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BIBLIOMETRIC ANALYSIS OF ACUPUNCTURE RESEARCH FRONTS AND THEIR WORLDWIDE DISTRIBUTION OVER THREE DECADES

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Abstract

Background: Considerable research has been conducted on acupuncture worldwide. This study chronologically examined the changing features and research fronts of acupuncture and elucidated the differences among the six most productive countries.

Methods: Bibliographic coupling is a powerful tool for identifying the research fronts of a field. Acupuncture-related publications worldwide and from the six most productive countries during 1983–2012 were retrieved from the Science Citation Index Expanded and Social Science Citation Index. To form the research fronts, the 100 most highly cited papers (HCPs) were clustered in terms of references shared.

Results: The United States had the highest proportion of HCPs. The effectiveness of acupuncture in areas such as relieving neck and back pain, migraines and headaches, and knee osteoarthritis symptoms was a predominant topic. Initially, the endogenous opioid peptide system was the primary research focus in the acupuncture mechanism research; however, during 1993–2012, researchers focused more on the functional magnetic resonance imaging of brain activity. In addition, acupuncture use and prevalence, the attitudes of health practitioners, and the effects of expectancy and belief were also major topics. Researches from Western countries, including the United States, England, and Germany, showed more interest in clinical trials and economic- and ethics-related studies, whereas those from East Asian countries including China, Japan, and South Korea focused more on mechanism research.

Conclusion: Western countries dominated the research fronts of acupuncture. The patterns of the research fronts varied worldwide, indicating continuity and innovation in research in each country.

Keywords: Acupuncture; Bibliometric; Bibliographic Coupling; Research Front; Country Distribution

Introduction

Acupuncture is believed to have originated from the practice of striking sharpened or wedge-shaped stones and bones against human skin for pain relief. (Zhou 2001). During diffusion, the initial hand acupuncture technique

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evolved into other forms, including electroacupuncture (EA) as well as ear, scalp or skull, aqua, and dry acupuncture.

Acupuncture did not attract substantial global attention until the early 1970s; since then, the upsurge of acupuncture practice and research has continued over time. Much research has been conducted on the clinical effects and underlying mechanisms of acupuncture. Different research focuses and fronts of acupuncture have developed over time, and reporting these can aid in understanding the overall situation of the acupuncture field and guide further research. Recent studies have mainly focused on specific conditions that can be managed using acupuncture, such as types of pain, (da Silva et al. 2015; Tsao et al. 2015; Vickers et al. 2012; Yuan et al. 2015) or on mechanisms underlying neuroprotection by acupuncture, such as changes in endorphin levels or brain imaging (Fuxe et al. 2013; Ji et al. 2016; Kim and Bae 2010; Laureano et al. 2016; Zhao 2013). However, studies examining the history of acupuncture research from past to present, including the changes in trends and emerging topics, are rare. This has resulted in limited insight into how the research fronts of acupuncture have evolved over time and a lack of available data regarding the chronology of the evolution of acupuncture research, changes in research topics, and scientific communities mainly interested in the acupuncture field at each stage. Furthermore, the different emphases of countries with various medical systems and histories in the acupuncture research domain remain unknown.

Researchers believe that determining research fronts by using an expert-based approach is difficult because academic knowledge is rapidly increasing and the method is cost and time intensive. Bibliometrics is a powerful tool for overviewing scientific activities and identifying the research fronts of a field (Chen et al. 2014; García-Lillo, Úbeda-García, and Marco-Lajara 2016; Shibata et al. 2011). It suggests that papers sharing more common references have more similar themes; hence, the number of common references shared by two papers—called bibliographic coupling (BC) strength—is considered an indicator of topic similarity between them; two such papers are called a BC pair (Boyack and Klavans 2010; Ma 2012). Morris first clustered groups of papers tending to cite common references to form research fronts, obtain a global overview of research domains, and visualize structural and dynamic changes in research specialties such as cystic fibrosis and anthrax. (Morris et al., 2003; Yang et al., 2009) In other studies, bibliometric analysis has also been used to map the evolution of research activities or to conduct technology foresight such as in personalized medicine, information science, and organic light-emitting diode (OLED) field (Huang and Chang 2014; Stelzer et al. 2015; Yang et al. 2016).

The trends in acupuncture publication activity have been explored using bibliometric analyses; (Danell and Danell 2009; Han and Ho 2011) our previous study further analyzed the intellectual impact of the research output in the acupuncture field (Fu et al. 2012). In the present study, we identified the research fronts of acupuncture worldwide and the special features of the six most productive countries in the acupuncture research domain through bibliometric analysis of related published papers. The time trends of indicators were explored by analyzing data divided into three decades. To our knowledge, this is the first report mapping the evolution of research activities in the acupuncture field during 1983–2012. Our findings may present researchers, research and development managers, and policy makers with an intellectual basis for constructing strategies for further acupuncture-related research.

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Methods

Research subject

Acupuncture-related papers published between 1983 and 2012 were retrieved from the Science Citation Index Expanded (SCIE) and the Social Science Citation Index (SSCI) on the Web of Science (WOS) on December 1, 2013.

Acupuncture-related publications were searched using keywords determined by experts, namely "acupuncture* or electroacupuncture or acupoint*" as a part of a title or abstract, or in the keywords. The analysis covered only one document type, "articles," because articles mainly represent original scientific achievements and embody the research fronts. A total of 6,947 acupuncture papers were retrieved and categorized into three groups according to their publication date. There were 994, 1555, and 4398 papers published during 1983–1992, 1993–2002, and 2003–2012 respectively.

