Comparative study of scientific publications in orthopedics journals originating from USA, Japan and China (2000-2012)

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ABSTRACT

PURPOSE: To compare orthopedics publications from USA, Japan and China.

METHODS: Scientific papers belong to ''Orthopedics'' category of Science Citation Index Expanded subject categories were retrieved from the "PubMed'' and ''Web of Knowledge'' online databases.

RESULTS: In the field of orthopedics, the annual number increased significantly from 2000 to 2012 in the three countries ($p<0.001$). The share of articles increased significantly in China, but decreased significantly in Japan and USA ($p<0.05$). In 2012, USA contributed 35.3% of the total world output in orthopedics field and ranked 1st; Japan contributed 5.9% and ranked 4th; China contributed 5.2% and ranked 5th. Publications from USA had the highest accumulated IFs and the highest total citations of articles (USA > Japan > China, $p<0.001$). Average IF from USA was much higher than Japan and China ($p<0.001$). USA published the most articles in the top ten orthopedics journals (USA (14355) > Japan (1702) > China (487), $p<0.01$).

CONCLUSION: Although China has undergone significant increase in annual number and percentage of scientific publication in orthopedics journals, it still lags far behind USA and Japan in the field of orthopedics in terms of quantity and quality.

Key words: Scientific Publication Indicators. Orthopedics. United States. Japan. China.

Introduction

The increasing incidence and prevalence of orthopedic disease has become a global public health challenge[1,2]. With more than 1.37 billion people, China is the world's largest and most populous country. In China, the overall prevalence of traumatic fracture, spine degeneration disease, osteoarthritis and osteoporosis is higher than 15%, and the total number of patients with acute and chronic orthopedic disease is estimated to be more than 200 million[3-5], which is larger than that of the USA[1,6]. More than 400,000 patients received joint replacement and spinal fusion surgery every year in China[5,7]. As a large and growing clinical problem, orthopedic diseases consume a considerable proportion of health care resources, and have posed large economic burdens on patients' families and the government[1,3]. In a word, orthopedic disease has become an important public health problem in China[4].

The study of scientific publications in a particular field, based on international bibliographic data, is one of the widely used methods to measure scientific achievement[8]. The development of "Pubmed" database and "Web of knowledge" online database[9], has improved the speed and precision of literature data collection and comparison. It is known that USA is the leading power in biomedical investigation and publications in most scientific disciplines[8]. Japan, as a neighboring country of China, is also among the top-ranking countries of scientific research[10]. In the past decades, we have witnessed remarkable development of China in scientific research, which ranks second in annual total number of scientific publications in the world since 2007, second only to the USA[11]. So far, little is known about China's scientific contribution in the field of orthopedics. This study aimed to evaluate the quantity and quality of scientific publications in the field of orthopedics in China in the new century (2000-2012), and to compare these with USA and Japan.

Methods

This retrospective study examined 65 journals related to orthopedics that were selected from the ''orthopedics systems'' category of the Science Citation Index Expanded (SCIE) for 2011[12]. This category included resources for the diagnosis and treatment of orthopedics diseases: general orthopedics publications, and specialized research on the musculoskeletal disorders, spine diseases, injury, arthroplasty, arthroscopy, hand surgery, sport medicine, traumatology, foot and ankle surgery, connective tissue diseases, osteoarthritis and physical therapy. Current orthopedics, Journal of the Neuromusculoskeletal System, Global Spine J, Chinese Journal of Spine and Spinal Cord were not indexed by Medline and were excluded from this study. Our search of the ''Pubmed'' and ''Web of knowledge'' database on May 20th, 2013 sought articles published in the 65 journals between January 1st 2000 and December 31th 2012 by researchers from USA, China and Japan[13]. The ISSN numbers of the journals were used to perform this search.

Scientific output from the three countries was identified using the authors' institutional affiliations. Original clinical trials, randomized controlled trials (RCT) and case reports were compiled using the publication type categories of the PubMed database. We used online database (US National Science Foundation[14], National Institution of Health[15], Nature Science Foundation of China[16], Japan Science and Technology Agency (JST) [17]), to retrieve information on government funding spending on scientific research.

