

## Scientific production and citation impact: a bibliometric analysis in acupuncture over three decades

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**Abstract** Acupuncture, the most important nonpharmacological therapy in traditional Chinese medicine, has attracted significant attention since its introduction to the Western world. This study employs bibliometric analysis to examine the profile of publication activity related to it. The data are retrieved from the database of Science Citation Index Expanded during 1980–2009, and 7,592 papers are identified for analysis. This study finds that almost 20 % of papers are published in CAM journals, and the average cited times per acupuncture paper is 8.69. While the most cited article has been cited 2,109 times, however, 38.15 % of total publications have never been cited. Europe has the largest amount of authored papers with high h-index values; the USA has the largest number of publications on and citations of acupuncture based on country distribution, and this has continued as a significant rising trend. The proportion of collaborative papers shows this upward trend on the worldwide scale while the percentage shares of national collaborations are the highest. The USA produces the most international collaborative documents, although South Korea occupies the highest percentage figure for international collaborative papers. International collaborative papers are the most frequently cited. The average number of authors per paper is 3.69 in the top eight countries/regions. Papers contributed by South Korea are authored by the most people. International collaboration papers are authored by more people, except in Taiwan. South Korea's Kyung Hee University is ranked first in terms of number of papers while Harvard University in the USA accounts for the largest proportion of citations. The University of Exeter, Harvard University and Karolinska Institute have the highest h-index values.

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## Introduction

Acupuncture, one of the primary methods of treatment in traditional Chinese medicine (TCM), is an ancient form of medical practice that was developed over 3,000 years ago under the influence of oriental philosophical theories such as Yin-Yang duality, the five elements and Dialectical Unity. Various and more recent iterations, such as electroacupuncture, ear acupuncture, acupressure and moxibustion are included. (Longhurst 2010; Huang et al. 2009). The original method entails penetration of the skin with thin needles at certain points on the meridians that reflect the specific dysfunctional organs.

Acupuncture therapy in particular has shown a recent upsurge. The use of acupuncture as a complementary and alternative medicine (CAM) therapy has started in the USA since early 1970s. The number of practicing acupuncturists, which reached over 7,200 in 1998 (Wang et al. 2008), is expected to quadruple between 2002 and 2015 (Kaptchuk 2002). Studies from Europe also report an increased acceptance of the use of acupuncture (Widmer et al. 2006; Vas et al. 2007). To some extent, acupuncture has been officially accepted in the late twentieth century. For example, since 1998 Swedish health-care providers have been allowed to use acupuncture treatment as long as its use is based on scientific knowledge and clinically tested experience (Martensson et al. 2011), though the regulation of health insurance coverage for acupuncture varies greatly due to diverse national health patterns (Bishop et al. 2011; Loh et al. 2009; Weidenhammer et al. 2007). The integration of acupuncture in primary care setting also exhibits a cost-effective result (Lin et al. 2011).

With the surge of public interest in acupuncture as well as its wide utilization, the scientific community has begun investigating acupuncture's efficacy and safety. Many scientific examinations of acupuncture have been completed and identified that research into the use of acupuncture for conditions such as insomnia, nausea, vomiting, drug addiction, depression, spinal cord injury, asthma, allergic rhinitis, inflammatory bowel disease, arthritis and mastitis (Witt and Brinkhaus 2010; Lu et al. 2009; MacPherson and Schroer 2007; Shin et al. 2009; Scheewe et al. 2011; Schneider et al. 2007; Wu et al. 2010; Kvist et al. 2007) often shows positive results. Evidence is especially strong for pain alleviation such as lower back pain (Moritz et al. 2011), headache (Zhao et al. 2011), trigeminal neuralgia (Sert et al. 2009; Ahn et al. 2011), and dental pain (Karst et al. 2007). Further studies have examined the possible bases behind it, such as physiological factors, neurovascular transmission mechanisms, neurochemical factors, neurohormonal networks, and immunological function (Bishop and Lewith 2008; Lee et al. 2008; Mao and Kapur 2010; Takahashi et al. 2009). On the other hand, some neutral and negative results were found in animal and human studies on acupuncture (Venzke et al. 2010).

The prospects for acupuncture in disorder management has shown, however, that more rigorous scientific studies are required on the basis of appropriate research methods, such as patient selection, acupoint selection, treatment frequency, needling techniques, and mode of acupuncture (Lee and Chan 2006). In order to improve the quality of studies, and provide practitioners, patients, and policy-makers identified information; and greater access to rational, effective and efficient acupuncture intervention, high-quality randomized clinical trials of acupuncture with proper sham and blinding procedures will be required.

Although acupuncture has been demonstrated to be comparatively safe, there have been reported complications associated with acupuncture manipulation. Among them, the most common ones are pneumothoracic, stabbing injuries of internal organs (especially the lungs), infection, vasovagal reaction, recurrent asthma attacks with hypertension, angina and other neurovascular injuries (Vilke and Wulfert 1997; Peuker and Gronemeyer 2001; Lao et al. 2003; Melchart et al. 2004), with minor complications including bleeding, haematoma, needling pain, faintness and drowsiness, which may be related to inexperienced acupuncturists and inaccurate techniques (White et al. 2001). Consequently, acupuncture practices require rigorous training, financial discipline, and good communication skills, however, requirements for acupuncture education do not seem to be in accordance with what might be expected for this type of qualified intervention at present. As a result, a great many acupuncture-related research projects have been initiated all over the world, and the number of related publications has increased rapidly since the 1990s (Han and Ho 2011).

The bibliometric method is the application of quantitative analysis and statistics to publications such as journal articles and their accompanying citation counts, which is used in research performance evaluation (Thomson Reuters 2008). A few experts have tried to explore the trends in acupuncture publication activity after analyzing related papers indexed in the Medline database (Danell and Danell 2009) and the Science Citation Index Expanded (SCI-E) database (Han and Ho 2011). However, the analysis of citation impact in acupuncture publications as well as the trends over decades has not yet been reported.