Aside from analyzing the data through a global perspective, six countries were selected for further analyses. Acupuncture-related papers from the six most productive countries—the United States, England, Germany, China, Japan, and South Korea—were identified for comparison of the main features of their research fronts.

Research method

Using bibliographic coupling to map the evolution of research activities in the acupuncture field, the paper will combine literature review, database searching, and bibliographic coupling analysis as its major methods.

Bibliographic coupling. Two papers that cite the same references are called BC pairs. It is believed that the greater the number of shared references between papers, the more similar the research is. The number of shared references is referred to as BC strength. We grouped acupuncture papers by references and coupled every paper pair. BC pairs with high similarity can be organized into a citation network in which most papers dealing similar topics are linked. A group of papers in a cluster is referred to as a "research front" (Morris et al., 2003).

Research procedures

The conducting of research was composed of the following parts:

Searching relevant literature*:* It was important to study the theories, methodologies, and background involved in related studies on acupuncture. We used domestic and international databases to search for relevant publications and reference materials.

Database searching: To conduct an overview of scientific activities in the acupuncture field, we first retrieved acupuncture related papers using the aforementioned keywords. Then, highly cited papers (HCPs), which were defined as the top 100 most cited publications, were identified to produce data sets for revealing the core documents (those with high scientific impact). To access the evolution of the research fronts of acupuncture, papers were divided into three groups according to the following time spans: 1983–1992, 1993–2002, and 2003–2012. For countries where fewer than 100 papers were published in any given decade, all the available papers were considered, regardless of the number of

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citations they received.

Constructing BC matrics and calculating BC strengths: In this study, BibExcel was used to construct BC matrics and obtain BC pairs based on the shared references of HCPs. The BC pairs with low BC strengths were excluded because the BC strength represents the correlation between two papers. Only papers in BC pairs with BC strengths of ≥ 5 were included in this analysis to ensure topic similarity (Morris and Boyack, 2005).

Conducting cluster analyses and mapping the evolution of research activities: After obtaining the BC pairs with high similarity, HCPs can be divided into clusters covering similar topics using UCINET. We clustered acupuncture-related papers through social network analysis based on included BC pairs, and the clusters with three or more papers were accepted as research fronts. Next, a subject matter expert classified and labeled the research fronts obtained.

Results

Number of papers, highly cited papers and BC strength

The numbers of acupuncture-related papers and HCPs over these three decades are shown in Table 1. However, noted that the references cited in some papers were incompletely covered by the databases, particularly during 1983-1992, so the number of BC pairs likely decreased compared with that in the other decades.

Table 1: Number of acupuncture papers and HCP over three decades

Countries	All papers			HCP (Cited times ≥)			CR coverage* of HCP (%)		
	83-92	93-02	03-12	83-92	93-02	03-12	83-92	93-02	03-12
USA	200	452	1188	113(3)	100(47)	105(35)	63	100	100
England	36	118	339	36(0)	101(6)	101(13)	69	99	100
Germany	8	101	350	8(0)	101(0)	104(12)	55	95	100
China	126	174	1034	126(0)	105(6)	109(18)	55	89	100
Japan	63	118	192	63(0)	100(5)	113(4)	47	92	100
Korea	3	49	498	3(2)	49(1)	100(12)	33	96	100
World	994	1555	4398	100(29)	100(73)	101(51)	91	100	100

* Coverage of cited references in the SCIE and the SSCI databases

The BC strength varied among the papers (Table 2), which was only 1 in 52%–65% of the BC pairs, whereas it was ≥5 in <20% of the BC pairs.

Table 2: Number of BC pairs with different BC strengths in acupuncture field.

Decade	Countries	Number of BC pairs based on BC strength (%*)					
		≥5	4	3	2	1	mean
83-92	USA	31 (7.7)	23 (5.7)	32 (8.0)	100 (24.9)	216 (53.7)	2.02
	England	2 (3.7)	1 (1.9)	3 (5.6)	13 (24.1)	35 (64.8)	1.80
	Germany	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
	China	20 (9.0)	4 (1.8)	30 (13.5)	53 (23.8)	116 (52.0)	2.11
	Japan	10 (11.1)	5 (5.6)	3 (3.3)	20 (22.2)	52 (57.8)	2.36
	Korea	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
	World	43 (6.0)	27 (3.7)	51 (7.1)	144 (20.0)	456 (63.2)	1.88
93-02	USA	46 (4.3)	24 (2.2)	82 (7.6)	227 (21.1)	699 (64.8)	1.72
	England	55 (5.3)	44 (4.2)	88 (8.5)	216 (20.8)	637 (61.3)	1.85
	Germany	24 (6.3)	14 (3.7)	27 (7.1)	80 (20.9)	237 (62.0)	2.09
	China	23 (6.5)	8 (2.2)	27 (7.6)	70 (19.7)	228 (64.0)	1.88
	Japan	31 (8.7)	17 (4.7)	26 (7.3)	75 (20.9)	209 (58.4)	2.07
	Korea	11 (8.7)	8 (6.3)	9 (7.1)	19 (15.0)	80 (63.0)	2.09

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	World	44 (4.6)	36 (3.7)	64 (6.6)	187 (19.4)	633 (65.7)	1.71
	USA	122 (12.5)	45 (4.6)	105 (10.7)	187 (19.1)	519 (53.1)	2.50
	England	55 (6.4)	35 (4.1)	78 (9.1)	158 (18.5)	528 (61.8)	1.96
	Germany	100 (7.3)	59 (4.3)	136 (9.9)	284 (20.7)	793 (57.8)	2.06
03-12	China	154 (18.6)	45 (5.4)	81 (9.8)	113 (13.6)	437 (52.7)	2.92
	Japan	55 (7.9)	18 (2.6)	58 (8.3)	120 (17.2)	448 (64.1)	2.20
	Korea	54 (8.5)	26 (4.1)	57 (9.0)	121 (19.1)	377 (59.4)	2.17
	World	101 (10.1)	34 (3.4)	94 (9.4)	190 (19.0)	582 (58.1)	2.17