Five methods were used to evaluate publication quality. Firstly, the accumulated and average IFs were determined using the ISI's 2011 Journal Citation Reports (JCR)[11]. Secondly, we quantified citations of articles written by researchers from the three countries. Thirdly, we calculated the number of Randomized Controlled Trials (RCT) and clinical trials, which were associated with a higher grade of evidence. Fourthly, the number of articles published by each country in the top 10 high-impact orthopedics journals was also compared. Fifthly, we determined the top 10 popular orthopedics journals for the three countries according to the number of articles published by each journal.

Statistical analysis

Statistical analysis were performed using SPSS 17.0 (SPSS, Chicago, IL). The linear regression analysis was performed to determine any significant change of the total numbers over the period of time. ''r'' means correlation coefficient. The Kruskal-Wallis test was used to detect differences among the three countries, and rank-sum tests were conducted for detecting the differences between two countries when necessary. The test for significance was two-tailed and $p<0.05$ was considered significant.

Results

Total number of scientific articles in USA, Japan and China

A total of 7,393,001 articles were published in the SCI-cited journals from 2000 to 2012 in the three countries; 30.07% of publications in the SCI-cited journals from 2000

to 2012 were from USA (4,996,002/16,615,643), 6.96% were from Japan (1,156,481/16,615,643) and 7.47% were from China (1,240,518/16,615,643). The annual number of published scientific articles increased significantly from 2000 to 2012 in USA (322,713 to 427,140, annual incremental rate =2.36%, r = 0.961, p < 0.001), Japan (82,234 to 89,383, annual incremental rate = 0.70%, r = 0.676, p = 0.011) and China (31,059 to 190,607, annual incremental rate=16.32%, r = 0.987, p < 0.001) (Figure 1).

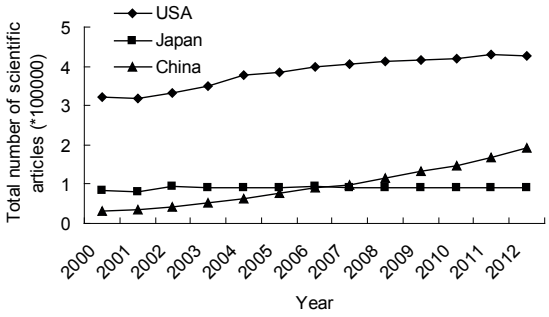

FIGURE 1 - Trends in annual numbers of scientific articles published by researchers from USA, Japan and China (2000–2012).

The number of scientific articles from China has exceeded that from Japan since 2007, and ranked second in the world thereafter (Figure 1). USA always ranked first in the production of scientific articles. The share of articles decreased significantly over time in USA (32.56% to 27.14%, annual incremental rate = -1.51%, r = 0.968, p < 0.001) and Japan (8.30% to 5.68%, annual incremental rate = -3.11%, r = 0.983, p < 0.001), but increased significantly over time in China (3.13% to 12.11%, annual incremental rate = 11.92%, r = 0.993, p < 0.001). The government funding spending on scientific research increased slowly in USA (21,000 to 38,290 million dollars, annual incremental rate =5.13%, r = 0.910, p < 0.001) and Japan (1,210 to 1,610 million dollars, annual incremental rate =2.41%, r = 0.896, p < 0.001), but increased rapidly in China (207 to 3,815 million dollars, annual incremental rate= 27.49%, r = 0.850, p < 0.001) (Figure 2).

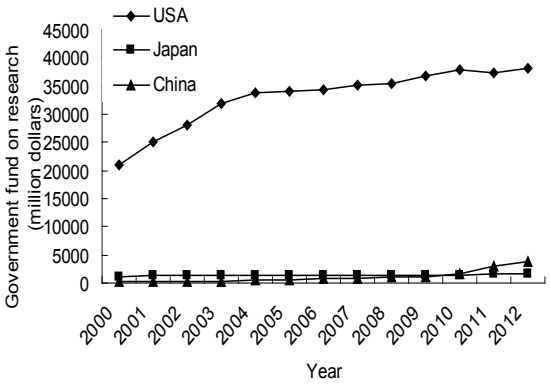

FIGURE 2 - Government fund spending on scientific research from USA, Japan and China (2000–2012).

