 0300-8207 OR 1305-8282 OR 0940-6719 OR 1071-1007 OR 1083-7515 OR 1268-7731 OR 0966-6362 OR 0749-0712 OR 1120-7000 OR 0019-5413 OR 0020-1383 OR 0973-6042 OR 0341-2695 OR 0959-3020 OR 0883-5403 OR 1053-8127 OR 0021-9355 OR 1067-2516 OR 1757-1146 OR 0363-5023 OR 1753-1934 OR 0894-1130 OR 1538-8506 OR 0190-6011 OR 0736-0266 OR 0949-2658 OR 1022-5536 OR 1749-799X OR 0890-5339 OR 0271-6798 OR 1060-152X OR 1836-9553 OR 2000-656X OR 1058-2746 OR 1536-0652 OR 1067-151X OR 8750-7315 OR 0968-0160 OR 0942-2056 OR 0934-6694 OR 0085-4530 OR 0744-6020 OR 1757-7853 OR 1877-0568 OR 0030-5898 OR 0147-7447 OR 1063-4584 OR 0031-9023 OR 0091-3847 OR 0309-3646 OR 0364-2348 OR 0362-2436 OR 1529-

9430 OR 0932-0555 OR 1864-6697 OR 0301-620X". The publication date (print) was confined between January first, 2005 to December 31, 2014.

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Scientific research output in orthopedics from China and other top-ranking countries: A 10-year survey of the literature

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Scientific research output in orthopedics from China and other top-ranking countries: A 10-year survey of the literature

Yuming Zou[1] MD, Quan Li[1] MD, PhD, Weidong Xu[1] MD, PhD

1 Department of Orthopedics, Changhai hospital: The first affiliated hospital of the Second Military Medical University, Yangpu DIST, Shanghai, P.R. China

Yuming Zou and Quan Li contributed equally to this paper.

Yuming Zou: ymzousmmu@163.com

Quan Li: drliquan@126.com

Corresponding to Weidong Xu:

Postal address: Changhai Hospital of Second Military Medical University, Yangpu DIST, Shanghai, P.R. China

Email: xwdsmmu@163.com

Tel: +86-13901814702

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Abstract

Objectives: Orthopedics-related diseases and conditions are a significant burden worldwide. In this study we aimed to compare the quantity and quality of research output in the field of orthopedics from mainland China (MC), United States (USA), UK (United Kingdom), Japan, and Germany.

Setting: USA, UK, Japan, Germany, and MC

Participants: We selected orthopedics journals from the subject category "orthopedics" from the Science Citation Index Expanded (SCIE).

Outcome measures: The number of publications, the number of publications in the surveyed publication types, impact factor (IF), and citations from the corresponding country from 2005 to 2014 were collected for quantity and quality comparisons.

Results: A total of 128,895 articles were published worldwide in orthopedics-related journals from 2005 to 2014. The United States contributed the largest proportion (31,190 [24.20%]), followed by the United Kingdom (6703 [5.20%], Japan (5718 [4.41%]), Germany (4701 [3.66%]), and mainland China (3389 [2.63%]). Publications from MC represented the fewest but this quantity is rapidly increasing. The quantity of annual publications from MC has exceeded that of Germany since 2012. The USA occupies a predominant role in all kinds of publication types under investigation in the study, except in the category of meta-analysis. MC was in the last place for cumulative IFs, and the average IF actually decreased from the beginning of the study. For total and average citations, MC still lags behind the other countries in the study.

Conclusions: The USA has occupied the dominant place in orthopedics-related research for the last ten years. Although MC has made great progress in the number of published works in the field of orthopedics over the last ten years, the quality of these publishing efforts needs further improvement.

Trial registration: None

Strength and limitations of this study

1. Only journals listed in the Science Citation Index Expanded (SCIE) orthopedics category

were identified. Some other orthopedics-related journals not included in SCIE were not collected for this study.

2. Some articles pertaining to orthopedics that were published in some general journals were not included in our study.
3. The country of origin of an article was classified according to the affiliation of the first author, but some of the articles were efforts of international collaboration.
4. The top 10 high-impact journals were selected solely based on IF.

Introduction

Orthopedic diseases and conditions represent a significant burden worldwide. Globally, by 2013, two of the five leading causes of disability-adjusted life years were orthopedics related[1]. In China, musculoskeletal disorders accounted for 25.8% of the causes for which adults live with disability [2].