* Percentage of BC pairs in terms of BC strength in the decade in a country or worldwide

Distribution of countries publishing HCP

Figure 1 shows the country-wise distribution of authorship of HCPs as well as all acupuncture-related papers published between 1983 and 2012. Publications without an identifiable country were not analyzed. The United States contributed the highest proportion of HCPs over the three decades, and these figures exhibited a continual upward trend over this period. Furthermore, these figures have been consistently higher than the proportions of all acupuncture papers contributed to by American authors, indicating the great attention attracted by and high impact of American-authored papers. After the United States, the proportions of HCPs published in England and Germany, ranking second and third worldwide, respectively, increased over the decades, accounting for 24.8% and 13.9% of the HCPs, respectively. However, less than 10% of all acupuncture-related papers were written by English or German authors in each decade.

The East Asian countries showed a different trend. In 2003–2012, China contributed 7.92% of HCPs and 24.42% of all acupuncture-related papers worldwide; the proportion of all acupuncture-related papers worldwide reached a level similar to that of the United States. South Korea showed results similar to those of China. By contrast, in Japan, both the proportions of HCPs and all acupuncture-related papers decreased over the three decades, with a more rapid decrease in the proportion of HCPs.

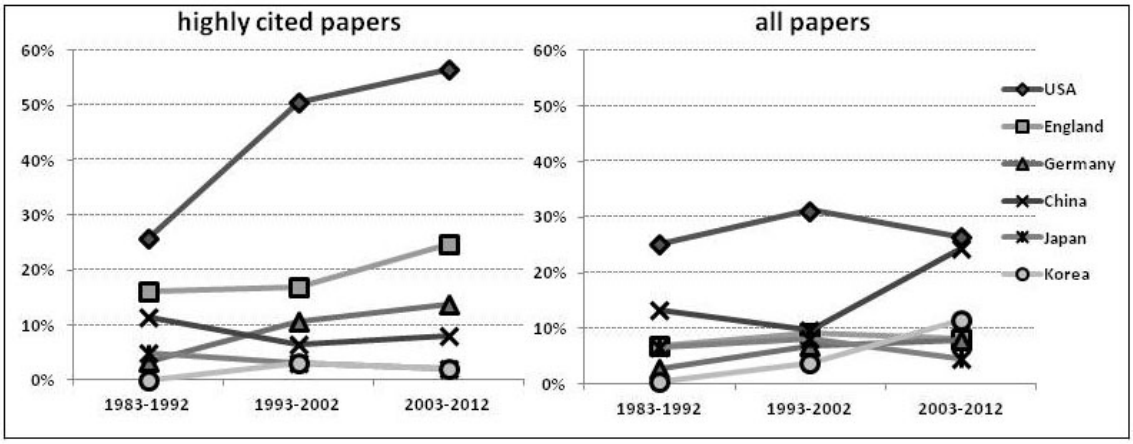

Figure 1: Percentages of HCP as well as all papers for selected six countries over three decades

Research fronts over the three decades

In every decade, distinct and evolved research fronts of acupuncture were noted. Global acupuncture research conducted over the three decades could be broadly classified into the following five categories (Figure 2):

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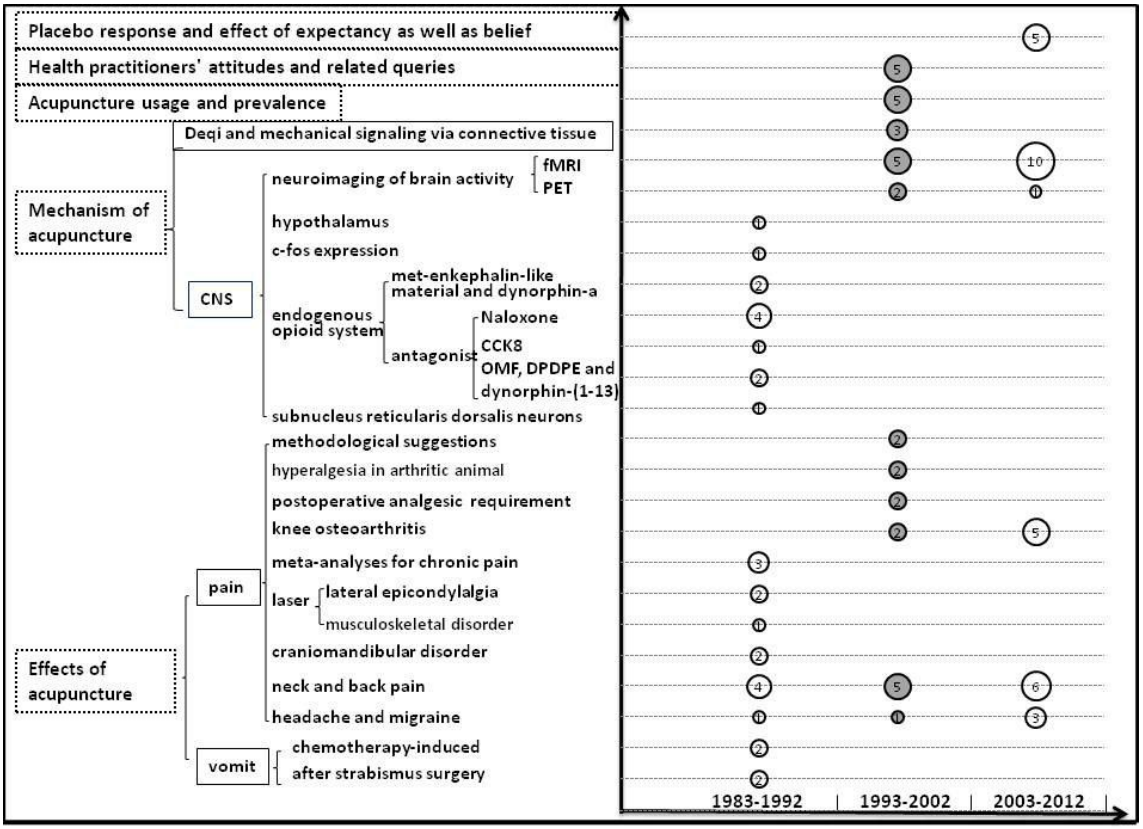