Number of articles in the field of orthopedics in USA, Japan and China

A total of 52,290 articles were published in the 65 journals by the three countries from 2000 to 2012; 81.69%(42,714/52,290) of these were from USA, 12.98%(6,788/52,290) were from Japan and 5.33%(2,788/52,290) were from China. The annual number of published articles in the field of orthopedics increased significantly from 2000 to 2012 in USA (2,557 to 4,323, annual incremental rate= 4.47%, r = 0.980, p < 0.001), Japan (371 to 720, annual incremental rate= 5.68%, r =0.942, p < 0.001) and China (42 to 635, annual incremental rate = 25.40%, r = 0.908, p < 0.001) (Figure 3).

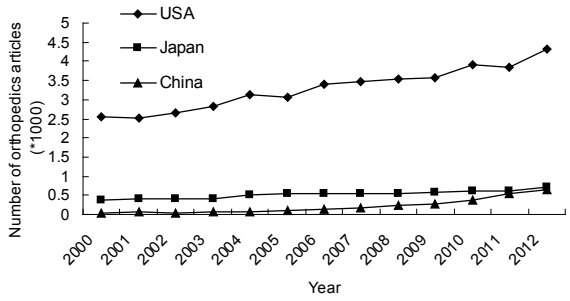

FIGURE 3 - Annual numbers of articles in the 65 orthopedics journals written by researchers from USA, Japan and China (2000–2012).

The share of articles increased significantly over time in China (0.67% to 5.19%, annual incremental rate= 18.57%, r = 0.923, p < 0.001), and decreased significantly in Japan (5.94% to 5.88%, annual incremental rate = -0.08%, r = -0.589, p = 0.034), and USA (40.94% to 35.33%, annual incremental rate = -1.22%, r = -0.882, p < 0.001) (Figure 4).

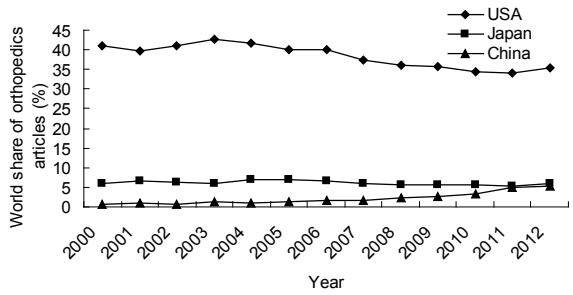

FIGURE 4 - Annual proportion of articles in the 65 orthopedics journals written by researchers from USA, Japan and China (2000–2012).

In 2012, USA contributed 35.3% of the total world output in orthopedics field and ranked 1st; Japan contributed 5.9% and ranked 4th; China contributed 5.2% and ranked 5th.

Clinical trials, randomized controlled trials and case reports (Figure 5)

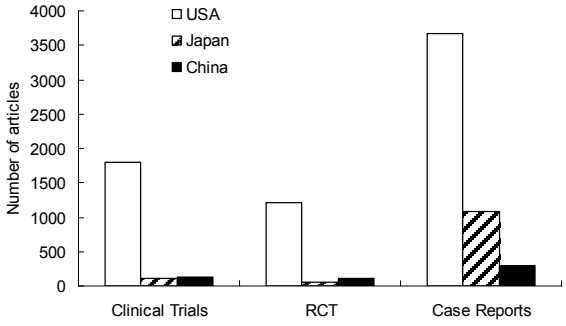

FIGURE 5 - Number of clinical trials, randomized controlled trials (RCT), and case reports published by researchers from USA, Japan and China (2000–2012).

Researchers from USA published 1806 clinical trials in orthopedics between 2000 and 2012, which far exceeded those from China (n= 121, $p < 0.001$) and Japan (n= 108, $p < 0.001$), surpassing the combined number of Japan and China. But there was no significant differences between Japan and China in the number of clinical trials ($p = 0.296$). Researchers from USA published more RCTs than those from Japan and China (USA(1219) > China(110) >Japan(59), all p values were less than 0.001, (Figure 5). The numbers of case reports from USA, China and Japan differed significantly (USA(3676) > Japan(1089) > China(298), all p values were less than 0.001) (Figure 5).