The aim of this present study is to describe the profile of publication activity in the field of acupuncture by analyzing related published papers. Citation data and h-index will be used as a bibliometric tool to indicate the intellectual impact of the research output. The time trends of indicators will be explored by analyzing data divided into 3 decades.

## Materials and methods

The information analysis in this paper was obtained from the SCI-E database on Web of Science (WOS) for the period from 1980 to 2009 on 24 April 2010. SCI-E, a multidisciplinary database maintained by the Institute for Scientific Information (ISI) in Philadelphia for the purpose of indexing publications and forming the basis for bibliometric analysis, was chosen for bibliometric research in this study due to its index of address information for almost all the authors, and citation information for all the items in its database.

In this study, “Acupuncture or Acupuncturist\* or electroacupuncture” were used as the keywords to search a part of the title, abstract or keyword for acupuncture related publications. All the 13 types of documents, including articles, editorial materials, letters, meeting abstracts, notes, reviews, proceedings papers, book reviews, news items, corrections, reprints, biographical items, and corrections/additions were used.

In this paper, the distribution of document types, number of citations and most-cited papers, continents, countries/regions, national and international collaboration, mean numbers of authors, and institutions are analyzed. The data are resolved to geographical representation of authorship by the following regional categories: North America, Latin America, East Asia, West Asia, Europe, Oceania, and Africa. Countries are assigned regions on a geographical basis. Papers with multiple authors are counted more than once when the co-authorship is cross regional and inter institutional. At the same time, time trends of acupuncture publications are analyzed over 3 decades in this research.

The bibliometric impact of publications is assessed in terms of the h-index value and the number of received citations. Hirsch proposed the h-index, a new metric for characterizing the scientific output of a piece of research, which is defined as “A scientist has index h if h of his or her  $N_p$  papers have at least h citations each and the other  $(N_p - h)$  papers have  $\leq h$  citations each”, where  $N_p =$  total number of papers. The idea was effectively publicized by scientometrics literature and has received a positive reception in the scientific community (Hirsch 2005). Experts suggested an h-type index for journals, countries, institutes as well as scientists to supplement their impact degree (Braun et al. 2006; Huang and Chi 2010; Zhao and Ye 2011; Pagel and Hudetz 2011; Alonso 2011). The average number of citations per paper (CPP) is an indicator that is often used to compare scientific impacts of publications among countries, institutions, and journals. CPP is defined as the number of citations divided by the number of publications. In this study, we would like to extend CPP into three levels, including CPPs, CPPn and CPPi. CPPs is defined as the number of citations received by single-authored publications, divided by the number of single-authored publications. CPPn is defined as the number of citations received by national collaborative publications, divided by the number of national collaborative publications. And CPPi is defined as the number of citations received by international collaborative publications, divided by the number of international collaborative publications. CPPs, CPPn and CPPi are employed respectively to evaluate the impact of scientific outputs accomplished by single author, national collaboration and international collaboration on the scientific community, and also compare the bibliometric impacts among different types of collaborations in different countries/regions. Collaboration network will be further observed on the basis of the result elicited in this paper, but is not the focus investigated at present.

$$\begin{aligned} \text{CPPs} &= \frac{C_s}{N_s} \\ \text{CPPn} &= \frac{C_n}{N_n} \\ \text{CPPi} &= \frac{C_i}{N_i} \end{aligned}$$

- $C_s$  the number of citations received by single-authored publications;  
 $N_s$  the number of single-authored publications;  
 $C_n$  the number of citations received by national collaborative publications;  
 $N_n$  the number of national collaborative publications;  
 $C_i$  the number of citations received by international collaborative publications; and  
 $N_i$  the number of international collaborative publications.

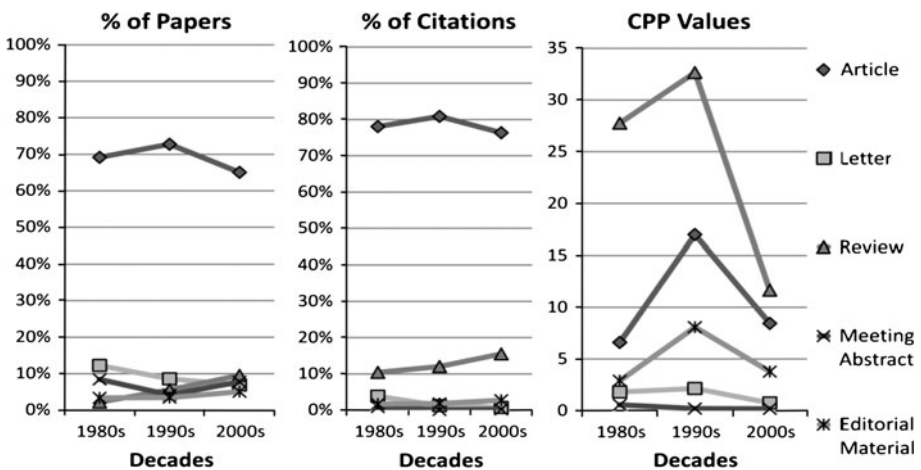
Nevertheless, some scientists have pointed out citation counts of publications published in different fields or in different years cannot be directly compared with each other (Waltman et al. 2011). And studies found a quality parameter based on peer review was neither significantly correlated with the two parameters in the past citations per paper/mean journal citation score (CPP/JCSm) or CPP/FCSm (citations per paper/mean field citation score) nor h-index, at least, citation analysis is not always helpful in distinguishing between good and excellent research as the peer review could do though a very high citation impact discriminated very well between departments rated excellent or good and those receiving lower peer ratings (Ophhof and Leydesdorff 2011; Bornmann et al. 2010; van den Besselaar and Leydesdorff 2009). Furthermore, unlike the impact factor, the

