



Scientometric analysis of researches on Tai Chi and health promotion based on literatures from 1991 to 2021

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Background: Although there are a growing number of studies on Tai Chi and health promotion, only a few have conducted analysis from the perspective of bibliometrics and scientometrics. This paper aimed to analyze bibliographic data of Tai Chi practices and health promotion in the past 30 years from the perspective of scientometrics.

Methods: In total, 1,936 relevant articles were downloaded from the Core Collection of Web of Science [WoS; Science Citation Index Expanded (SCIE) and Social Science Citation Index (SSCI)] and analyzed using CiteSpace V.

Results: China had the highest number of published articles, followed by the USA and Australia, and the vast majority of influential authors were from the USA. Most journals publishing papers on Tai Chi research were those concerned with geriatrics gerontology, sport sciences, and integrative complementary medicine. Our analysis indicated that studies on Tai Chi and health promotion could be divided into 4 knowledge groups: preventing falls in older adults, promotion of physical fitness, promotion of psychological well-being, and chronic disease intervention. Effects of Tai Chi on cognitive function are emerging trends in this field. Furthermore, topics of high-quality trials, advanced technologies, mechanistic research, and translation should be carefully considered in future research.

Conclusions: This study may provide potentially valuable information for academics in the field of Tai Chi research, and give meaningful guidance and suggestions for future studies.

Keywords: Tai chi; health promotion; scientometric analysis; knowledge group; CiteSpace

Submitted Jul 12, 2022. Accepted for publication Oct 27, 2022.

doi: 10.21037/apm-22-843

View this article at: <https://dx.doi.org/10.21037/apm-22-843>

Introduction

As a branch of Chinese Wushu (martial arts), Tai Chi has a history of more than 300 years in China (1,2). On the evening of December 17, 2020, Tai Chi was officially included on the UNESCO (The United Nations

Educational, Scientific and Cultural Organization) Representative List of the Intangible Cultural Heritage of Humanity. Historically, Chen Wangting [1600–1680] from Chenjiagou Village, Jiaozuo City, Henan, has been regarded as the founder of Tai Chi (Chen style) (3). During

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the continuous development and evolution of Tai Chi, it finally formed 5 main styles, known as Chen, Yang, Wū, Wu, and Sun (3). Among the 5 styles, Yang is the most popular while Chen is the oldest. The movement of Tai Chi is slow, supple, and graceful, which helps to bring about calm and peace of mind as well as to enhance the flow of Qi in our bodies (1). Although it originated in China, Tai Chi has gained international recognition and become a popular exercise worldwide, spreading to more than 150 countries and regions on all 5 populated continents (3).

Over the past 30 years, a multitude of articles have reported the potential benefits of Tai Chi for health in different populations (1). Numerous meta-analyses and systematic reviews have been performed to explore the efficacy of Tai Chi practices on falls prevention (4-6), cardiorespiratory fitness (CRF) (7,8), chronic musculoskeletal pain (9,10), rheumatoid arthritis (11,12), psychological well-being (13,14), and cognitive function (15-17).

However, only a small number of articles have analyzed Tai Chi studies from the perspective of bibliometrics and scientometrics (18-20). Through the analysis of bibliographic data with statistical methods, bibliometrics can provide guidance and suggestions on new scientific research trends, future directions, and decision-making (18,21). Scientometrics is a subfield of bibliometrics, involving the measurement of the impact of authors, articles, and academic journals, as well as the understanding of scientific citations, knowledge structures, and emerging trends of a given field (22). CiteSpace was designed by Professor Chaomei Chen (Drexel University, Philadelphia, PA, USA) and is free for personal use (22). It can help researchers to conduct bibliometric or scientometric analyses by drawing various networks derived from literature (23).

The objectives of this paper were to analyze bibliographic data of Tai Chi and health promotion over the past 30 years from the perspective of scientometrics. In total, 1,936 relevant articles from Web of Science (WoS; 1991 to 2021) were downloaded and selected as data sources. Then, with the help of CiteSpace V, scientific knowledge networks were drawn and comparative analyses of authors, institutions and countries, journals and categories, keywords, and references were conducted. Notably, through analysis, we aimed to answer the following 3 key questions:

- (I) Question 1 (Q1): How many knowledge groups are there for scientific research on Tai Chi and health promotion?
- (II) Question 2 (Q2): What are the emerging trends in the field of Tai Chi and health promotion?