Figure 2: Research fronts worldwide over three decades

Effects of acupuncture

Clinical studies on acupuncture have continually evaluated the efficacy of the practice. During 1983–1992, EA and the noninvasive stimulation of acupoints efficaciously treated chemotherapy-induced sickness but not postoperative vomiting in children. The analgesic effect of acupuncture, particularly for headaches or neck or back pain, had been a predominant topic since the 1980s. The efficacy of acupuncture against craniomandibular and musculoskeletal disorders and lateral humeral epicondylalgia was also studied. During 1993–2002, the analgesic effect of transcutaneous acupoint electrical stimulation or transcutaneous electrical nerve stimulation for reducing the opioid requirement and opioid-related side effects after lower intraabdominal surgery received increased attention. During 2003–2012, the research fronts in clinical studies were mainly focused on the beneficial effects of acupuncture treatment of headaches and migraines, neck and back pain, and knee osteoarthritis-related pain.

Mechanisms of acupuncture

The therapeutic mechanisms of acupuncture have also been a topic of substantial interest. Numerous extensive experimental studies from various aspects and viewpoints have elucidated the mechanisms, such as the functions of neural and humoral factors. During 1983–1992, researchers paid more attention to the functions of the central nervous system (CNS) in acupuncture. The acupuncture efficacy was believed to be primarily mediated by the endogenous

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opioid peptide (EOP) system. The involvement of the hypothalamus, c-fos expression, and subnucleus reticularis dorsalis neurons in the management of acupuncture analgesia was simultaneously noted. During 1993–2002, brain activity investigated using functional neuroimaging methods including functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) became a research front, replacing EOP system-related research. In addition, the hypothesis that mechanical signaling through connective tissue may be a mechanism was stated, and a needle grasp called *deqi* in traditional Chinese medicine was suggested as a measurable biomechanical response associated with the therapeutic effect. During 2003–2012, the most attention was still paid to brain activity studies, particularly those using fMRI.

Acupuncture use and prevalence

The widespread use of acupuncture since the early 1970s increased the emphasis on the need for more information regarding its use and prevalence in the subsequent decades. The use of acupuncture, one of the most crucial complementary and alternative medicine (CAM) therapies, was highly prevalent among women with breast cancer and older adults. The potential physician malpractice liabilities associated with CAM caused by relatively poor communication between patients and doctors were also noted.

Attitudes of health practitioners and related queries

Another research front emerged following the widespread use of acupuncture in the second decade (1993–2002): how and to what extent do physicians accept CAM therapy in general practice? Widespread acceptance of acupuncture was reported among general practitioners from Australia. Similar trends were observed among pediatricians in the United States. However, some researchers observed publication bias among the randomized clinical trials (RCTs) for CAM: remarkably high proportions of positive results were published by authors from some countries and regions, including China, Japan, Russia, and Taiwan.

Placebo response and effect of expectancy and belief

In the final decade (2003–2012), in addition to material, physical, and substantial structures, a relatively new research front developed. Psychological and spiritual factors, which are usually embedded in culture, history, individual experience, and even religion, were extensively considered for exploring the nonspecific mechanisms of effects induced through acupuncture-like manipulations.

Country-wise distribution of the research fronts

The patterns of the research fronts varied among the countries. We analyzed specific concerns on the basis of the geographical differences.

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1983–1992

In the United States, researchers attempted to use acupuncture as a detoxification modality for coping with opiate addictions. In addition to the EOP system, increased synaptosomal (Na^++K^+)-ATPase and acetylcholinesterase activities in the cerebral cortex as well as suppressed c-fos expression in the spinal cord were also discussed. Furthermore, EA, in addition to EOP, was reported as affecting other neurotransmitter substances and pathways, such as catecholamines in brain regions. Simultaneously, some experimental results indicated the sympathetic vasomotor effects of manual and electrical acupuncture evaluated through thermography (Figure 3).

In China, the EOP system gained substantial attention from researchers, who observed a considerable increase in Met-enkephalin-Arg-Pheand dynorphin a immunoreactivity in human lumbar cerebrospinal fluid. In addition, opioid antagonists were used to identify the functions of EOP or dynorphin alone. In addition to opiate peptides, the functions of the diencephalon and mesencephalon were also explored by creating local lesions in rats.

In Japan, researchers focused on researching the function of diencephalon, particularly the hypothalamus–hypophysis system. Researchers also studied the acupuncture analgesia-associated afferent and efferent nerve pathways, which could be abolished through a drenalectomy, resulting in the reduction of sodium ions and hypophysectomy.