h-index is dependent on the number of publications and cannot decrease for a given set, which be considered an accumulating indicator for lifetime achievement in the case of individual scholars (Leydesdorff 2008). However, this study still utilizes CPP and h-index to evaluate the scientific impacts of publications though flaws existed in these citation-based indicators. Because firstly, acupuncture is the only observed subject here, and no comparison between fields and individuals is conducted; moreover, proportions of publication and citation besides values of CPP and h-index are used widely to compare the changes over 3 decades, which are rather more comparable than direct citation counts; furthermore, experts also admit citation-based indicators can be expected to remain important in scientometric evaluation studies (Leydesdorff and Opthof 2011), anyway, CPP and h-index are useful for distinguishing between good and poor acupuncture researches, which is also significant for related scientific community; lastly, quantificational indicators could illustrate some points in a field though they are not perfect at present, and it is a required complement to a qualitative comment like peer review.

**Results and discussion**

**Distribution of document types**

An overall total of 7,592 acupuncture papers from 1980 to 2009 was distributed across 13 document types, however, notes and corrections/additions disappeared entirely in the 2000s. According to Fig. 1, articles were the most popular document type, but their proportion in the 2000s decreased to 65.05 %, which is markedly lower than that in the 1990s. Its percentage share of citations is 78.41 %, which is almost 10 % higher than its share of total papers, though both of them experienced a similar up and down trend over the 3 decades. These results suggest that original research in the field of acupuncture were the focus for the scientists who have engaged in and drawn the most attention from the scientific community.



**Fig. 1** Percentages of acupuncture papers and citations, and CPP values of main five document types over 3 decades

Letters are the second major document type, but its proportions of both papers and citations have kept decreasing during the past 30 years, which shows entirely the opposite trend when compared with reviews that account for almost 10 % of the papers in the latest decade.

The ratio of citations to papers by types of documents was further considered. Reviews are ranked first, with a CPP value of 16.06, followed by articles, with a value of 10.07. This means reviews provided much valuable information for interested researchers, as they integrated and systemized results of related clinical and basic studies, and also gave justifiable perspectives based on acupuncture history, developments and barriers. Furthermore, the CPP values of all document types in the 2000s are the lowest, and the ones in the 1990s are the highest. The lack of cumulative cited period in published papers, as well as rapid and large-scale expansion of publications in the latest decade may be amongst the factors behind these changes.

### Distribution of journals

There were 1,458 journals that published acupuncture papers between 1980 and 2009. As shown in Table 1, *American Journal of Acupuncture*, *Journal of Alternative and Complementary Medicine*, *Acupuncture & Electro-Therapeutics Research*, and *American Journal of Chinese Medicine* published more than 300 related papers and could be considered as the most core acupuncture journals. However, it is to be noted that *American Journal of Acupuncture*, which ranked first among all the journals based on number of papers, ceased publication in 1999. Moreover, the number of acupuncture papers published in almost all the core journals has shown a rising trend over 3 decades, with the exclusion of *Acupuncture & Electro-Therapeutics Research*, which showed a slight reduction in later decades compared with the 1980s. *Complementary Therapies in Medicine*, meanwhile, was ranked among the ten core journals despite starting publishing acupuncture related papers only in the 2000s.

These source journals include 120 subject categories, which are advanced by Thomson Reuters(Thomson Reuters 2011). Table 2 shows the distribution of major categories, including the fields of Integrative and Complementary Medicine, Medicine, General and Internal and Clinical Neurology, which implies that acupuncture papers have been mainly published on CAM journals.

### Distribution of number of citations and most-cited papers

The average cited times per acupuncture paper between 1980 and 2009 was 8.69. Figure 2 shows the distribution of papers by number of citations. There are 2,896 papers, which accounts for 38.15 % of total publications, that have never been cited by other papers, which mean that more than one-third of acupuncture publications only slightly contributed to scientific society. Only 1,929 papers had been cited over eight times, which suggested that about one quarter of acupuncture publications have dedicated ideas, methods, conclusions, challenges and disputes to the further studies in this field.

Table 3 shows the ten most-cited acupuncture related papers with their number of citations. All these papers were published in the 1990s, except for the two oldest in the 1980s; the oldest one was published in 1980 and the latest three in 1998. Although the most cited article has been cited 2,109 times, 80 % of the most-cited papers have been cited between 200 and 350 times. The contribution of countries/regions was further observed by the institute of the affiliation with at least one author in the most-cited papers. Among the