- (III) Question 3 (Q3): What should be carefully considered for Tai Chi research in the future?

This study may provide potentially helpful information for researchers in the field of Tai Chi practice and health promotion and offer meaningful guidance and suggestions for future scientific research.

Methods

Data sources

As a web-based product, the WoS has always been recognized as the world's most authoritative academic literature-indexing tool and can provide researchers with the most relevant research results in the academic field. The Core Collection of WoS includes Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SSCI), which are relatively of high quality. In this study, data were downloaded from WoS (SCIE or SSCI). The topic words for searches were "(Tai Chi) OR (taichi) OR (tai-chi) OR (tai ji) OR (taiji) OR (tai-ji) OR (taijiquan) OR (taichiquan) OR (taijichuan) OR (taichichuan)", and the time span was from 1991 to 2021 (the date of downloading the data in this study was May 2, 2022). Furthermore, only articles written in English language were chosen for analysis. Studies not focusing on Tai Chi and health promotion were excluded. After searching and screening, 1,936 papers were obtained (Table 1).

Data statistical analysis

In this paper, the application CiteSpace V was employed to analyze the articles obtained from WoS. Downloaded data were preprocessed and imported into CiteSpace V software. Networks of collaboration, co-occurrence and cocitation of authors, institutions and countries, journals and categories, keywords, and references were analyzed in detail (22).

Results

Analysis of institution and country/region

The numbers of publications for institutions and countries/regions are shown in Tables 2,3, respectively. From the data, we can see that China had the highest number of published articles (n=801), which accounted for more than one-third of the total number of papers, followed by USA (n=753) and Australia (n=126). For Institutions, Harvard University published 166 papers on Tai Chi research, followed by

Table 1 Literature sources, search strategy and results for this study

Items	Contents
Literature sources	Core Collection of Web of Science: SCIE and SSCI
Topic words	TS=(Tai Chi) OR (taichi) OR (tai-chi) OR (tai ji) OR (taiji) OR (tai-ji) OR (taijiquan) OR (taichiquan) OR (taijichuan) OR (taichichuan)
Time span	1991–2021
Literature language	English
Literature type	Article
Results	1,936 Journal articles (after screening to remove some irrelevant literatures)

SCIE, Science Citation Index Expanded; SSCI, Social Science Citation Index.

Table 2 Number of published papers for Tai Chi research in each institution

Institution	Country/region	Number of published papers	Percentage of total (n=1,936)
Harvard University	USA	166	8.574%
Chinese Academy of Sciences	China	141	7.283%
Chinese University of Hong Kong	China	77	3.977%
University of California System	USA	74	3.822%
Hong Kong Polytechnic University	China	72	3.719%
Shanghai University of Sport	China	62	3.202%
Brigham Women's Hospital	USA	51	2.634%
Beth Israel Deaconess Medical Center	USA	50	2.583%
University of Hong Kong	China	47	2.428%
Massachusetts General Hospital	USA	44	2.273%
University of California Los Angeles	USA	44	2.273%

Table 3 Number of published papers for Tai Chi research in each country/region

Country/region	Number of published papers	Percentage of total (n=1,936)
China	801	41.374%
United States of America	753	38.895%
Australia	126	6.508%
Canada	87	4.494%
England	87	4.494%
South Korea	66	3.409%
Japan	59	3.048%
Germany	46	2.376%
Spain	39	2.014%
Italy	34	1.756%

the Chinese Academy of Sciences (n=141), the Chinese University of Hong Kong (n=77), University of California System (n=74), and Hong Kong Polytechnic University (n=72). As a professional college for sports, Shanghai University of Sport published 62 papers.

Analysis of category and journal

Most of these articles were focused on the categories of geriatrics and gerontology (25.103%), sport sciences (13.843%), integrative complementary medicine (12.345%), rehabilitation (9.452%), and general medicine internal (7.076%).