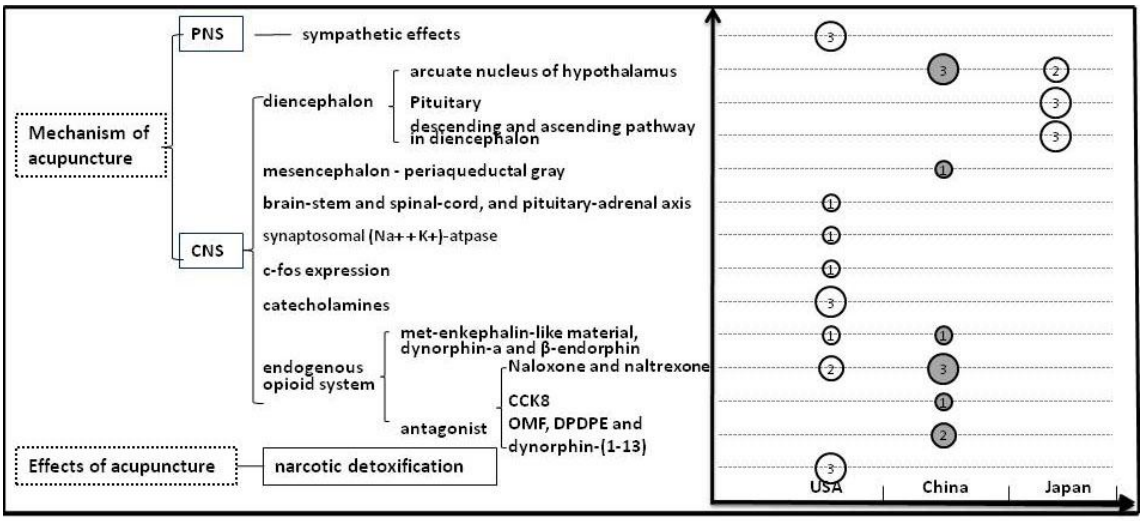

Figure 3: Research fronts for selected three countries during 1983-1992

1993–2002

First, regarding the effects of acupuncture, among the researchers in the East Asian countries, only those in South Korea conducted clinical research on bee venom acupuncture treatment. Nevertheless, the effects of acupuncture, particularly analgesia, appeared to be a predominantly studied topic among Western researchers, though they did not focus on a particular condition or treatment (Figure 4). American researchers concentrated on recurrent headaches, chronic neck pain, postoperative oral surgery pain, postoperative opioid analgesic requirements, and HIV-related peripheral neuropathy. English researchers focused the most on the effect of acupuncture on the relief of chronic neck and back pain, temporomandibular joint dysfunction, and acute dental pain. In addition to pain relief, English authors also identified the use of acupuncture for treating nicotine withdrawal symptoms. Furthermore, German researchers focused on the clinical effects of acupuncture for migraines and headaches, pain related to osteoarthritis of the hip, and

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lower back pain.

Second, regarding the mechanisms of acupuncture, U.S. researchers conducted trials on *deqi* and related mechanical signaling through connective tissue and successfully used fMRI to identify CNS pathways. In addition, they extensively focused on the effect of different frequencies of EA and its inhibitory effects on sympathetic cardiovascular reflex responses. Chinese researchers continually attempted to obtain additional evidence regarding the functions of neurotransmitters such as cholecystokinin octapeptide and endogenous orphanin. They also extensively investigated the attenuation of morphine-induced immunosuppression by using EA and studied the neuroprotective effects of EA on focal cerebral ischemia. Japanese researchers also conducted some high-impact research regarding the functions of neurotransmitters such as 5-hydroxytryptamine (5-HT) and substance P. They focused mainly on the responses of the peripheral nervous system (PNS), including viscerosomatic reflex and afferent and efferent nerve pathways, rather than on those of the CNS; in addition, they reported the skeletal muscle vasodilation effect of EA. South Korean researchers were more focused on cell proliferation and neuropeptide Y expression in the dentate gyrus. Researchers in England and Germany did not focus much on the mechanisms of acupuncture.

Finally, in the United States, related results from national or regional surveys appeared frequently and caused extensive concern in the scientific community, such as CAM use among women with breast cancer and elderly people. In England, however, attitudes toward using CAM gained more attention among physicians. Simultaneously, methodological limitations in related trials increased concern. Both English and Japanese experts were deeply concerned about the risks associated with acupuncture.