Over the last few decades, due to rapid improvement in the economy, MC's gross domestic spending on research and experimental development (R&D) has grown from $78.7 billion in 2005 to $317.8 billion in 2014, and now this spending is second only after the USA, according to estimates made by the Organization for Economic Cooperation and Development (OECD)[3]. Mainland China (MC) has made remarkable progress in the field of medicine. To a certain extent, the quantity and quality of scientific publications are measurable indexes of the research impact of an individual [4], and to a larger extent, a nation. As revealed by the Chinese Institute of Scientific and Technical Information in the *Statistical Data of Chinese S&T Papers 2013*[5], the USA, MC, Germany, Japan, and UK were the top five countries with the most scientific articles published. Articles have compared publications between MC, Hong Kong, and Taiwan in the field of orthopedics[6, 7]. However, little is known about the situation with regard to publication of scientific articles specifically in the field of orthopedics in MC compared with the other top-ranking countries for the period covering the last ten years.

In this study, we aimed to compare the contributions of mainland Chinese researchers

with contributions from the other top five most published countries in the field of orthopedics between the years 2005 and 2014, and to provide a more accurate measure to evaluate the development status of orthopedics in MC.

Methods

We included 73 orthopedics journals from the Orthopedics category of the Science Citation Index Expanded (SCIE) designed by Thomson Reuters[8].The full list of the journals, including the ISSN, full title, abbreviated journal title, and impact factors (IF) from 2014 included in our study is shown in the appendix. (See Electronic Supplementary Material 1.) All of the 73 journals in the orthopedics category, which could be retrieved by PubMed and Web of Science, cover resources on surgery and medical appliances as a means to preserve or restore function or alleviate pain in the musculoskeletal system, particularly the bones and joints. A computerized bibliographic retrieval was conducted on September 29, 2015 and the articles published in the 73 journals from the USA, UK, Japan, Germany, and MC between January 1, 2005 and December 31, 2014 were identified. Because the name of the *JBJS Br* journal was changed to *Bone Joint J* in 2013, articles from the journals with these two names were pooled together for this study. The entire retrieval and data extraction process was conducted in duplicate by two independent researchers (YM Zou and Q Li). Differences of opinion were solved though discussion, until agreement was reached. The full search strategy was included in the supplementary file. (See Electronic Supplementary Material 2.) Articles that showed the first author's affiliation (AD) with these five countries were considered as research outputs from the countries. The numbers of each specific type of article such as clinical trials, randomized controlled trials (RCTs), meta-analysis, reviews, and case reports were also identified according to the publication types generated by PubMed.

Three methods were used to evaluate the quality of articles. First, the cumulative and average IF were calculated according to *Journal Citation Reports* (JCR) 2014 published by Thomson Reuters[9]. Second, citation reports for the literature from each region were collected through Web of Science[10]. Third, the number of articles published in the top 10 high-impact

orthopedics journals (based on IF) were counted and the 10 most published orthopedics journals for each region (based on the number of publications) were also identified.

Statistical analysis

The non-parametric test for trend and time series analysis was performed using SPSS Version 13.0 (SPSS Inc., Chicago, IL, USA) to determine any significant change over the study period. The Kruskal–Wallis test was used to detect the differences among the five countries, and to rank-sum test between two countries if necessary. The test for significance was two-tailed and the value of $p < 0.05$ was considered significant.

Results

Total amount and share of publications

A total of 128, 895 articles were published worldwide between 2005 and 2014 in orthopedics-related journals. Overall, the USA contributed the largest proportion (31,190 [24.20%]), followed by the UK (6703 [5.20%], Japan (5718 [4.41%]), Germany (4701 [3.66%]), and China (3389 [2.63%]) (Figure 1). Despite such large publication numbers, the share of publication numbers attributed to the USA has decreased for the last 10 years. However, the total number and share of publications from MC increased significantly from 2005 to 2014 (31 to 768, respectively, $P < 0.01$, Figure 1A and 0.43% to 4.26%, respectively, $p < 0.01$, Figure 1B). From 2012 forward, the number of articles from MC has exceeded that of Germany.

Publication types

The number of different article types, which include RCTs, clinical trials, reviews, case reports, and meta-analysis published by each region, are shown in Figure 2. The USA accounts for the largest share and highest quality in all types of articles except meta-analysis. In the last decade, MC has published the largest number of meta-analysis among all five countries. In addition, MC had published more RCTs and reviews than Japan for the last 10 years in total.