Over the past 30 years, more than 100 international English journals (indexed by WoS) published papers on Tai Chi practices and health promotion. Among the

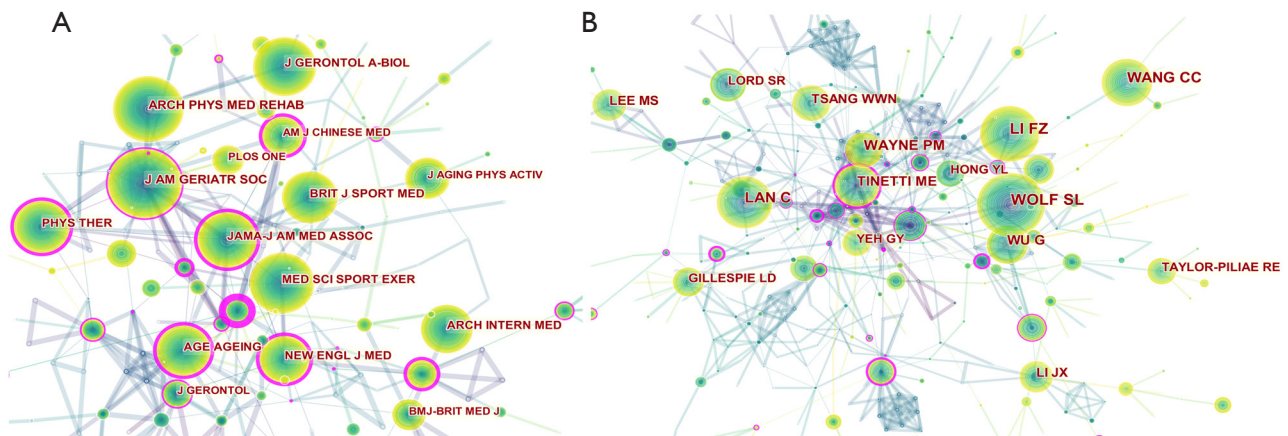


Figure 1 Network map of cocited journals and cocited authors. Cocited journals (A); cocited authors (B).

top 10 journals with the highest number of published papers, *Evidence Based Complementary and Alternative Medicine* ranked first with 56 papers, followed by *Journal of the American Geriatrics Society* (n=42), *Archives of Physical Medicine and Rehabilitation* (n=39), *Complementary Therapies in Medicine* (n=37), *Journal of Aging and Physical Activity* (n=34), *PLoS One* (n=32), *International Journal of Environmental Research and Public Health* (n=29), *American Journal of Chinese Medicine* (n=25), *Journal of Alternative and Complementary Medicine* (n=25), and *Research in Sports Medicine* (n=19). Among these journals, some are especially well-known, such as *Journal of the American Geriatrics Society* (JAGS, 42 papers), *Journals of Gerontology Series A-Biological Sciences and Medical Sciences* (17 papers), and *Archives of Physical Medicine and Rehabilitation* (APMR; 39 papers).

Both of JAGS and *Journals of Gerontology Series A* are leading journals in the category of geriatrics and gerontology, while APMR is at the forefront in the category of rehabilitation. For the category of sport sciences, *British Journal of Sports Medicine* (BJSM) and *Medicine and Science in Sports and Exercise* (MSSE) are 2 of the more impactful journals and have published 11 and 12 papers, respectively. Furthermore, some excellent articles have been published in the world's leading medical journals, namely *British Medical Journal* (BMJ; 3 papers), *Journal of the American Medical Association* (JAMA; 2 papers), and *New England Journal of Medicine* (NEJM; 2 papers).

In order to clarify the relationship of the cocitation network, cocitation analysis of journals was performed using CiteSpace V. In the finally formed network, the size of a node indicates the number of times that the journal has been cited, and the connection between nodes reflects the

strength of cocitations (22). The network of cocited journals for this study is shown in Figure 1A. From the map, we can see that the top 2 journals are JAGS and APMR, respectively, followed by MSSE, *Journals of Gerontology Series A-Biological Sciences and Medical Sciences*, and *Physical Therapy*.

Analysis of authors

Globally, more than 600 authors have contributed to studies of Tai Chi and health promotion. The top 8 authors published a combined total of 216 papers. Among them, Wayne had the highest number of papers (n=44), followed by Tsang (n=29), Li (n=29), Harmer (n=25), Yeh (n=25), Liu (n=22), Wolf (n=22), and Wang (n=20).