**Table 1** Ten core journals in the field of acupuncture over 3 decades

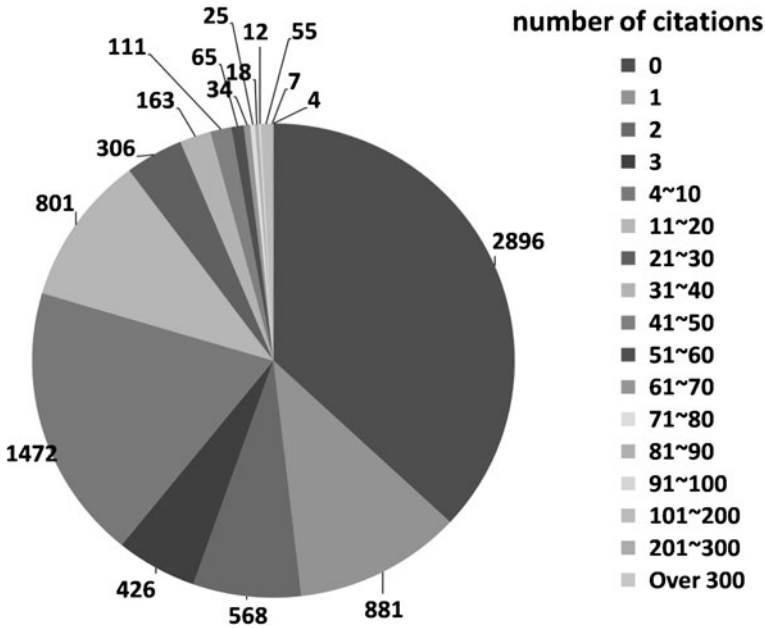
Rank	Name of journal	Category belonged	Papers			
			1980s	1990s	2000s	Total
1	<i>American Journal of Acupuncture</i>	Clinical neurology	285	197	0	482
2	<i>Journal of Alternative and Complementary Medicine</i>	Integrative and complementary medicine	0	21	314	335
3	<i>Acupuncture &amp; Electro-Therapeutics Research</i>	Integrative and complementary medicine; neurosciences	130	104	107	341
4	<i>American Journal of Chinese Medicine</i>	Integrative and complementary medicine; medicine, general and internal	76	66	161	303
5	<i>Neuroscience Letters</i>	Neurosciences	7	11	102	120
6	<i>Pain</i>	Anaesthesiology; clinical neurology; neurosciences	28	30	56	114
7	<i>Complementary Therapies in Medicine</i>	Integrative and complementary medicine	0	0	111	111
8	<i>British Medical Journal</i>	Medicine, general and internal	20	18	41	79
9	<i>Anesthesia and Analgesia</i>	Anaesthesiology	2	12	56	70
10	<i>Brain Research</i>	Neurosciences	9	14	42	65

**Table 2** Ten top subject categories in the field of acupuncture between 1980 and 2009

Rank	Subject categories	Number of papers	Percentage of all papers (%)
1	Integrative and complementary medicine	1,452	19.13
2	Medicine, general and internal	965	12.71
3	Clinical neurology	933	12.29
4	Anaesthesiology	464	6.11
5	Neurosciences	425	5.60
6	Veterinary sciences	327	4.31
7	Obstetrics and gynaecology	227	2.99
8	Gastroenterology and hepatology	180	2.37
9	Medicine, research and experimental	156	2.05
10	Rheumatology	148	1.95

21 involved institutes, 16 of them are from the USA, followed by England with two institutes; the People's Republic of China (P. R. China), Sweden, and Germany each have one institution that contributed at least one most-cited paper. Eisenberg DM, who works for Beth Israel Hospital in the USA, has been involved in three most-cited papers, including the paper ranked first in the world.

Furthermore, eight journals that had published the ten most-cited acupuncture papers were analyzed. All are core and non-CAM journals with high impact factors based on the definition in SCI-E database by Thomson Reuters. Also, those journals are core clinical journals, except the *British Medical Journal* and *Annual Review of Pharmacology and Toxicology*, based on the definition by Abridged Index Medicus on Medline (U.S. National



**Fig. 2** Distribution of acupuncture papers by number of citations between 1980 and 2009

**Table 3** Ten most-cited acupuncture papers between 1980 and 2009

Rank	Article	Times cited
1	Eisenberg DM, Kessler RC, Foster C, et al. Unconventional medicine in the United States—prevalence, costs, and patterns of use. <i>New England Journal of Medicine</i> , 1993, 328(4):246–252	2109
2	Watcha MF, White PF. Postoperative nausea and vomiting—its etiology, treatment, and prevention. <i>Anesthesiology</i> , 1992, 77(1):162–184	715
3	Ramsay DJ, Bowman MA, Greenman PE, et al. Acupuncture. <i>Journal of the American Medical Association</i> , 1998, 280(17):1518–1524	334
4	Fisher P, Ward A. Medicine in Europe .8. Complementary Medicine in Europe. <i>British Medical Journal</i> , 1994, 309(6947):107–111	323
5	Han JS, Terenius L. Neurochemical basis of acupuncture analgesia. <i>Annual Review of Pharmacology and Toxicology</i> , 1982, 22:193–220	274
6	Law M, Tang JL. An analysis of the effectiveness of interventions intended to help people stop smoking. <i>Archives of Internal Medicine</i> , 1995, 155(18):1933–1941	251
7	Eisenberg DM. Advising patients who seek alternative medical therapies. <i>Annals of Internal Medicine</i> , 1997, 127(1):61–69	242
8	Streitberger K, Kleinhenz J. Introducing a placebo needle into acupuncture research. <i>Lancet</i> , 1998, 352(9125):364–465	221
9	Wetzel MS, Eisenberg DM, Kaptchuk TJ. Courses involving CAM at US medical schools. <i>Journal of the American Medical Association</i> , 1998, 280(9):784–787	209
10	Clementjones V, Mcloughlin L, Tomlin S, et al. Increased beta-endorphin but not metenkephalin levels in human cerebrospinal-fluid after acupuncture for recurrent pain. <i>Lancet</i> , 1980, 2(8201):946–949	202



Library of Medicine 2010). Almost 20 % of acupuncture papers were published in 23 CAM journals with comparatively low impact, implying that papers in high impact journals may be read by more researchers and health practitioners, and may receive more attention from inter-disciplinary experts and wider scopes. On the other hand, studies with rigorous design and execution may more likely to be accepted by the high quality journals.

The highly-cited papers were chronologically analyzed and grouped into two stages: (1) 1980s: focused on the discovery of the neurochemical mechanism of acupuncture analgesia, which has been recommended in the Western world since President Nixon's visit to China in the early 1970s (Hopwood 2003), and (2) 1990s: focused on the national survey of CAM prevalence, costs, patterns of use, related courses in medical schools, methodological improvement such as introducing a placebo needle into acupuncture research, and identification of its effectiveness against vomit and smoking, indicating the importance of describing the use of acupuncture therapy by the public and providing a comprehensive overview. The necessity of developing scientific evidence for the validity was then widely realized.