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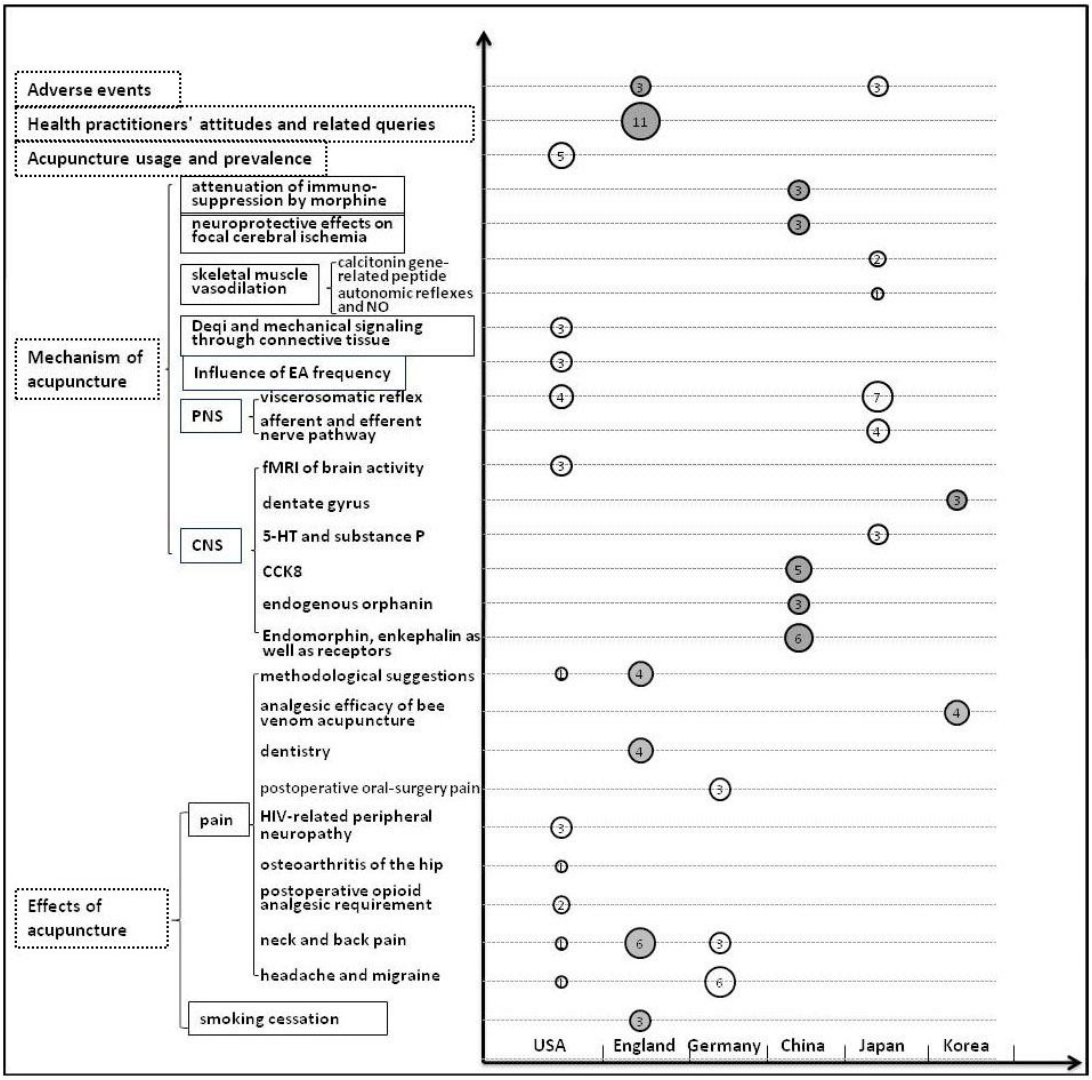

Figure 4: Research fronts for selected six countries during 1993-2002.

2003–2012

First, regarding the effects of acupuncture, researchers attempted to use acupuncture for treating conditions other than pain alone (Figure 5). In the United States, researchers were interested in the efficacy of acupuncture for treating nausea and vomiting, vasomotor symptoms, depression, and cancer. In England, researchers continued to focus mainly on acupuncture analgesia; in addition, analyses of large-scale RCTs showed acupuncture to be relatively cost-effective. In Germany, in addition to pain, allergic rhinitis, nausea and vomiting, and gastrointestinal diseases were also reported to respond well to acupuncture treatments. German researchers were also interested in the cost-effectiveness of acupuncture treatment. In China, researchers revealed that EA could attenuate morphine withdrawal symptoms and suppress morphine-induced conditioned place preference. Moreover, the optimal stimulation frequency of EA gained attention. In Japan, researchers demonstrated that both standard acupuncture and dry needling may be useful adjuncts to other therapies for chronic pain. Simultaneously, some trials were conducted to investigate the dual effects of

acupuncture on the gastrointestinal canal. In South Korea, researchers continually researched aqua-acupuncture, such as deer antler aqua-acupuncture, for arthritis treatment; in addition, acupuncture was reported to be effective against Parkinson's disease.

Second, regarding the mechanisms of acupuncture effectiveness, great efforts were made to use fMRI and identify the neural substrates and neurobiological mechanisms of acupuncture actions. Simultaneously, American researchers remained focused on the effect of acupuncture on the viscerosomatic reflex and connective tissue mechanotransduction. In England, the mechanisms of acupuncture stimulation were not studied over the three decades.

Nevertheless, German researchers began investigating components that appear to participate in the production of acupuncture effectiveness, such as the viscerosomatic reflex and brain activity, as detected through fMRI. In China, researchers were highly interested in neuroimaging studies using fMRI and electroencephalography. Simultaneously, Chinese researchers focused on pain-related studies of pituitrin. In Japan, the effects of acupuncture on the PNS were the main focus during the second and third decades (1993–2012). In addition to the viscerosomatic reflex and the efferent and afferent nerve pathways, Japanese researchers closely focused on the release and activation of peripheral opioid receptors. In South Korea, researchers also attempted to understand the neurobiological mechanisms through fMRI. In addition, results reported by South Korean researchers suggested that the spinal cholinergic systems, opioid receptors, adrenergic and 5-HT pathways, and c-fos expression mediate the acupuncture-induced antinociceptive effect.

Finally, the effects of expectancy, belief, and placebo responders on the action of acupuncture, such as how expectations modulate acupuncture treatment, drew great attention in the Western scientific community. The results from RCTs and fMRI studies showed a significant association between improvement and higher outcome expectations.

In the United States, surveys were again conducted to elucidate the prevalence and patterns of and correlation between different types of CAM, along with the communication behaviors between and styles of physicians and patients.