Impact factors

Based on the *Journal Citation Reports* (JCR) 2014, we calculated the cumulative and average IF for each region in each year from 2005 to 2014. During the last decade, the total cumulative IFs were ranked in the following order: USA, Japan, UK, Germany, and MC; MC was listed in the last place ($p < 0.01$). According to the average IF calculation, the UK was lower than the USA （$p < 0.001$）, Germany ($p < 0.001$), Japan ($p = 0.003$), and MC ($p = 0.018$) for the past 10 years. No statistical differences were detected between MC and the USA ($p = 0.119$), Germany ($p = 0.055$), and Japan ($p = 0.534$). The details of cumulative and average IFs each year from each country are listed in Table 1.

Table 1. Cumulative and average IFs for articles from the five countries

Year	Cumulative IF					Average IF				
	USA	UK	Japan	Germany	MC	USA	UK	Japan	Germany	MC
2005	5865.896	1056.832	1089.882	634.944	78.716	2.047	1.929	2.112	2.116	2.385
2006	6425.466	1045.266	1120.177	831.133	140.899	2.061	1.883	2.114	2.199	2.168
2007	6482.460	1195.260	1103.435	848.391	222.186	2.094	1.853	2.138	2.215	2.314
2008	6262.057	1094.861	1072.712	893.142	303.679	2.024	1.777	2.039	2.142	2.266
2009	7880.583	1135.516	1154.643	910.234	506.102	2.447	1.769	2.073	2.073	1.763
2010	6636.580	1035.284	1123.844	1084.724	561.488	2.126	1.681	2.025	2.135	1.707
2011	8127.619	1136.579	1178.769	1071.755	852.724	2.339	1.645	2.072	2.144	1.814
2012	7885.948	1311.986	1279.197	1089.660	997.298	2.087	1.676	2.508	2.137	1.885
2013	7716.064	1359.962	1308.423	1275.919	1279.832	2.387	1.828	2.035	2.137	1.888
2014	5048.107	1708.500	1637.344	1524.299	1555.280	2.305	1.980	2.057	2.278	2.025
Total	68,330.780	12,080.046	12,068.426	10,164.201	6498.204	2.191	1.802	2.111	2.162	1.917

Citation reports

As shown in Table 2, the USA had the highest total citations and the UK had the highest average number of citations per article over the 10 years, while MC had the lowest total or average number of citations. However, citations to articles from MC grew rapidly from 2005

to 2011. By 2014, the gap between Japan, Germany, and MC was quite narrow. In fact, MC has exceeded Japan in annual citations since 2011.

Table 2. Total and average citations of articles from the five countries

Year	USA	UK	Japan	Germany	MC
2005	79,575	13,760	9455	9386	1348
2006	78,313	12,996	8943	11,592	1483
2007	71,782	13,202	7624	9287	1987
2008	62,347	13,924	6089	9619	2536
2009	54,476	10,722	5989	8886	3487
2010	45,068	9683	4892	8150	3275
2011	36,709	9954	4135	6303	4147
2012	27,476	7898	3380	4414	3683
2013	17,455	7447	2011	3234	2598
2014	8162	4913	1226	1405	1243
Total citations	481,363	104,499	53,744	72,276	25,787
Average citations	27.63	35.52	11.68	18.76	2.49

Top 10 high-impact orthopedics journals

The top 10 high-impact journals were selected according to their IFs in 2014. Articles from each region published in these journals from 2005 to 2014 were counted. Again, the USA (8820 articles) had the biggest share, far more than the combination of the other four countries. In addition, 28.4% of the articles from the USA were published in the top 10 high-impact journals, while only 13.7% from MC were published in those journals (Table 3). If journals that were closely related to physical therapy and with a small volume of publication (J Physiother and J Orthop Sports Phys Ther) were excluded and Spine (IF = 2.297) and J Arthroplasty (IF = 2.666), two highly influential journals, were included in the analysis, the percentage would have been 27.4% for MC, much higher than the previous result.