Meanwhile, cocitation analysis of authors was performed to explore the influence of researchers (Figure 1B and Table S1). According to the count (times of cocitation), the top 15 authors were selected, and relevant information, including their representative papers, are listed in Table S1. Among these authors, Li has the highest count number (n=470), followed by Wolf (n=409), Wang (n=338), Lan (n=323), and Wayne (n=252).

Analysis of keywords

Frequency of keywords

The frequency of keywords appearing from high to low were as follows: “Tai Chi”, “exercise”, “balance”, “older adult”, “randomized controlled trials” (RCTs), “falls”, “physical activity”, and “quality of life”. Therefore, Tai Chi studies have mainly focused on the older adult population. Many of these studies assessed the positive effects of Tai Chi practice

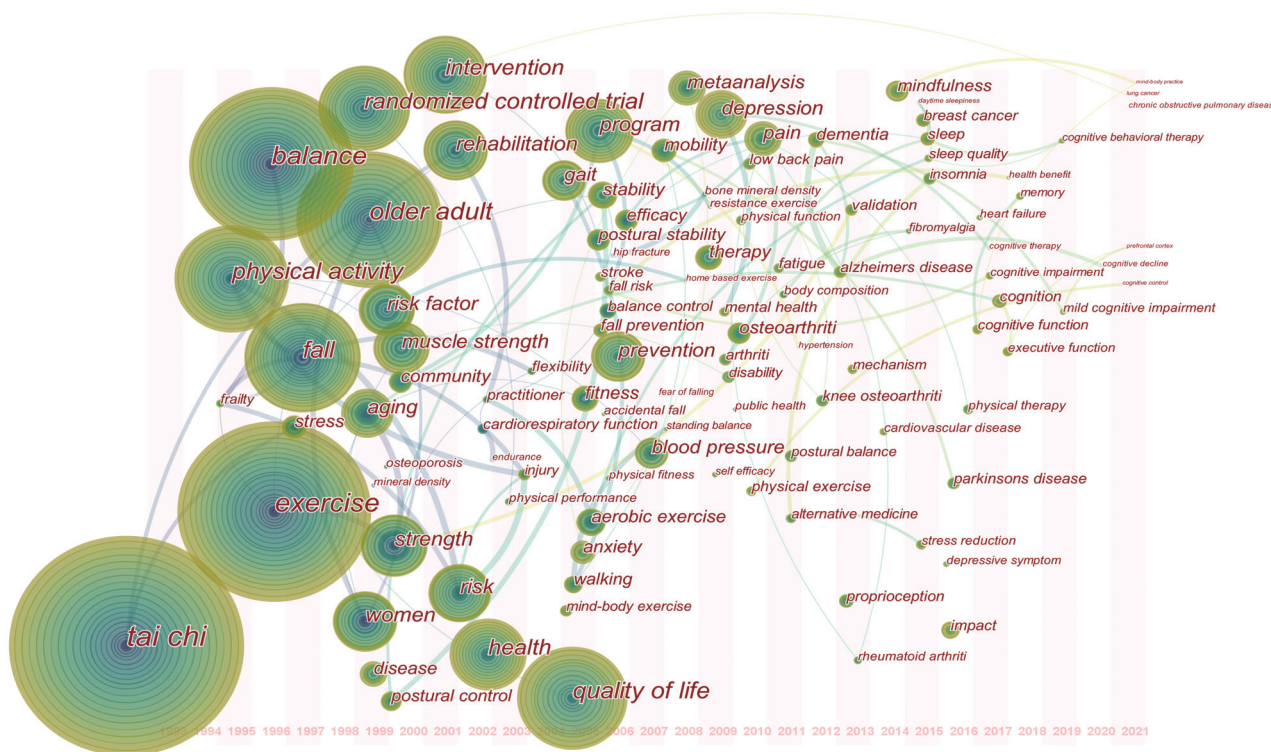


Figure 2 Timezone view of keywords.

on health promotion for older adults, such as improving balance function and preventing accidental falls, increasing aerobic capacity and muscular strength, and reducing depression, anxiety, stress, and mood disturbance (1,13).

Time period and keywords

Figure 2 shows that before 2012, the majority of keywords, such as “gait”, “muscle strength”, “blood pressure”, “bone mineral density”, and “rheumatoid arthritis”, were associated with balance and falls. From 2012 onward, new words such as “Parkinson’s disease” (PD), “dementia”, “depression”, and “Alzheimer’s disease” emerged.