In England, researchers began closely studying the importance of qualitative evaluations and a constant comparative method by using a questionnaire design and the *deqi* needling sensation. Simultaneously, poor methodology and insufficient evidence for the efficacy of acupuncture remain great concerns. In Germany, researchers conducted surveys on adverse events induced through acupuncture.

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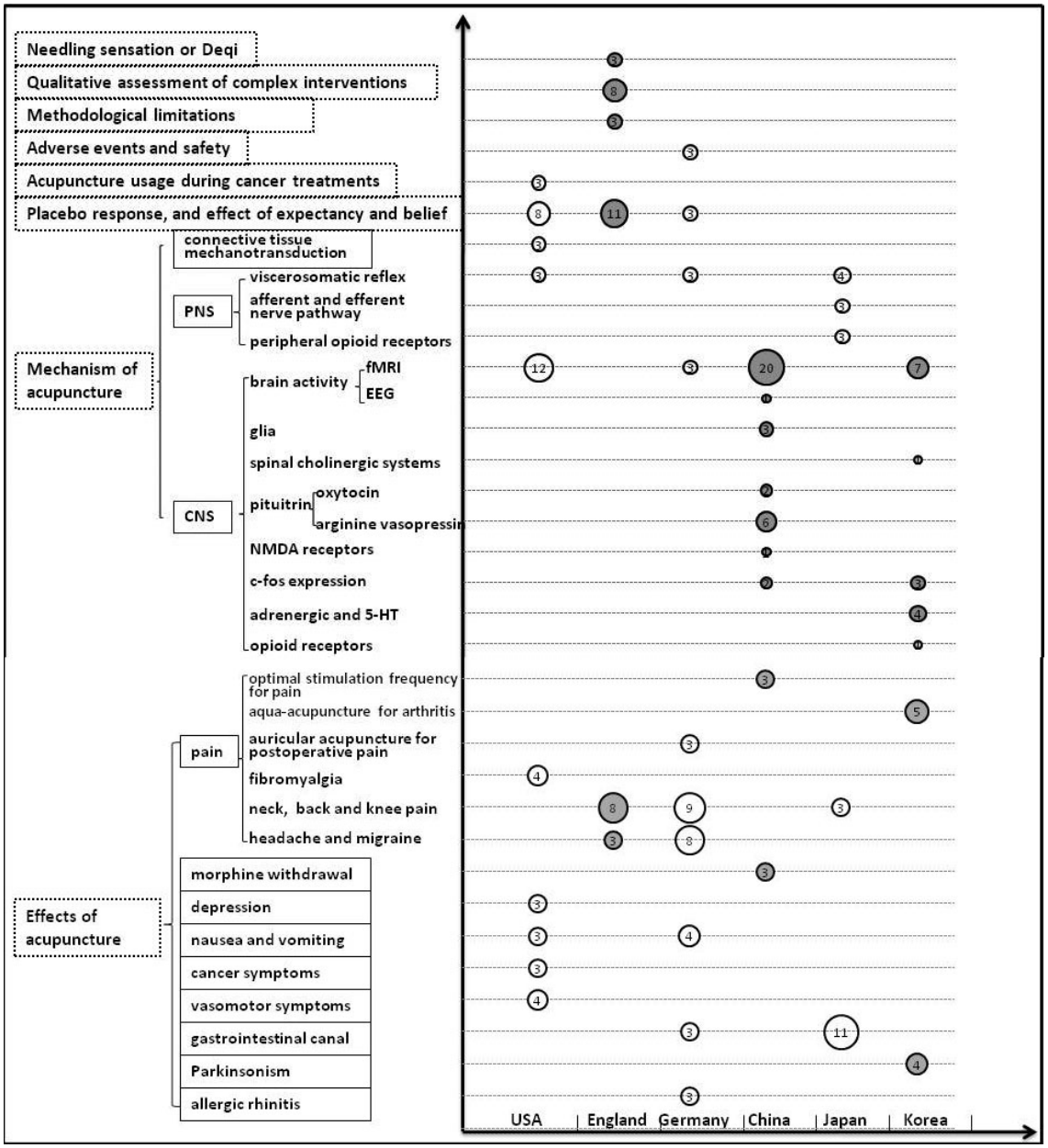

Figure 5: Research fronts for selected six countries during 2003-2012

Discussion

This study identified research fronts through bibliographic coupling, a method that is distinct from traditional approaches and which reviews research on basis of related literature. The country distribution of HCPs indicated that acupuncture research conducted by researchers from Western countries, particularly the United States—but not from East Asian countries with long histories of acupuncture use—attracted more attention and dominated the research fronts and topics in the acupuncture field.

Regarding the research fronts detected worldwide, the effectiveness of acupuncture in the relief of chronic pain, such as neck and back pain, headaches and migraines, and knee osteoarthritis symptoms, was a continually

dominant topic, which partly corroborates with a previous study demonstrating that among all pain conditions, postoperative pain, lower back pain, knee osteoarthritis, and chronic headache were the most popular topics.(Lin and Chen 2009; Patil et al. 2016) Regarding the research on the mechanisms of acupuncture, the function of the CNS was consistently the focus worldwide. During 1983–1992, the EOP system was the only research focus. However, after1993, the effect of acupuncture on the brain activity gained attention with the advancement of neuroimaging techniques, particularly fMRI. Our BC measure-based findings were in agreement those of previous studies, which did not report the chronology of findings regarding the neural mechanisms underlying acupuncture analgesia.(Bai and Lao 2013; Zhang, Wang, and McAlonan 2012) Yang et al. (2013) reported that *deqi* has recently been studied extensively by using questionnaires, neuroimaging studies, and physiological examinations to qualify and quantify *deqi* sensations; (Shi et al. 2016) moreover, we observed that *deqi* and mechanical signaling through connective tissue were the main topics during 1993–2002, conducted primarily by American and English researchers.

