Review

Tracing scientific outputs in the osteoarthritis research field in China based on publications in the Web of Science

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SUMMARY
Objective: To evaluate and identify osteoarthritis (OA) study trends in China based on bibliometrics.
Methods: In the core database of Web of Science™, we used a common search method and “osteoarthritis” as the keyword to search for articles, and we analyzed the relevant literature published from 2014 to 2018. The included items were indexed according to the countries of publication, document types, organizations, publication years and conference titles. The characteristics of the OA studies conducted in China and the United States (U.S.) were compared according to the following aspects: h-index, average number of citations per item, total number of times cited and number of cited articles. We used Excel 2007 for data analysis.
Results: A total of 3603 publications on OA in China, with the number of publications increasing annually, were retrieved from the database. While Chinese institutes were ranked second in the world in terms of the number of OA studies published, the average number of citations per article and h-indexes of the Chinese studies were far below those of the articles from the U.S., as they were 7.51 versus 9.15, respectively, and 45 versus 82, respectively. OA research in China mostly originates from universities. OA researchers in China prefer to publish their studies in specialized journals and conferences.
Conclusion: Although large advances in OA research have been developed in China over the past 5 years, a large amount of effort is still required to improve the research quality, influence and novelty in the field of OA.

1. Introduction

Osteoarthritis (OA) is one of the most common chronic joint diseases and can involve the hip, knee, ankle, hand and spine [1]. The major clinical manifestations include pain and dysfunction, which can seriously affect the quality of life of patients and may even lead to an increase in all-cause mortality [2]. With the aging of the global population, the incidence of OA is increasing yearly [3]. Ma [4] et al. evaluated the incidence, prevalence, cost and functional impact of eight common diseases in the United States. The results showed that OA and low back pain were the most prevalent diseases and symptoms affecting health, and the incidence of these conditions were relatively high. However, it is difficult to determine the overall incidence or morbidity of OA because of the various joint sites and populations involved [5]. For knee OA in China, epidemiological investigations and information provided by the public database show that the prevalence of symptomatic knee osteoarthritis of the knee joint in China is 8.1%, and there are regional differences [6–8].

It is necessary to sufficiently address OA research. Current research studies on OA are related to many aspects, such as morbidity, etiology, prognostic factors, disease typing, diagnosis and treatment [9], which suggests that (1) OA is a disease of clinical concern and (2) there are still many unsolved problems.

This study uses bibliometrics to search the Web of Science (Thomson Reuters, USA) Core Collection. The identified documents were indexed according to author’s country, conference name, document type, author's affiliation, publication year and publication source name. The h-index [10], citation frequency and average citation frequency of published literature were used as descriptive statistics to compare the quality of studies between China and the United States. By analyzing the quantity and quality of the articles published in the OA research field in China as well as comparing the characteristics of highly cited research articles in China with those in the United States, this paper provides suggestions for future research in the field of OA in China.

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2. Methods

2.1. Data source

Web of Science [11] is an online subscription-based scientific citation indexing service that is maintained by Thomson Reuters (New York, NY, USA). It allows citations to be searched in multiple databases that reference cross-disciplinary research and enables an in-depth exploration of specialized subfields [12]. The keyword “Osteoarthritis” was used to identify papers for the purposes of this review. To include all published items, we used the basic search method. The retrieval period was from Jan. 1st 2013 to Dec. 31st, 2018 and this period was considered to be sufficient to retrieve a large number of articles. This review is concerned with all types of papers on OA: articles, reviews, editorial materials, and news items, etc. The retrieved papers were assessed using the following criteria: (1) publication year, (2) document type, (3) language(s), (4) countries/territories, (5) institution(s), (6) author(s), (7) research field, (8) journal of publication, and (9) number of citations. The search was performed on Aug. 10th, 2019.