### Geographical distribution

Table 4 shows the geographical distribution of authorship for acupuncture papers between 1980 and 2009. Seven hundred and twenty four publications without country address identified were not analyzed in this paper. Europe, with 2,303 papers, has the largest amount of authored papers, accounting for 33.53 % of all documents, followed by North America and East Asia with 2,284 and 2,089 papers respectively. In the first half of the nineteenth century, acupuncture was practiced in Europe by some members of the medical profession. Acupuncture was actually mentioned in the first issue of the *Lancet* in 1823 (Hopwood 2003). It is not surprising that one-third of acupuncture papers are contributed by European scientists, which get 39.49 % of total citations with a high h-index value of 66.

33.26 % of acupuncture papers are written by authors located in North America, which receives 43.40 % of citations, with the highest CPP value of 12.5 and the highest h-index value of 66. Its proportions of both papers and citations remain rapidly increasing trends over 3 decades. Authors in East Asia contribute 30.42 % of papers though only receive 21.58 % of the total citations with a h-index value of 44, implying that acupuncture is not a prevalent line of research in East Asia, where its theories and practice originated from 1000 years ago.

**Table 4** Geographical distribution of acupuncture publications over 3 decades

Rank	Continent	Papers (% <sup>a</sup> )				Times cited (% <sup>a</sup> )				CPP values	h-index
		1980s	1990s	2000s	Total	1980s	1990s	2000s	Total		
1	Europe	32.61	36.46	32.79	33.53	43.80	39.73	38.18	39.49	11.3	66
2	North America	24.22	30.32	36.70	33.26	27.11	45.04	46.41	43.40	12.5	66
3	East Asia	27.85	26.24	32.53	30.42	27.67	18.63	22.25	21.58	6.81	44
4	West Asia	11.68	7.04	3.54	5.65	2.39	1.03	1.97	1.67	2.84	15
5	Oceania	4.15	2.62	3.52	3.44	3.65	2.22	3.51	3.04	8.5	22
6	Latin America	0.17	1.45	2.58	1.94	0.13	0.42	1.28	0.81	4	11
7	Africa	1.56	0.35	0.12	0.41	0.77	0.06	0.10	0.17	4	7

<sup>a</sup> Percentage of papers or citations in the decade in the continent

## Distribution of countries/regions

Table 5 shows the top ten countries and regions according to the amount of acupuncture papers released. The USA, with 2,075 papers, has the largest number of publications. It is followed by P. R. China, England, and Germany with 948, 686, and 552 papers respectively. South Korea and Japan have similar numbers of publications, ~400 papers.

Number of citations was further observed, with USA-authored papers cited most at 26,177 citations, accounting for 39.70 % of all citations, about 10 % higher than its percentage of all papers, with CPP value of 12.62 and highest h-index of 63. England is the second highest with 10,617 citations, contributing 9.99 % of the total publications but receiving 16.10 % of the total citations. Furthermore, England has the highest CPP value with 15.48 among the five top prodigious countries/regions in acupuncture papers and it has the second highest h-index of 52, indicating the research conducted by British scientists has drawn much attention and had high citation impact in the acupuncture field. Sweden performs similarly, with 3.67 % of papers published, 6.31 % of citations received and the highest global CPP value, 16.52, despite its small absolute number of papers. However, P. R. China is the opposite; it receives 9.70 % of citations with 13.80 % of papers, as do Germany and South Korea.

The time trends for the top ten countries/regions due to acupuncture publications and citations were also presented. USA not only takes first place in the number of papers and citations, but also shows a significant rising trend over 3 decades, as do England and Germany. Other notable increases in percentage of all papers can be found in South Korea, which was less than 1 % in the first 2 decades but has risen to almost 10 % in the latest decade. However, opposite trends are noticed in Japan.

## National and international collaboration

Collaboration in science is a process in which two or more authors share their ideas, resources and data to create a joint work (Nikzad et al. 2011). Scientific collaboration

**Table 5** Distribution of top ten countries/regions by acupuncture publications over 3 decades

Rank	Country	Papers (% <sup>a</sup> )				Citations (% <sup>a</sup> )				CPP values	h-index
		1980s	1990s	2000s	Total	1980s	1990s	2000s	Total		
1	USA	21.54	27.62	33.44	30.21	22.99	40.87	43.19	39.70	12.62	63
2	P. R. China	14.19	11.95	14.33	13.80	19.75	7.31	8.90	9.70	6.75	34
3	England	8.39	9.53	10.58	9.99	21.61	15.04	15.47	16.10	15.48	52
4	Germany	3.98	5.66	9.94	8.04	1.79	4.28	9.88	6.72	8.03	33
5	South Korea	0.43	0.76	9.36	6.04	0.09	1.62	6.06	3.60	5.73	22
6	Japan	7.18	7.80	4.76	5.81	5.45	6.26	4.00	5.05	8.34	27
7	Taiwan	2.34	4.21	4.22	3.90	1.28	3.55	3.37	3.17	7.79	22
8	Sweden	2.25	6.01	3.26	3.67	8.26	8.52	4.11	6.31	16.52	34
9	Canada	2.68	3.04	4.03	3.60	4.12	4.59	4.64	4.55	12.16	28
10	Australia	2.16	2.56	3.21	2.90	1.88	2.22	3.33	2.72	9.02	21

<sup>a</sup> Percentage of publication/citation in the decade in the country/region