Table 3. Articles in the top 10 high-impact orthopedics journals from the five countries

Rank	Journal Title	2014 IF	USA	UK	Japan	Germany	MC
1	*J Bone Joint Surg Am*	5.280	1729	98	126	102	33
2	*Am J Sports Med*	4.362	1424	54	154	155	33
3	*Osteoarthritis Cartilage*	4.165	600	186	119	93	64
4	*J Physiother*	3.708	107	8	1	0	0
5	*Arthroscopy*	3.206	902	41	165	136	70
6	*Knee Surg Sports Traumatol Arthrosc*	3.053	309	195	267	351	88
7	*J Orthop Sports Phys Ther*	3.011	345	19	16	10	0
8	*J Orthop Res*	2.986	546	59	200	174	88
9	*Acta Orthop*	2.771	51	65	45	80	11
10	*Clin Orthop Relat Res*	2.765	2789	134	182	129	75
Total			8802	859	1230	1275	462
Divided by total article volume of each country (%)			28.40	14.88	22.06	27.54	13.76

Most published orthopedics journals

The details for the top 10 most published journals in each region were listed in Table 4. Four of the top 10 most published orthopedics journals in the USA (*Clin Orthop Relat Res, J Bone Joint Surg Am, Am J Sports Med, Arthroscopy*) were listed in the top 10 high-impact journals. Meanwhile, three journals in Germany *(Knee Surg Sports Traumatol Arthrosc, J Orthop Res, Arthroscopy)* and three journals in Japan *(Knee Surg Sports Traumatol Arthrosc, J Orthop Res, Clin Orthop Relat Res*), and one journal in MC *(J Orthop Res)*, but none in the UK were ranked in the top 10 high-impact journals.

Table 4. Top 10 most published orthopedics journals in the five countries

	USA	N	UK	N	Japan	N	Germany	N	MC	N
1	*CORR*	2789	*BJR*	981	*JOC*	856	*AOTS*	555	*Spine*	390

2	*Spine*	2088	*Injury*	547	*Spine*	677	*KSSTA*	351	*ESJ*	318
3	*JBJS*	1729	*JHS-E*	271	*ESJ*	269	*ESJ*	335	*Int Orthop*	283
4	*Orthopedics*	1657	*HIP INT*	263	*KSSTA*	267	*Int Orthop*	294	*Orthopade*	238
5	*AJSM*	1424	*Knee*	260	*JA*	228	*Injury*	240	*Orthopedics*	176
6	*JFAR*	1420	*ESJ*	237	*JHS-A*	213	*Spine*	205	*AOTS*	175
7	*SPINE J*	1166	*SR*	234	*AOTS*	206	*BMD*	186	*Injury*	152
8	*JHT*	1086	*BMD*	226	*JOR*	200	*JOR*	174	*JSDT*	124
9	*JAAOS*	914	*BJJ*	216	*CORR*	182	*AJSM*	155	*BMD*	113
10	*Arthroscopy*	902	*Int Orthop*	208	*JSDT*	177	*Arthroscopy*	136	*JOR*	88

AJSM, Am J Sports Med, IF = 4.362; AOTS, Arch Orthop Trauma Surg, IF = 1.597; Arthroscopy, IF = 3.206; BJJ, Bone Joint J, IF = 1.961; BJR, Bone Joint Res, IF = 1.64; BMD, BMC Musculoskelet Disord; IF = 1.717; CORR, Clin Orthop Relat Res, IF = 2.765; ESJ, Eur Spine J, IF = 2.066; Hip Int, IF = 0.756; Injury, IF = 2.137; Int Orthop, IF = 2.11; JA, J Arthroplasty, IF = 2.666; JAAOS, J Am Acad Orthop Surg, IF = 2.527; JBJS, J Bone Joint Surg Am, IF = 5.28; JFAR, J Foot Ankle Res, IF = 1.462; JHS-A, J Hand Surg Am, IF = 1.667; JHS-E, J Hand Surg Eur Vol, IF = 2.037; JHT, J Hand Ther, IF = 2; JOC, J Orthop Sci, IF = 0.941; JOR, J Orthop Res, IF = 2.986; JSDT, J Spinal Disord Tech, IF = 2.202; Knee, IF = 1.936; KSSTA, Knee Surg Sports Traumatol Arthrosc, IF = 3.053; Arthrosc, IF = 3.053; Orthopade, IF = 0.359; Orthopedics, IF = 0.962; Spine, IF = 2.297; SPINE J, IF = 2.426; SR, Skeletal Radiol, IF = 1.51.

Discussion

Our study compared the quantity and IF of scientific publications in the field of orthopedics from MC with the USA, UK, Japan, and Germany. These five countries had the largest scientific output in the world and were also the top five areas with the highest GDP.

In 2005, only 31 articles in orthopedics journals were from MC, and rapid growth in both absolute number and share of publications was observed from 2005 to 2014. The number of articles from MC in 2014 reached almost 25 times the quantity of 2005, and that number has exceeded Germany and Japan since 2011, and is now quite close to that of the UK. An increase in R&D funding in addition to improved economic status has undoubtedly been the

main reason for such progress in MC's output in scientific reports.