2.2. Data analysis

The analyses were performed using the “analysis results” in Web of Science and the statistics function in Microsoft Office Excel 2007. Through the “create citation report” function in the database, descriptive statistics were calculated for the h-index, citation frequency and average citation frequency of the published literature. China and the US were compared in terms of (1) the number of articles published, (2) the average citation frequency, (3) the h-index, and (4) the highly cited studies. The results of the analyses are displayed in figures and tables at the end of this paper.

3. Results

3.1. Changes in the number and ranking of articles published in the field of OA in China between 2014 and 2018

A total of 32,538 research papers on OA topics were retrieved, and 132 countries/regions participated in OA research worldwide (Fig. 1A). Based on these studies, scholars from the United States (the US) published the largest number of articles (9775), followed by China (3603), England (3038), Germany (2215), Australia (2115), Canada (2061), Japan (1795), Netherlands (1709), Italy (1308) and France (1295) (Table 1). Over the past five years, the number of articles published in the field of OA in China has increased yearly, from 408 in 2014 to 1026 in 2018. The trend is similar in the US (Fig. 1B). The number of articles published by other countries has not increased significantly in the past five years; however, it is in a state of fluctuation (Fig. 1B). In addition, the increase in the number of articles published on OA in China is more

![Fig. 1. Osteoarthritis (OA) related articles in world and in China from 2014 to 2018 in the Web of Science Core Collection Database. A: The heat map showing the distribution of OA publications in world. B: The number of articles published in the field of OA in top 10 countries C: The growth trend of the number of published articles is more obvious than that in the United States. D: The total citation frequency of OA articles in China and the United States.](image-url)
dramatic than that in the United States. The number of articles published in China in 2018 is 2.52 times that in 2014, while the number of articles published in the United States in 2018 is 1.30 times that in 2014 (Fig. 1C).

3.2. Changes in the citation frequency of Chinese OA papers and the comparison with that of the United States between 2014 and 2018

Over the past five years, the number of citations of Chinese OA papers has gradually increased from 166 in 2014–9360 in 2018, and the trend is similar to that in the US (Fig. 1D). The h-index, average number of citations per year, total number of times cited (including and excluding self-citations) and number of cited articles (including and excluding self-citations) in American OA research studies were higher than those in studies published in China (Table 2). The total number of citations in China in 2018 was 56.3 times that in 2014, while the number of articles published in the United States in 2018 was 31.6 times that in 2014 (Fig. 1D).

3.3. Characteristics of highly cited articles on OA in China and the United States between 2014 and 2018

The topics, types, names of source journals and total citation frequencies of the top 10 papers on highly cited OA studies in China and the United States are shown in Table 3. The highly cited articles by Chinese authors included 5 basic science studies and 5 reviews. Five of the 10 studies in the United States were epidemiological studies, and three were guidelines.

3.4. The difference in research categories and article types worldwide and in China

Worldwide, there were 166 categories of OA research articles, among which orthopedics (12,031, 36.97%), rheumatology (8205, 25.21%), surgery (3609, 11.09%), sport sciences (3438, 10.56%), and medicine research experiments (1643, 5.05%) were the most common areas (Fig. 2A). In this regard, the categories of the Chinese research articles on OA were different from those of the articles published worldwide; the categories of the Chinese articles included medicine research experiments (705, 19.57%), orthopedics (679, 18.85%), rheumatology (542, 15.04%), cell biology (345, 9.58%) and biochemistry molecular biology (282, 7.83%) (Fig. 2B). As shown in Fig. 2C, China’s OA research output in the literature consisted mainly of articles, followed by reviews and meeting abstracts.

3.5. Main institutions, source journals & meetings that published most studies of OA research in China

Colleges and universities are still the main publishing institutions in the OA research field in China. The top three universities are Shanghai Jiaotong University, Peking University and Xi’an Jiaotong University (Table 4).