Impact factors

The impact factor (IF) indicates the average number of citations to articles in publications. According to the JCR, the 65 orthopedics journals had IF in 2011[11]. The accumulated IF of articles from USA were much higher than that of Japan and China (97,560.1 vs. 13,461.7 vs. 5,381.1, all p values were less than 0.001). The average IF of orthopedics articles from USA was much higher than that of Japan and China (2.29 vs. 1.99 vs. 1.82, $p < 0.001$), but there were no significant differences between Japan and China ($p = 0.067$, Table 1).

TABLE 1 - The accumulated and average impact factors of articles published in orthopedics journals by researchers from USA, Japan and China from 2000 to 2012

	Accumulated impact factor			Average impact factor		
Year	USA	Japan	China	USA	China	Japan
2000	5603.4	730.8	50.1	2.19	1.97	1.19
2001	5698.3	868.6	99.7	2.27	2.06	1.66
2002	6063.7	854.9	58.3	2.29	2.11	1.36
2003	6637.0	870.0	153.7	2.35	2.19	1.83
2004	7626.2	1030.8	151.7	2.45	2.02	1.92
2005	6998.5	1025.1	209.9	2.30	1.91	1.86
2006	7919.4	1049.4	250.9	2.34	1.91	1.99
2007	8011.7	1072.0	312.3	2.31	1.94	1.89
2008	8016.8	1048.9	482.0	2.27	1.95	2.05
2009	8029.8	1046.5	555.9	2.25	1.86	2.01
2010	8851.1	1266.2	778.0	2.27	2.02	2.01
2011	8358.6	1141.7	1046.1	2.18	1.90	1.93
2012	9745.6	1456.8	1232.5	2.25	2.02	1.94

Citations of articles published in orthopedics journals

Articles from USA were most cited (1,258,137 citations), followed by those from Japan (116,625 citations) and China (15,993 citations). These differences among the three countries were all significant ($p < 0.001$, Figure 6).

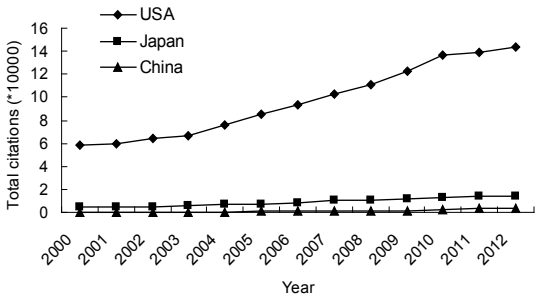

FIGURE 6 - Annual citations of articles published in orthopedics journals by researchers from USA, Japan and China (2000–2012).

Articles in the 10 top-ranking orthopedics journals

A total of 16,544 articles from the three countries were published in the 10 top-ranking orthopedics journals. Among them, 27.39% (4,532/16,544) were in the top three journals: Osteoarthr Cartilage, Am J Sport Med, Spine J. Researchers from USA published 14,355 (86.8%) articles in 10 high-impact orthopedics journals, those from Japan published 1,702 (10.3%) articles, and those from China published 487 (2.9%) articles (Table 2).

TABLE 2 - Articles published in the 10 highest-impact orthopedics journals by researchers from USA, Japan and China from 2000 to 2012.