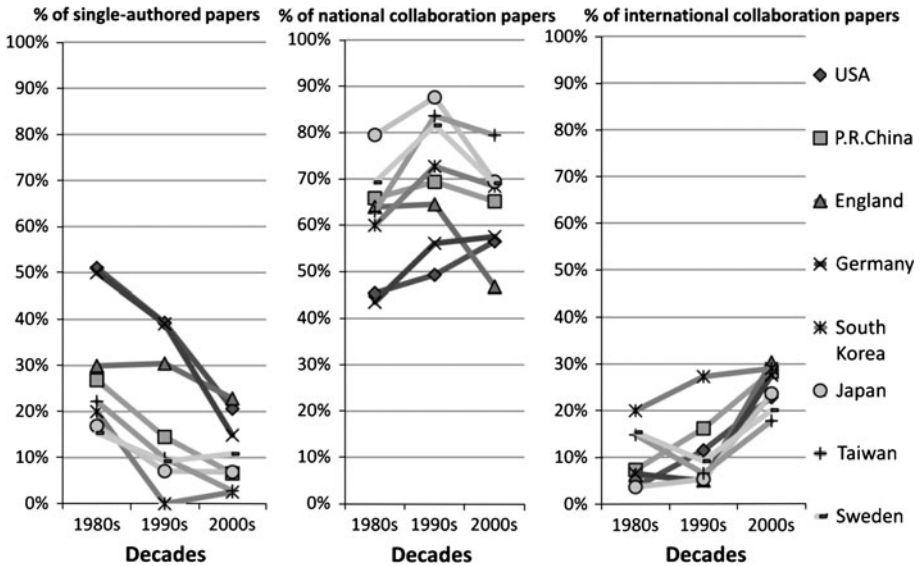
among authors affiliated to an academic institution improves the sharing of competences and the production of new scientific knowledge (De Stefano et al. 2011; Shi et al. 2011), which could be made more effective by developing an extraordinary grasp of partners' culture, science and history (Dodson 2011). This was in conformity with the results of this study, that show that national collaboration publication holds the highest percentage figures compared with international collaboration and single-authored papers.

Among top eight countries/regions, USA produces the most international collaborative documents, releasing 381 papers based on its largest amount of acupuncture publications, followed by P. R. China with 213 papers. Existing research results indicate that homophily structures collaboration when scientists adhere to a norm of exclusivity in selecting similar partners at a higher rate than dissimilar ones during the process, and that geographic proximity plays an important role when they seek collaborators outside their own institutions (Evans et al. 2011). This may partly account for percentage shares of national collaborations being much higher than that of international ones in all countries/regions.

The highest percentage share of international collaboration is 28.92 % in South Korea, implying that South Korea is making great efforts to conduct multi-location projects. On the second level, countries such as USA, P. R. China, England and Germany, collaborate with other overseas institutes in about 18–23 % of their publications. On the lowest level, Japan, Taiwan and Sweden internationally collaborate in 14–16 % of their papers, which account for the highest percentage share of national collaboration in 73–79 %. As to the single-authored papers, it seems that more than 25 % of authors engaged in acupuncture field would like to research and compose all by themselves in USA and England. In contrast, only <3 % of authors located in South Korea would choose this way.

The absolute numbers of acupuncture papers conducted under inter-institutional collaboration, international collaboration and national collaboration both show increasing trends over 3 decades. The time tendency of percentage share in terms of the diverse patterns of collaboration in over 3 decades was further analyzed. Figure 3 shows that proportions of publications contributed by single author continues to decrease in all countries/regions without exception. Especially in South Korea, which has shown a massive drop in its percentage share, from 20.00 % in 1980s to 0 % and 2.51 % respectively in the latest 2 decades, indicating the increasing awareness of the importance of cooperation and knowledge exchange in the acupuncture field. Most of the proportion figures of national collaborative papers have varied in all countries and regions, except P. R. China and South Korea, which have kept comparative stabilization with 67 % over the 3 decades. However, these figures increase about 10 % in USA, Germany and Taiwan between 1980 and 2009; at the same time, an impressive opposite tendency could be observed in England, with an almost 20 % reduction during the past 30 years. Furthermore, both Japan and Sweden have experienced increases in the 1990s then obvious decreases in the 2000s. As for proportions of international collaborative papers, figures for almost all countries/regions have continued rising significantly, except Taiwan and Sweden which showed a decreasing trend first and then rose in the latest decades.

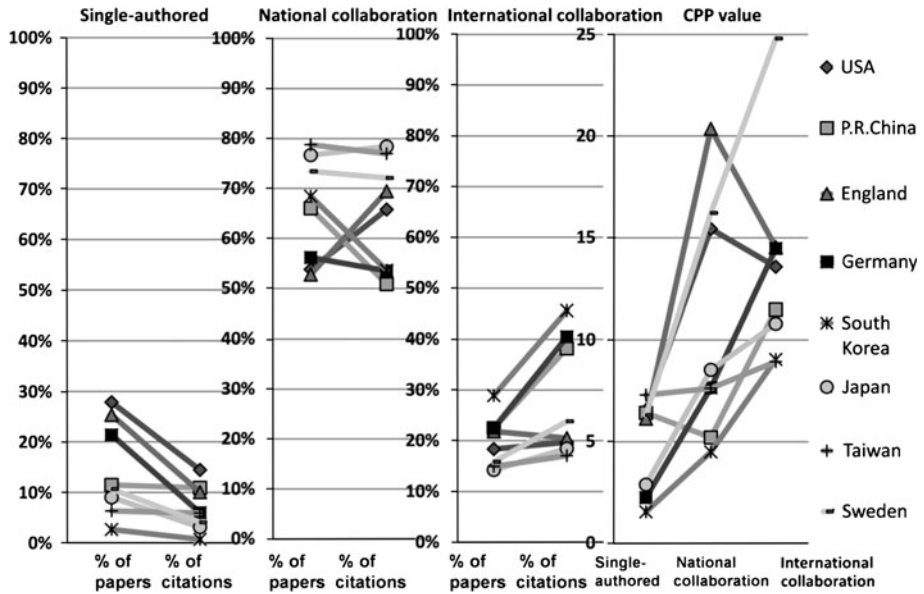
Figure 4 shows the comparison of percentage share of papers and that of citations on the basis of three types of cooperation in top eight countries/regions. It reveals that single-authored papers specialized in the field of acupuncture receive lower citations. However, countries/regions in East Asia, including Taiwan, P. R. China, South Korea and Japan, the subtraction between percentage share of single-authored paper and citation is <6 %. While in Germany, England and USA, the subtraction could reach to more than 13 %, implying that collaboration could cause obviously different results between the west and the east. When it comes to national cooperation papers, there were diverse situations. Research