According to the publishing journals of Chinese OA research, OSTE-OARTHRITIS and CARTILAGE published most of the articles on OA, followed by comprehensive open access journals (Fig. 2D). However, among the countries from which articles published in the top ten magazines in the world originated, China ranked last among the top five countries overall (Table 5). As is shown in Table 6, The World Congress of The Osteoarthritis Research Society International (OARSI) annual conference published most meeting abstracts from Chinese scholars (103 abstracts); followed by CONGRESS OF THE EUROPEAN LEAGUE AGAINST RHEUMATISM, EULAR (7 abstracts), and ANNUAL MEETING OF THE AMERICAN SOCIETY FOR BONE AND MINERAL RESEARCH (5 abstracts). In the US, the largest number of contributions to meeting abstracts also came from the OARSI conference (403 abstracts), accounting for 4.12% of all the abstracts published in the OA conference in the United States.

4. Discussion

4.1. Current scenarios

This study evaluated the development of OA research in China over the past five years by searching the Web of Science core collection database and preliminarily compared the research in China and the US. The bibliometric method, that is, the method of indexing published documents and analyzing and identifying research directions and commonly studied topics through the Web of Science core collection database, has become an established research method [13,14]. And we believe that the research strategy based on this method has high reliability and feasibility and that the results can provide some theoretical support for an accurate analysis of the current situation and commonly studied OA research topics in China.

While the number of publications demonstrates the quantity of research studies, the evaluation of research quality and its influence is mainly assessed by the average number of citations and h-index, which reflect the average impact of the research. The h-index is more effective than other measures in quantifying academic output and academic influence [10].

In the Web of Science core collection database, the number of articles published in the field of OA in China has increased each year, and China is now ranked second in the world for the highest number of articles on OA. The number of articles published in China in 2018 is 2.52 times that in 2014, while the number of articles published in the United States in 2018 is 1.30 times that in 2014 (Fig. 2B). Additionally, the total number of citations in China in 2018 was 56.0 times that in 2014, while the number of articles published in the United States in 2018 was 31.6 times that in 2014 (Table 2). These numbers can also demonstrate an improvement in the quantity and quality of Chinese scholars on OA, but there are still differences and gaps between China and the US. The results also show that the average number of citations and h-index of Chinese articles are 7.39 and 45, which are much smaller than those of the US, which are 8.96 and 81, respectively.

From the source journals of Chinese OA research papers, most scholars choose comprehensive open access journals with a relatively weak influence [15], such as the INTERNATIONAL JOURNAL OF CLINICAL AND EXPERIMENTAL MEDICINE, MOLECULAR MEDICINE REPORTS and PLOS ONE. As shown in Table 4, Chinese scholars have not published as many articles as scholars from other countries (the US, England, Germany, etc.) in journals with high impact factors (IFs), such as ANNALS OF THE RHEUMATIC DISEASES (IF 14.299), ARTHRITIS RHEUMATOLOGY (IF 9.002), and AMERICAN JOURNAL OF SPORTS MEDICINE (IF 6.093).

Table 2
Comparison of the quantity and quality of articles published in OA between China and the United States from 2014 to 2018 in the Web of Science Core Collection Database.

| Country | Total publication | h-index | Average citations per item | Sum of Times Cited | Sum of Times Cited (Without self citations) | Citing articles | Citing articles (Without self citations) |
|---------|------------------|---------|---------------------------|-------------------|---------------------------------------------|----------------|----------------------------------------|
| USA     | 9775             | 82      | 9.15                      | 89400             | 74455                                       | 50832          | 46231                                  |
| China   | 3603             | 45      | 7.52                      | 27107             | 22975                                       | 19025          | 17437                                  |
### Table 3
The top ten papers about OA with high citation participated by Chinese and US scholars from 2014 to 2018 in Web of Science core collection database.