Rank	Journal	2011IF	USA (%)	Japan (%)	China (%)	Total
1	OSTEOARTHR CARTILAGE	3.90	1467 (80.7)	279 (15.3)	72 (4.0)	1818
2	AM J SPORT MED	3.79	1771 (88.8)	191 (9.6)	33 (1.6)	1995
3	SPINE J	3.29	640 (89.0)	37 (5.1)	42 (5.9)	719
4	J BONE JOINT SURG AM	3.27	3908 (94.8)	172 (4.2)	43 (1.0)	4123
5	PHYS THER	3.11	1109 (97.9)	9 (0.8)	15 (1.3)	1133
6	ARTHROSCOPY	3.02	1551 (82.2)	255 (13.5)	81 (4.3)	1887
7	J ORTHOP SPORT PHYS	3.00	979 (97.4)	16 (1.6)	10 (1.0)	1005
8	J BONE JOINT SURG BR	2.83	373 (53.4)	273 (39.1)	52 (7.4)	698
9	J ORTHOP RES	2.81	1477 (78.4)	288 (15.3)	118 (6.3)	1883
10	J SHOULDER ELB SURG	2.75	1080 (84.2)	182 (14.2)	21 (1.6)	1283
Total			14355 (86.8)	1702 (10.3)	487 (2.9)	16544

Popular orthopedics journals

The journals that published the most articles written by researchers from the three countries are listed in Table 3.

TABLE 3 - The 10 orthopedics journals publishing the most articles written by researchers from USA, Japan and China.

Rank	USA (IF)	N	Japan (IF)	N	China (IF)	N
1	COR (2.53)	4081	SPINE (2.08)	944	SPINE (2.08)	415
2	SPINE	3992	JOS (0.84)	792	IO (2.03)	227
3	(2.08)	3908	COR (2.53)	365	ESJ (1.97)	210
4	JBJSA	2155	AOTS (1.37)	300	INJURY (1.98)	139
5	(3.27)	2050	JOR (2.81)	288	AOTS (1.37)	133
6	JHSA (1.35)	1792	OC (3.90)	279	JOR (2.81)	118
7	ORTH (2.66)	1771	JBJSB (2.83)	273	ORTH (2.66)	103
8	JA (2.38)	1477	JHSA (1.35)	271	COR (2.53)	97
9	AJSM (3.79)	1467	JA (2.38)	246	JHSA (1.35)	95
10	JOR (2.81)	1417	ARTH (3.02)	230	JA (2.38)	80
Total	OC (3.90)	24110		3988		1617
	JPO (1.16)					

COR: Clin Orthop Relat R, **JBJSA**: J Bone Joint Surg Am, **JHSA**: J Hand Surg Am, **ORTH**: Orthopedics, **JA**: J Arthroplasty, **AJSM**: Am J Sport Med, **JOR**: J Orthop Res, **OC**: Osteoarthr Cartilage, **JPO**: J Pediatr Orthoped, **JOS**: J Orthop Sci, **AOTS**: Arch Orthop Traum Su, **JBJSB**: J Bone Joint Surg Br, **ARTH**: Arthroscopy, **IO**: Int Orthop, **ESJ**: Eur Spine J.

Most articles from USA were published in Clin Orthop Relat R, most articles from China were published in Spine, and most articles from Japan were published in Spine. Clin Orthop Relat R, Spine, J Hand Surg AM, J Arthroplasty, J Orthop Res appeared among the 10 top popular journals for all three countries.

Discussion

USA, Japan and China are all major countries in the world in terms of population, economy and scientific research. As two of the most developed countries, USA and Japan have been leading global scientific research for many years. As a developing country, China has changed greatly in the past decades, with rapid development in education, urbanization, economy, and scientific research. The number of articles published in scientific journal is a reflection of research activity in a country[18,19]. Due to generous funding support and competitive research environments, USA leads all other countries in scientific publication productivity in the orthopedics field[20-22]. Although the annual number of published articles in the field of orthopedics increased in Japan with statistic significance ($p < 0.001$), the share of articles declined from 6.65% in 2001 to 5.32% in 2011 ($r= -0.598$, $p < 0.05$). However, there is no doubt that the Japan still plays an important role in the orthopedics field. With great increase in the number of researchers and research funding and more frequent international collaboration[23,24], the annual total number of scientific publications in China increased rapidly in the past decades and ranked second in the world since 2007. From 2000 to 2012, the government funding spending on scientific research increased rapidly in China (207 million dollars in 2000 to 3815 million dollars in 2012), with an annual incremental rate of 27.49% (Figure 2).