Well-designed, conducted, and reported RCTs represent the gold standard in evaluating healthcare intervention[11]. It is noteworthy that the number of RCTs from China has exceeded that of Japan in the last decade, indicating that a greater quantity of original work is coming out of China. Furthermore, our results also revealed that MC published more meta-analysis than the other four countries. In fact, a 10-fold increase in the number of orthopedic systematic reviews and/or meta-analysis was observed in the past ten years[12]. It is worth mentioning that though meta-analyses are secondary research, they provide one of the best tools for quality clinical evidence on very specific topics, and well-performed meta-analyses are the best evidence in the hierarchy of clinical evidence.

The IF for an academic journal is frequently used for measuring and comparing the influence of the journal. Journals with higher IF are generally considered to be more important and more influential[13,14]. We took IF as an objective parameter evaluating the quality of publications from each region. However, it is possible that articles published in journals with low IF may be excellent work, and the opposite situation could also happen. Thus, we further compared average number of citations of articles from each country. The data on cumulative and average IF is interesting in that it makes the point that while more publications came out of MC in recent years, this quantity did not change the average IF, which actually went down (Table 1). The data on total and average citations is actually also quite telling, as it shows that although MC has greatly increased its number of publications, the average number of citations per article is extremely low compared to the other countries (Table 2). The same result was found in publication status in the top 10 high-impact orthopedics journals. All this data indicates that orthopedics researchers from MC should be looking at improving the quality of their publications. Nevertheless, the very recent nature of the boom in publications from MC might also contribute to the low average number of citations from MC.

Some of the limitations with these articles should be addressed. First, we focused on publications only in the journals listed in the SCIE database "orthopedics" category; there may be some good orthopedics journals that were not included by

SCIE. Second, some published articles in the journals included in our analysis may not be related closely to orthopedics, while some articles pertaining to orthopedics may have been published in some general journals that were not included in our study. Finally, we decided on the country of origin of a paper based on the affiliation of the first author, which was consistent with similar studies in other fields[15, 16], however, some of the articles may be international collaborative efforts. Therefore, the contributions of other countries were ignored.

Conclusion

The number and share of scientific research articles from Chinese authors are increasing every year. These numbers are now comparable to the UK, Japan, and Germany. However, the general quality of publications from MC is still in need of improvement. Of note and worth mentioning is the fact that articles from the UK, despite having the lowest average IF, have the highest average number of citations.

As the second largest economy in the world with a population of 1.3 billion, MC has great potential in the field of orthopedics. However, there is still room for considerable improvement on the part of researchers in MC to achieve their potential. The world will benefit from even better performance in the field of orthopedics research from China

Contributorship statement X-WD planned the study. Z-YM and L-Q researched and analyzed the data and wrote the manuscript. X-WD is the guarantor of this work and had full access to all the data in this study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Competing interests None.

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Data sharing statement No additional unpublished data are available.

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Figure Legends

Fig. 1A–B. The number (A) and share (B) of papers published in orthopedics journals from the top five most published countries.

Fig. 2. The number of papers of each different publication type (including RCTs, clinical trials, reviews, case reports, and meta-analysis) from different countries.