| Chinese Title                                                                 | Source Title               | Document Types | Total Citations | USA Title                                                                 | Source Title               | Document Types | Total Citations |
|--------------------------------------------------------------------------------|----------------------------|----------------|-----------------|--------------------------------------------------------------------------|----------------------------|----------------|-----------------|
| 1 Circular RNA Related to the Chondrocyte ECM Regulates MMP13 Expression by Functioning as a MiR-136 'Sponge' in Human Cartilage Degradation | SCIENTIFIC REPORTS Basic Research | 86             |                 | Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013 | LANCET Epidemiology | Guideline | 1931            |
| 2 Implant-derived magnesium induces local neuronal production of CGRP to improve bone-fracture healing in rats | NATURE MEDICINE Basic Research | 85             |                 | OARSI guidelines for the non-surgical management of knee osteoarthritis | OSTEOARTHRITIS AND CARTILAGE Guideline | 832            |                 |
| 3 Functionalized TiO2 Based Nanomaterials for Biomedical Applications | ADVANCED FUNCTIONAL MATERIALS Basic Research | 72             |                 | CDC Guideline for Prescribing Opioids for Chronic Pain - United States, 2016 | MMWR RECOMMENDATIONS AND REPORTS Guideline | 633            |                 |
| 4 Metabolic triggered inflammation in osteoarthritis | ADVANCED FUNCTIONAL OSTEOARTHRITIS AND CARTILAGE Review | 69             |                 | The global burden of hip and knee osteoarthritis: estimates from the Global Burden of Disease 2010 study | JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION Epidemiology | 602            |                 |
| 5 Current research on pharmacologic and regenerative therapies for osteoarthritis | BONE RESEARCH Review | 62             |                 | Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015 | ANNALS OF THE RHEUMATIC DISEASES Epidemiology | 480            |                 |
| 6 Osteoarthritis: toward a comprehensive understanding of pathological mechanism | BONE RESEARCH Review | 50             |                 | Health Effects of Overweight and Obesity in 195 Countries over 25 Years | LANCET Epidemiology | 354            |                 |
| 7 Long Noncoding RNA Related to Cartilage Injury Promotes Chondrocyte Extracellular Matrix Degradation in Osteoarthritis | ARTHRITIS & RHEUMATOLOGY Basic Research | 58             |                 | Effect of Structured Physical Activity on Prevention of Major Mobility Disability in Older Adults The LIFE Study Randomized Clinical Trial Pharmacological Management of Obesity: An Endocrine Society Clinical Practice Guideline | NEW ENGLAND JOURNAL OF MEDICINE Clinical Research | 399            |                 |
| 8 Circulating C reactive protein in osteoarthritis: a systematic review and meta-analysis | ANNALS OF THE RHEUMATIC DISEASES Review | 60             |                 | A large genome-wide association study of age-related macular degeneration highlights contributions of rare and common variants Repair and tissue engineering techniques for articular cartilage | JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION Guideline | 257            |                 |
| 9 Bone-cartilage interface crosstalk in osteoarthritis: potential pathways and future therapeutic strategies | OSTEOARTHRITIS AND CARTILAGE Review | 64             |                 | | JOURNAL OF CLINICAL ENDOCRINOLOGY & METABOLISM Epidemiology | 232            |                 |
| 10 Exosomes derived from miR-140-5p-overexpressing human synovial mesenchymal stem cells enhance cartilage tissue regeneration and prevent osteoarthritis of the knee in a rat model | THERANOSTICS Basic Research | 43             |                 | | NATURE REVIEWS RHEUMATOLOGY Review | 233            |                 |

By comparing the top 10 cited articles from Chinese and American scholars, we found that half of the articles in China are systematic reviews and basic science research articles, which is consistent with the idea that Chinese scholars value basic research. The types of highly influential research in the clinical field in the United States are guidelines and epidemiological studies. The total number of citations of the top 10 cited articles are not comparable to those of the top 10 cited articles in the US.