Our study demonstrated that the absolute number of Chinese articles in orthopedics journals had a 15-fold increase (from 42 papers in 2000 to 635 paper in 2012, $p < 0.001$), and the share of articles also increased significantly in China (from 0.67% in 2000 to 5.19% in 2012, $p < 0.001$). In orthopedics field, even in 2012 China only contributed 5.19% of the total world output and ranked 5th, lagging far behind USA (35.33%). That is to say, China remains one of the smaller players in the orthopedics field, with its share of total publications of 5.19%. There are many causes attributing to the low quantity of scientific publications in orthopedics field in China[25]. Firstly, the relatively low amount of government funding is a major reason. Government fundings on medical research account for more than 80% of the total fundings in USA. However, Chinese government fundings on medical research only account for 20-30% of the total government fundings. Secondly, the relative late initiation of this discipline is also an important reason. Orthopedics work in China started in early 60s, but it was not until the middle of the 1980s before it became an independent discipline and linked with the international orthopedics community[5]. Thirdly, unbalanced development between urban and vast rural areas in China is also an important cause. Although China has gained great achievement in economy in the past decades, most residents in the rural areas are still in poverty. More than 50% of the rural population cannot afford any kind of medical care[26,27]. So, orthopedics development is at a relatively low level in the rural areas, far from the modernization level to publish scientific articles in international journals. Fourthly, the use of English as the language of publication for most scientific publications is also a hard problem for Chinese researchers. And a lot of articles by Chinese authors are published in journals in Chinese.

Although IF is not an appropriate measure of the scientific quality of individual articles[28], it is still one of the most useful tools to evaluate the relative importance of scientific research[29]. The average IF of orthopedics articles from USA was much higher than that of Japan and China ($p < 0.001$), but there was no significant differences between Japan and China ($p > 0.05$), suggesting research quality is much better in USA. The phenomena may have something to do with the fact that most orthopedic doctors of China reside in metropolis of the coastal region, which has a higher education background than most of the rest of the country[5]. It is reported that the research output of China was mainly from four cities, Shanghai, Beijing, Nanjing and Guangzhou[25]. In summary, our comparison of publication quality using IF, citation index, number of clinical trails and number of articles published in the top 10 journals demonstrated that China still lagged far behind USA and Japan even at the end of the study period (2012).

There are some inherent limitations in this study. Firstly, the orthopedics journals were selected from the ‘‘orthopedics’’ category of Science Citation Index Expanded (SCIE) for 2011. The included journals have been changing year by year, although most of journals remained unchanged. In addition, some relevant journals were not included in the orthopedics category of the SCIE. Secondly, we limited the author’s affiliation to country names (USA, China, Japan), which would omit articles that did not designate country names. For some studies that were conducted in joint collaboration with other regions or countries, only affiliations of corresponding authors were included as the origin of research in the PubMed database, which neglected the contributions of other researchers from different geographic areas. Thirdly, in terms of

government funding for scientific research we only search the NIH and NSF for USA, JST for Japan and NSFC for China[26-29]. As we know, every country has different government funding distribution system, it was impossible to search fundings from Ministry of Health, Ministry of Education, Ministry of Science and Technology, local governments at all levels. Although we only statistically evaluated the national government scientific funding, the trend and amount was still comparable and believable. Fourthly, the accumulated IF and the average IF were evaluated by utilizing the IFs of JCR 2011. In the past decade, the IFs of the journals had changed year by year. Therefore, the accumulated IF and average IF reported in this study is only estimation, but it is likely to reflect the trend since the alteration of IF is relatively slight for most journals in the past decade. However, despite these limitations, we believe that the results in this study are likely to reflect the real situation of orthopedics research in USA, Japan and China.

Conclusions

As a developing country, China has made progress significantly in scientific publication since the new century, exceeded Japan and ranked second in the world since 2007. In the field of orthopedics, China has made a remarkable progress in annual number and percentage of scientific publication in the past 13 years (2000-2012). The results of this study also imply that China still lags far behind USA and Japan in this field. The quantity and quality of orthopedics articles need to be improved and effective measures should be taken for China to promote scientific research in the orthopedics field.

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