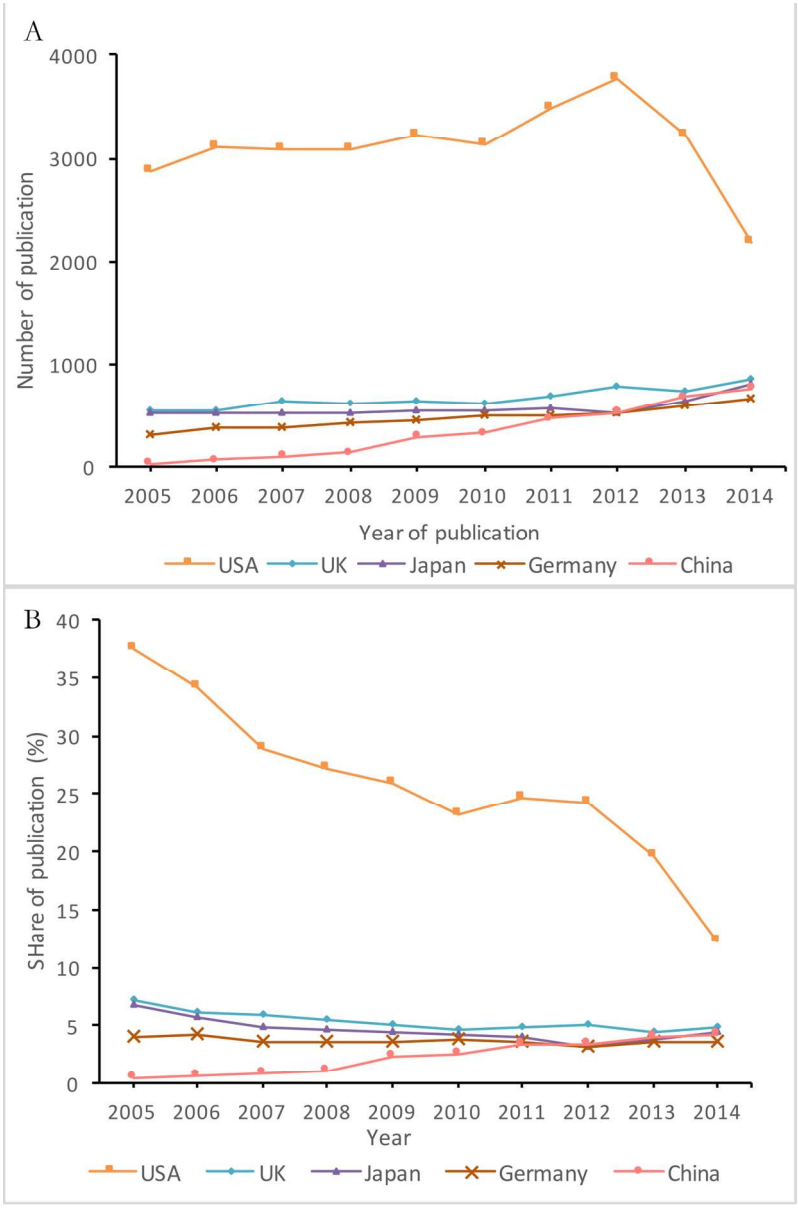

Fig. 1A–B. The number (A) and share (B) of papers published in orthopedics journals from the top five most published countries.

173x262mm (300 x 300 DPI)

Fig. 2. The number of papers of each different publication type (including RCTs, clinical trials, reviews, case reports, and meta-analysis) from different countries.

42x17mm (600 x 600 DPI)

	ISSN	Full Name	Abbreviated Journal Title	IF
1	0021-9355	JOURNAL OF BONE AND JOINT SURGERY-AMERICAN VOLUME	J BONE JOINT SURG AM	5.28
2	0363-5465	AMERICAN JOURNAL OF SPORTS MEDICINE	AM J SPORT MED	4.362
3	1063-4584	OSTEOARTHRITIS AND CARTILAGE	OSTEOARTHR CARTILAGE	4.165
4	1836-9553	JOURNAL OF PHYSIOTHERAPY	J PHYSIOTHER	3.708
5	0749-8063	ARTHROSCOPY-THE JOURNAL OF ARTHROSCOPIC AND RELATED SURGERY	ARTHROSCOPY	3.206
6	0942-2056	KNEE SURGERY SPORTS TRAUMATOLOGY ARTHROSCOPY	KNEE SURG SPORT TR A	3.053
7	0190-6011	JOURNAL OF ORTHOPAEDIC & SPORTS PHYSICAL THERAPY	J ORTHOP SPORT PHYS	3.011
8	0736-0266	JOURNAL OF ORTHOPAEDIC RESEARCH	J ORTHOP RES	2.986
9	1745-3674	ACTA ORTHOPAEDICA	ACTA ORTHOP	2.771
10	0009-921X	CLINICAL ORTHOPAEDICS AND RELATED RESEARCH	CLIN ORTHOP RELAT R	2.765
11	0966-6362	GAIT & POSTURE	GAIT POSTURE	2.752
12	0883-5403	JOURNAL OF ARTHROPLASTY	J ARTHROPLASTY	2.666
13	1067-151X	JOURNAL OF THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS	J AM ACAD ORTHOP SUR	2.527
14	0031-9023	PHYSICAL THERAPY	PHYS THER	2.526
15	1529-9430	SPINE JOURNAL	SPINE J	2.426
16	0362-2436	SPINE	SPINE	2.297
17	1058-2746	JOURNAL OF SHOULDER AND ELBOW SURGERY	J SHOULDER ELB SURG	2.289
18	1050-642X	CLINICAL JOURNAL OF SPORT MEDICINE	CLIN J SPORT MED	2.268
19	1536-0652	JOURNAL OF SPINAL DISORDERS & TECHNIQUES	J SPINAL DISORD TECH	2.202
20	0020-1383	INJURY-INTERNATIONAL JOURNAL OF THE CARE OF THE INJURED	INJURY	2.137
21	0341-2695	INTERNATIONAL ORTHOPAEDICS	INT ORTHOP	2.11
22	0940-6719	EUROPEAN SPINE JOURNAL	EUR SPINE J	2.066
23	1753-1934	JOURNAL OF HAND SURGERY-EUROPEAN VOLUME	J HAND SURG-EUR VOL	2.037
24	0894-1130	JOURNAL OF HAND THERAPY	J HAND THER	2
25	0268-0033	CLINICAL BIOMECHANICS	CLIN BIOMECH	1.97
26	2049-4394	BONE & JOINT JOURNAL	BONE JOINT J	1.961
27	0968-0160	KNEE	KNEE	1.936
28	0890-5339	JOURNAL OF ORTHOPAEDIC TRAUMA	J ORTHOP TRAUMA	1.803
29	1471-2474	BMC MUSCULOSKELETAL DISORDERS	BMC MUSCULOSKEL DIS	1.717
30	0363-5023	JOURNAL OF HAND SURGERY-AMERICAN VOLUME	J HAND SURG-AM	1.667
31	2046-3758	BONE & JOINT RESEARCH	BONE JOINT RES	1.64
32	0300-8207	CONNECTIVE TISSUE RESEARCH	CONNECT TISSUE RES	1.607