### 4.2. Future implications

China has a large population and a high prevalence of OA [16]. With the progression of population aging in China [17], OA will lead to a large disease burden in China in the future [18]. Clinic-oriented and patient-centered translational medicine should be a future focus of research in China [19]. Translational research should be encouraged and enhanced. Through advancements in translational medicine [20],...
scholars and associated administrative departments from the country should aim to shorten the process of translating basic research to clinical applications and promote the use of new technologies, drugs, and therapies for patients.

At the same time, with developments in society and changes in people’s life-styles, the health industry has attracted attention worldwide. The traditional medical model also needs to gradually transition from the “treatment prioritized” model to the “prevention prioritized” model [21], which is in accordance with the “to prevent and treat diseases before it arises” [22] principle in traditional Chinese medicine. In recent years, Chinese governments have completed many tasks in this direction [23]; for example, they have established a medical insurance system covering urban and rural residents [24], increased the standard of medical insurance subsidies each year, and promoted the reform of county-level public hospitals, which have greatly improved the level of medical and health services.

Regarding OA treatment, primary care in particular is suboptimal [25] and requires more attention. A large number of clinical practice guidelines have recommended core treatments, namely, educational courses, weight loss programs and exercise therapy [26]. All these interventions should be initiated at the primary care phase but not at a tertiary hospital, which is where they are initiated in China [27]. Patient

Table 4
The top 10 organizations in China that published papers on OA between 2014 and 2018, indexed in the Web of Science (Total Articles 3603).

| Rank | Organizations               | Record Count | % of total publications |
|------|----------------------------|--------------|-------------------------|
| 1    | SHANGHAI JIAO TONG UNIV    | 224          | 6.217                   |
| 2    | PEKING UNIV                | 183          | 5.079                   |
| 3    | XI AN JIAO TONG UNIV       | 159          | 4.413                   |
| 4    | SICHUAN UNIV               | 155          | 4.302                   |
| 5    | CENT S UNIV                | 146          | 4.052                   |
| 6    | SOUTHERN MED UNIV          | 143          | 3.969                   |
| 7    | ZHEJIANG UNIV              | 137          | 3.802                   |
| 8    | SHANDONG UNIV              | 118          | 3.275                   |
| 9    | SUN YAT SEN UNIV           | 108          | 2.946                   |
| 10   | NANJING MED UNIV           | 95           | 2.637                   |

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Table 5
Number of publications in Top 10 journals from Top 5 regions on OA between 2014 and 2018, indexed in the Web of Science.

| Rank | Journal                                   | 2018 IF | USA (%) | China (%) | UK (%) | Germany (%) | Australia (%) | Total |
|------|------------------------------------------|---------|---------|-----------|--------|-------------|---------------|-------|
| 1    | OSTEOARTHRITIS AND CARTILAGE             | 4.879   | 1156    | 236       | 432    | 226         | 403           | 3268  |
| 2    | ANNALS OF THE RHEUMATIC DISEASES         | 14.299  | 181     | 164       | 107    | 82          | 76            | 1106  |
| 3    | ARTHRITIS RHEUMATOLOGY                   | 9.062   | 538     | 372       | 72     | 224         | 166           | 941   |
| 4    | KNEE SURGERY SPORTS TRAUMATOLOGY ARTHROSCOPY | 3.149 | 111 | 12 | 12 | 12 | 12 | 577 |
| 5    | JOURNAL OF ARTHROPLASTY                  | 3.524   | 272     | 180       | 20     | 14          | 14            | 555   |
| 6    | OSTEOPOROSIS INTERNATIONAL                | 3.819   | 31      | 10        | 65     | 11          | 24            | 533   |
| 7    | BMC MUSCULOSKELETAL DISORDERS            | 2.002   | 112     | 54       | 52     | 22          | 32            | 577   |
| 8    | PLOS ONE                                  | 2.776   | 97      | 45       | 56     | 22          | 32            | 577   |
| 9    | AMERICAN JOURNAL OF SPORTS MEDICINE       | 6.093   | 236     | 27       | 15     | 21          | 27            | 427   |
| 10   | JOURNAL OF ORTHOPAEDIC RESEARCH           | 3.043   | 187     | 20       | 22     | 19          | 19            | 399   |
| Total|                                          | 2931    | 559     | 991       | 625    | 742         | 742           | 8844  |
and physician education is essentially important; patients and physicians should be aware that the primary interventions mentioned above are effective and should be used regularly for every OA patient [28]. Developing clinical practice guidelines for osteoarthritis in primary care, based on disease burden and the health literacy of patients, etc. is also needed to regulate primary interventions [29].