Acupuncture is regarded as one of the most predominant CAM treatments. The first nationally representative survey of CAM was conducted in the United States in 1990, (Eisenberg et al. 1993) at a time when the understanding and utilization of acupuncture was growing in Western countries. Subsequently, both large- and small-scale surveys were conducted to obtain insights into CAM-related healthcare-seeking behaviors. (Nahin, Stussman, and Herman 2015) Our study also demonstrated that acupuncture use and prevalence were major topics during 1993–2002. During the same period, paradoxical results and widespread clinical use led to a subsequent emphasis on methodological flaws and health practitioners' attitudes toward acupuncture. Furthermore, the suggestion of a placebo response evoked by acupuncture because of expectancy and belief aroused concern in the scientific community during 2003–2012.

The six most productive countries showed various patterns regarding the identified research fronts. In general, the substantial differences between the Western and East Asian countries maybe attributed to differences in the indigenous healing systems, varying research paradigms, assumptions, and prevalent diseases. England and Germany showed higher mutual similarity. In addition, acupuncture developed in a similar manner in both China and South Korea, in accordance with findings by Park et al., (H.-L. Park et al. 2012; J. J. Park et al. 2012) who attributed this phenomenon to similarities in cultural background and national policies.

Researchers from the United States, the leading country in the acupuncture domain, conducted high-impact studies that were cited by numerous researchers overseas, such as research on the function of the nervous system and neuroimaging through fMRI. The focus of clinical research in the United States expanded from chronic pain to other conditions such as vasomotor symptoms, cancer, and depression. English and German researchers were greatly concerned regarding the clinical efficacy, particularly analgesic effectiveness, along with adverse events and cost-effectiveness. In addition, in England, methodological limitations in trial design were a continual focus during 1993–2012. Simultaneously, researchers from all Western countries paid great attention to the effect of expectancy and belief (i.e., the placebo effect) during acupuncture management.

The researchers in the East Asian countries published fewer high-impact papers reporting results from clinical studies. Researchers from China investigated the function of EOP in acupuncture treatment in the 1970s; later, fMRI studies became the primary focus. Japanese researchers concentrated on the arcuate nucleus of the hypothalamus and pituitary, and then the PNS became a predominant research focus, as also found by Kawakita et al. (Kawakita et al. 2006) Among the studies from the East Asian countries, only those by Japanese researchers reported adverse events.

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South Korean research on acupuncture mainly focused on aqua-acupuncture.

Conclusions

Acupuncture, rooted in traditional Chinese philosophy and ancient medical practice, has been widely disseminated across Asian and European countries for thousands of years and has attracted great attention worldwide since the 1970s. As a result, the number of related publications has increased rapidly over the past decades. This study detects research fronts throughout the world and further investigates the research features of the six most productive countries in the acupuncture research domain across three decades via bibliographic coupling. Our bibliometric analysis results provide a complete picture of acupuncture research history. First, the increase in the number of conditions treated with acupuncture has attracted more attention from the scientific community. The effect of acupuncture on nausea was one of the earliest research fronts, but has failed to remain a hot topic during the last two decades. The use of acupuncture as an analgesic—such as in the treatment of neck and back pain as well as of headache and migraine—has been a constant topic of the research fronts of the past 30 years. The treatment of knee osteoarthritis with acupuncture appeared later and became a hot topic of the last two decades.

Second, new approaches and measures employed in mechanism studies have continued to be developed. Acupuncture mechanism research originally focused primarily on the endogenous opioid peptide system, and this was the most prevalent topic during 1983–1992, whereas *deqi* was studied extensively during 1993–2002 and the functional magnetic resonance imaging of brain activity has been a major topic over the last two decades.

Third, in addition to examining the literature from the perspective of the effectiveness and underlying mechanism of acupuncture, this study also identified several emerging fronts, which include studies on acupuncture from sociological, economic, and ethics-related perspectives. The topics such as prevalence, physician's attitude, and cost were major topics during 1993–2002. The impact of expectation and belief has become a new hot topic during 2003–2012. More rigorous scientific studies with strong research designs, such as in developing appropriate sham acupuncture, are required on the basis of current plausible or contradictory outcomes.

As for the country-level analyses, the results show that Western countries dominate the research fronts of acupuncture and that the concerned research topics of Western and Eastern countries show different characteristics. Research from Western countries, including the United States, England, and Germany, shows more interest in clinical trials and economic and ethics-related studies, whereas that from East Asian countries, including China, Japan, and South Korea, is focused more on mechanism studies. The research fronts differed substantially between Western and East Asian countries, and both the continuity and innovation of research was elucidated for the six most productive countries. Although we have not conducted a deeper analysis in this study because of the limitations of our knowledge and time, it is a research domain worthy of further exploration.

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Competing interests

The authors declare that they have no competing interests.

Authors' contributions

The work presented here was carried out in collaboration with FJY, ZX, ZYH, THF, CDZ and HMH. HMH defined the research theme. FJY designed methods, named the research fronts identified, interpreted the results and wrote the paper. ZX co-designed methods and built research database. ZYH identified research fronts and discussed analyses.THF co-designed methods and drew all maps. HMH and CDZ co-designed methods, discussed analyses, interpretation, as well as reviewing the manuscript. FJY, ZX, ZYH, THF, CDZ and HMH all have contributed to, seen and approved the manuscript.

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