**Fig. 3** Proportions of acupuncture publications by three collaborative types in top eight countries/regions over 3 decades

conducted by scientists located in USA and England could receive an ~15 % increased proportion of citations than that of papers produced through countrywide teamwork efforts. However, entirely opposite results of the same extent could be found in countries such as South Korea and P. R. China; in other countries such as Germany, Japan, Taiwan and Sweden, percentage figures of papers and citations were almost equivalent. Scientists noted that international collaborative papers have been gradually more common in the journals of many disciplines. These types of papers are often more frequently cited (Sin 2011; Rojas-Sola et al. 2009), which is mostly in conformity with the results of this study except England. Germany, South Korea and P. R. China, whose percentage shares of international collaborative papers have been much less than that of citation, with the largest gap as high as 18.03 %. In the USA and Taiwan, it is <3 %, indicating that the countries/regions are in great need of international cooperation, which indeed improves the sharing of competences and impacts on the acupuncture community.

The citation per paper (CPP) in terms of diverse types of collaboration was also observed in this study. CPP value of international collaboration publication output (CPPi) is usually the highest if compare with that of single-authored publication output (CPPs) and with that of national collaboration publication output (CPPn) in the most of countries/regions. The CPPi value in Sweden is the highest among the top eight countries/regions. The value reaches to 24.80, and almost four times and 1.5 times higher than the CPPs value and CPPn value, which means cross-border cooperation usually can attract more attention. However, the CPPn values in the USA and England are the highest, imply that the collaboration among top scientists in a country with excellent research traditions and conditions may result in successful accomplishment with a higher quality. On the other hand, the opposite is shown in P. R. China, which the CPPn is the lowest value comparing with CPPs and CPPi. At the same time, it could be found that all the figures of CPPs, CPPn and CPPi are almost equal in Taiwan.



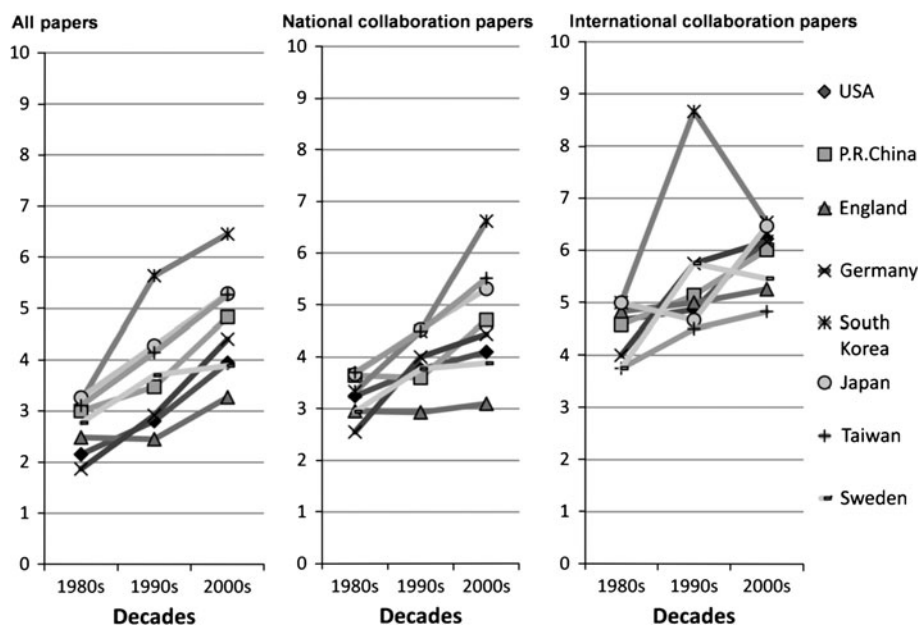
**Fig. 4** Proportions of acupuncture publication and citation, and CPP value by three collaborative types in top eight countries/regions from 1980 to 2009

Mean numbers of authors

The average number of authors per paper was 3.69 in the top eight countries/regions in the field of acupuncture over the past 30 years. The result was slightly lower than the average number of authors in occupational health, 4.10 (Navarro and Martín 2004). Various disciplines with diverse collaborative patterns may interpret the differences. Acupuncture papers contributed by South Korea were averaged by most persons reaching to 5.10. In contrast, papers released by England researchers had the least authors of 2.74. Generally speaking, international collaboration papers were authored by more persons than national collaboration papers were; except Taiwan, which the figures are 4.36 and 4.40 respectively. Figure 5 shows a rising trend of average number of authors over time in almost all the countries/regions except South Korea and Sweden, in which its international collaboration papers published in 1990s have the most average authors per paper. However, the numbers then have declined in 2000s.