33	0936-8051	ARCHIVES OF ORTHOPAEDIC AND TRAUMA SURGERY	ARCH ORTHOP TRAUM SU	1.597
34	0364-2348	SKELETAL RADIOLOGY	SKELETAL RADIOL	1.51
35	1071-1007	FOOT & ANKLE INTERNATIONAL	FOOT ANKLE INT	1.506
36	0271-6798	JOURNAL OF PEDIATRIC ORTHOPAEDICS	J PEDIATR ORTHOPED	1.474
37	1757-1146	JOURNAL OF FOOT AND ANKLE RESEARCH	J FOOT ANKLE RES	1.462
38	1538-8506	JOURNAL OF KNEE SURGERY	J KNEE SURG	1.442
39	1749-799X	JOURNAL OF ORTHOPAEDIC SURGERY AND RESEARCH	J ORTHOP SURG RES	1.386
40	0749-0712	HAND CLINICS	HAND CLIN	1.259
41	1877-0568	ORTHOPAEDICS TRAUMATOLOGY SURGERY RESEARCH	ORTHOP TRAUMATOL-SUR	1.256
42	0030-5898	ORTHOPEDIC CLINICS OF NORTH AMERICA	ORTHOP CLIN N AM	1.252
43	0091-3847	PHYSICIAN AND SPORTSMEDICINE	PHYSICIAN SPORTSMED	1.085
44	0309-3646	PROSTHETICS AND ORTHOTICS INTERNATIONAL	PROSTHET ORTHOT INT	1.041
45	0147-7447	ORTHOPEDICS	ORTHOPEDICS	0.962
46	1413-3555	BRAZILIAN JOURNAL OF PHYSICAL THERAPY	BRAZ J PHYS THER	0.944
47	1305-8282	EKLEM HASTALIKLARI VE CERRAHISI-JOINT DISEASES AND RELATED SURGERY	EKLEM HAST CERRAHISI	0.944
48	0949-2658	JOURNAL OF ORTHOPAEDIC SCIENCE	J ORTHOP SCI	0.941
49	1067-2516	JOURNAL OF FOOT & ANKLE SURGERY	J FOOT ANKLE SURG	0.845
50	1120-7000	HIP INTERNATIONAL	HIP INT	0.756
51	1083-7515	FOOT AND ANKLE CLINICS	FOOT ANKLE CLIN	0.755
52	0934-6694	OPERATIVE ORTHOPADIE UND TRAUMATOLOGIE	OPER ORTHOP TRAUMATO	0.719
53	1053-8127	JOURNAL OF BACK AND MUSCULOSKELETAL REHABILITATION	J BACK MUSCULOSKELET	0.705
54	1022-5536	JOURNAL OF ORTHOPAEDIC SURGERY	J ORTHOP SURG-HONG K	0.701
55	2000-656X	JOURNAL OF PLASTIC SURGERY AND HAND SURGERY	J PLAST SURG HAND SU	0.695
56	1947-6035	CARTILAGE	CARTILAGE	0.694
57	0001-6462	ACTA ORTHOPAEDICA BELGICA	ACTA ORTHOP BELG	0.654
58	8750-7315	JOURNAL OF THE AMERICAN PODIATRIC MEDICAL ASSOCIATION	J AM PODIAT MED ASSN	0.654
59	0973-6042	INTERNATIONAL JOURNAL OF SHOULDER SURGERY	INT J SHOULDER SURG	0.647
60	0019-5413	INDIAN JOURNAL OF ORTHOPAEDICS	INDIAN J ORTHOP	0.64
61	1017-995X	ACTA ORTHOPAEDICA ET TRAUMATOLOGICA TURCICA	ACTA ORTHOP TRAUMATO	0.614
62	1060-152X	JOURNAL OF PEDIATRIC ORTHOPAEDICS-PART B	J PEDIATR ORTHOP B	0.594
63	0891-8422	CLINICS IN PODIATRIC MEDICINE AND SURGERY	CLIN PODIATR MED SUR	0.561
64	0744-6020	ORTHOPAEDIC NURSING	ORTHOP NURS	0.561
65	1864-6697	ZEITSCHRIFT FUR ORTHOPADIE UND UNFALLCHIRURGIE	Z ORTHOP UNFALLCHIR	0.494