On the basis of the results of this study, we believe that in the future, we need to take the following actions to improve the quantity and quality of OA research: a) Give the full research leadership role to universities and support universities and their affiliated medical institutions in continuing to carry out OA research; b) Encourage primitive innovation in clinical and basic research: there is need to reform the clinical research platform, develop clinical methodology and strengthen data resources according to research purposes, and increase cooperation to accelerate the development of a shared platform and interdisciplinary cooperation; c) Continue to strengthen cross-regional and cross-border cooperation and enhance Chinese influence in the field of OA through cooperation; d) Develop clinical guidelines based on Chinese original research and the unique value system for the diagnosis and treatment of OA at the policy-making level; and e) Encourage translational research, especially in orthopaedics[30], aiming to shorten the process of translating basic research to clinical applications and promote the use of new technologies, drugs, and therapies for patients.

4.3. Advantages and limitations

There are some limitations in this study. First, in the process of data retrieval, it is impossible to distinguish between researchers from the same country and those from transnational cooperation, which may overestimate the quantity and quality of research in China to a certain extent. Second, to compare the research at the same level between countries and perform a bibliometric analysis at the same baseline level, we chose to use only the Web of Science core collection database, which does not include some important research studies with a large number of citations published in the Chinese language, which makes the analysis of the quantity and characteristics of our research biased. Although this study may have the above limitations, we believe that the methodology adopted is valid. This bibliometric research method can provide guidance for other disciplines and different research fields. Based on the results of the study, we also put forward suggestions and views for future work, which may be important for the selection of clinical and basic research directions and the improvement of the research level on OA in the future.

Author contributions

Qingxi Zhang, Yunfei Hou, Dan Xing, and Jianhao Lin were responsible for the conception and design of the study. Qingxi Zhang and Yunfei Hou acquired the data and performed the data analysis and quality assessment. All authors made substantial contributions in the interpretation of the results. Qingxi Zhang and Yunfei Hou drafted the article, and all authors revised it critically for important intellectual content. All authors approved the final version to be submitted.

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Declaration of competing interest

The authors declare that they have no conflicts of interest.

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Table 6

| Rank | Meeting Titles                                      | Records |
|------|-----------------------------------------------------|---------|
| 1    | WORLD CONGRESS OF THE OSTEOPHORISIS RESEARCH        | 103     |
| 2    | CONGRESS OF THE EUROPEAN LEAGUE AGAINST              | 7       |
| 3    | ANNUAL MEETING OF THE AMERICAN SOCIETY FOR BONE      | 5       |
|      | AND MINERAL RESEARCH                                 |         |
| 4    | WCO IFO ESCEO WORLD CONGRESS ON OSTEOPOROSIS        | 5       |
| 5    | OSTEOPHORISIS AND MUSCULOSKELETAL DISEASES           |         |
| 6    | ANNUAL MEETING OF THE AMERICAN SOCIETY FOR BONE      | 4       |
|      | AND MINERAL RESEARCH ASBMRS                         |         |
| 7    | ANNUAL MEETING OF THE AMERICAN COLLEGE OF SPORTS    | 3       |
| 8    | ANNUAL EUROPEAN CONGRESS OF RHEUMATOLOGY            | 2       |

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