Institutional distribution

The contribution of different institutes was assessed by the institute of the affiliation with at least one author in the published papers of acupuncture. The top 20 institutes were ranked by their published papers. According to Table 6, Kyung Hee University from South Korea ranked first in the world with a number of 201 papers, followed by Fudan University in P.R. China with 161 papers, and the University of Exeter in England with 158 papers. Seven universities from the top 20 academic institutes are American. P. R. China is the cradle of acupuncture, however only two of the top 20 institutes are from there, though acupuncture theory has remained integral and is practiced in hospitals all over the country until now. Moreover, there are two other leading institutes located in South Korea, Taiwan,



**Fig. 5** Time trends for the mean numbers of authors by countries/regions over 3 decades

England and Sweden each, and Hong Kong, Germany and Canada each have one institution.

With the emphasis of the time trends based on the number of publications, this study found that the 2000s was the most productive decade for acupuncture related researches. In the latest 10 years, almost all the related research units made efforts to enhance their studies and released many more publications than in the earlier 2 decades. The University of Plymouth in England and the University of Toronto in Canada in particular among the top 20 institutes just started their acupuncture research activities in the 2000s, and also achieved impressive output.

Citations attracted by acupuncture papers were further inspected in the light of institutional distribution. Harvard University in the USA accounts for 4,698 citations based on a comparably smaller number of publications, followed distantly by the University of Exeter with 2,399 citations. The results indicate that appropriate research methods may have been developed and many rigorous scientific studies have conducted by the scientists who have investigated acupuncture from entirely new angles to make great innovations and obtain a better understanding of effective mechanics that would surely grab more attention. Referring to the h-index values, the University of Exeter, Harvard University and the Karolinska Institute from Sweden, which are not ranked in the first place based on the number of publications, have the highest h-index figures of 26. The research result has shown their high impact on the related science community over the past 30 years.

## Conclusions

Acupuncture, a nonpharmacological TCM therapy, has attracted great attention through its introduction to the world from China. Better designed research has conducted to identify its

**Table 6** Top 20 productive organizations in acupuncture between 1980 and 2009

Rank	Organization (country/region)	Papers				Total times cited	h-index
		1980s	1990s	2000s	Total		
1	Kyung Hee University (South Korea)	1	4	196	201	1,442	18
2	Fudan University (P. R. China)	11	54	96	161	966	15
3	The University of Exeter (England)	0	31	127	158	2,399	26
4	Harvard University (USA)	4	14	138	156	4,698	26
5	Peking University (P. R. China)	5	47	70	122	1,957	23
6	University of California—Los Angeles (USA)	8	16	72	96	1,192	16
7	University of Plymouth (England)	0	0	96	96	855	15
8	Karolinska Institute (Sweden)	9	41	46	96	1,854	26
9	University of Maryland—Baltimore (USA)	7	18	63	88	460	22
10	China Medical University [ROC (Taiwan)]	0	15	73	88	1,745	10
11	Seoul National University (South Korea)	2	1	68	71	592	13
12	Göteborg University (Sweden)	2	19	44	65	1,103	18
13	University of Pennsylvania (USA)	9	8	47	64	734	13
14	University of California—Irvine (USA)	5	9	45	59	1,130	14
15	University of Minnesota—Twin Cities (USA)	2	3	54	59	669	17
16	The University of Hong Kong (Hong Kong)	9	1	46	56	374	11
17	National Yang Ming University [ROC (Taiwan)]	7	11	34	52	752	14
18	Technical University of Munich (Germany)	0	2	49	51	1,005	16
19	The University of Texas—Medical Branch (USA)	11	6	33	50	949	9
19	University of Toronto (Canada)	0	0	50	50	280	17

efficacy, safety and mechanism based on the wider utilization all over the world. As the results show, the number of related publications has increased rapidly.

This study evaluated acupuncture treatment by using bibliometric methods, which resulted in some significant points that may provide practitioners, patients, and policy-makers with identified information and more accesses to rational, effective and efficient acupuncture intervention. The paper noted that the total 7,592 of acupuncture papers was distributed across 13 types of document, with articles the most popular type.

There were 1,458 journals, which had published acupuncture papers covering 120 subject categories. Among the journals, *Integrative & Complementary Medicine* was ranked first. The average number of citations per acupuncture paper was 8.69, and 38.15 % of total publications had never been cited by other papers. Most of the institutes that released the top-cited papers were located in the USA, and Eisenberg DM was amongst the authors of three papers including the top one. The ten most-cited papers were all published in high impact journals, and concentrated on the discovery of neurochemical mechanisms of acupuncture analgesia, national surveys, methodological improvements, and so on.

Europe had the largest amount of authored papers with a high h-index value of 66, followed by North America and East Asia. North America received the highest CPP and h-index value. USA had the largest number of publications and citations, and maintained a significant upward trend over 3 decades. USA had the highest h-index, while England had the highest CPP value.

Proportions of publications contributed by single author have presented a decreasing trend in all the countries/regions, while collaboration paper showed increasing trends in worldwide, and percentage shares of national collaborations were the highest. The USA produced the most international collaborated documents, however, South Korea occupied the highest percentage figure of international collaboration paper. More than 25 % of papers released by the USA and England were single-authored. International collaborative papers were more frequently cited. National cooperation papers from the USA and England received a greater proportion of citations, while entirely opposite results could be investigated in South Korea and P. R. China. The values of CPPn were the highest in the USA and England and the value of CPPi in Sweden was the highest among all the top eight countries/regions.

The average number of authors per paper was 3.69 in the top eight countries/regions. Papers contributed by South Korea were authored by the most people and English papers had the least authors. International collaborative papers were authored by more people, except in Taiwan, and the average number of authors over time showed continuing rising trends except in South Korea and Sweden.

Among the top 20 institutes, Kyung Hee University was ranked first in terms of paper number, followed by Fudan University and the University of Exeter. Seven universities were located in USA, and Harvard University accounted for the largest part of citations. The University of Exeter, Harvard University and Karolinska Institute got the highest h-index values.

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