66	0959-3020	ISOKINETICS AND EXERCISE SCIENCE	ISOKINET EXERC SCI	0.488
67	0001-5415	ACTA CHIRURGIAE ORTHOPAEDICAE ET TRAUMATOLOGIAE CECHOSLOVACA	ACTA CHIR ORTHOP TR	0.388
68	0085-4530	ORTHOPADE	ORTHOPADE	0.359
69	0932-0555	SPORTVERLETZUNG SPORTSCHADEN	SPORTVERLETZ SPORTSC	0.333
70	1297-3203	CHIRURGIE DE LA MAIN	CHIR MAIN	0.287
71	1413-7852	ACTA ORTOPEDICA BRASILEIRA	ACTA ORTOP BRAS	0.19
72	1268-7731	FOOT AND ANKLE SURGERY	FOOT AND ANKLE SURGERY	0
73	1757-7853	ORTHOPAEDIC SURGERY	ORTHOPAEDIC SURGERY	0

The publication date (print) and ISSN(print) were used in our search strategy in the PubMed database. The search terms were “USA[ad]”, “UK[ad]”, “Japan[ad]”, “Germany[ad]”,“ China [ad] NOT Taiwan[ad] NOT (Hong Kong)[ad]” AND “0001-5415 OR 1745-3674 OR 0001-6462 OR 1017-995X OR 1413-7852 OR 0363-5465 OR 0936-8051 OR 0749-8063 OR 1471-2474 OR 2049-4394 OR 2046-3758 OR 1413-3555 OR 1947-6035 OR 1297-3203 OR 0268-0033 OR 1050-64921X OR 0891-8422 OR 0300-8207 OR 1305-8282 OR 0940-6719 OR 1071-1007 OR 1083-7515 OR 1268-7731 OR 0966-6362 OR 0749-0712 OR 1120-7000 OR 0019-5413 OR 0020-1383 OR 0973-6042 OR 0341-2695 OR 0959-3020 OR 0883-5403 OR 1053-8127 OR 0021-9355 OR 1067-2516 OR 1757-1146 OR 0363-5023 OR 1753-1934 OR 0894-1130 OR 1538-8506 OR 0190-6011 OR 0736-0266 OR 0949-2658 OR 1022-5536 OR 1749-799X OR 0890-5339 OR 0271-6798 OR 1060-152X OR 1836-9553 OR 2000-656X OR 1058-2746 OR 1536-0652 OR 1067-151X OR 8750-7315 OR 0968-0160 OR 0942-2056 OR 0934-6694 OR 0085-4530 OR 0744-6020 OR 1757-7853 OR 1877-0568 OR 0030-5898 OR 0147-7447 OR 1063-4584 OR 0031-9023 OR 0091-3847 OR 0309-3646 OR 0364-2348 OR 0362-2436 OR 1529-

9430 OR 0932-0555 OR 1864-6697 OR 0301-620X". The publication date (print) was confined between January first, 2005 to December 31, 2014.