Burst detection of keywords

Citation burst of keywords is a valuable indicator for exploring active topics (23). The burstness of keywords is shown in Figure 3, with keywords being sorted by strength of citation bursts. Among the top 10 keywords, “cognition” had a strength of 9.45 and started to burst from 2018 onward, which lasted until 2021, indicating that studies on Tai Chi and cognition might be an emerging trend in this field.

Analysis of references

Cocitation analysis of references is an important function of CiteSpace V and could help us to identify key literature in the research field. In this study, the 100 most-cited papers published in each year from 1991 to 2021 were selected by CiteSpace V. In the finally generated network map (Figure 4), each node represents a paper, the size of the node reflects the number of times that the paper has been cited, and the connection line between nodes reflects the strength of cocitations (22,24). The most-cited references are listed in Table S2 according to the citation counts calculated by CiteSpace V. By observing the map (Figure 4) and combing the important original articles identified in the network, we found that studies on Tai Chi and health promotion can be roughly divided into 4 knowledge groups: preventing falls in older adults, promotion of physical fitness, promotion of psychological well-being, and chronic disease intervention. The significant literature in each group and relevant information are shown in Table S3.

Detection of bursts for references was also conducted,

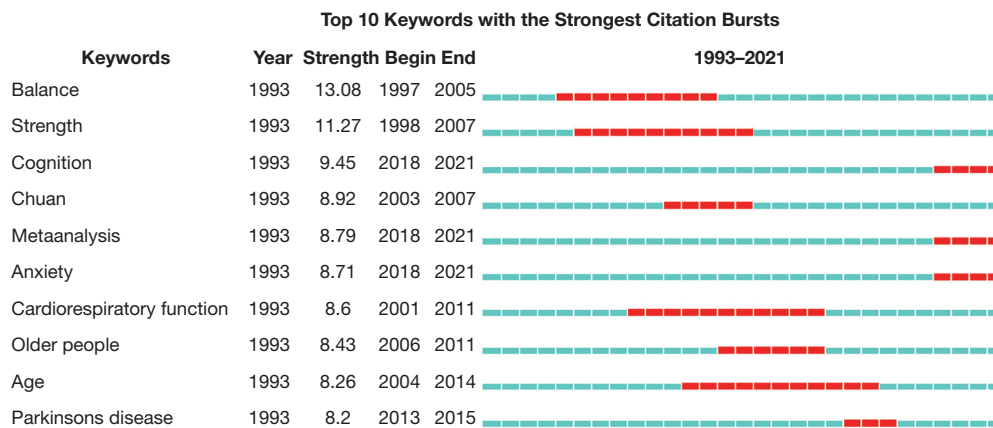


Figure 3 Top 10 keywords with the strongest citation bursts. The period time in which a keyword was found to have a burst is shown as a red line segment, indicating the beginning year and the ending year of the duration of the burst.

with the references being sorted by strength of bursts, the results of which are shown in *Figure 5*. Among the top 25 references, we were particularly interested in the tenth one with the strength of 20.64 because it started to burst from 2018 onward and lasted until 2021, indicating that the content of this literature had continued to receive great attention from researchers until the time of writing. After reading this paper, we found that it focused on the “effects of Tai Chi on cognitive performance among older adults” (17).

Discussion

As an old Chinese proverb says, “running water is never stale and a door-hinge never gets worm-eaten”, indicating that exercises are important for health and longevity. Tai Chi is a kind of Chinese Wushu (martial arts) and has been practiced for over 3 centuries to maintain health in China; in recent years, it has become a popular exercise worldwide, and studies on Tai Chi and health promotion are flourishing (1).

In the research field of Tai Chi and health promotion, China and the USA have published the largest number of papers, accounting for about 80% of total publications. Tai Chi originated in China and is a representative of China’s traditional national sports (3). Since the 1980s, Chinese researchers have been exploring the health-promoting effects of Tai Chi and have obtained numerous valuable results, providing a strong scientific basis for conducting Tai Chi exercise all over China (1,3). In the USA, due to the rapidly aging population, the government’s expenditure on Medicare for the older adult population is substantial. However, it is in the government’s interest to ensure the health and welfare of its aged individuals while also reducing

expenditures, and an urgent solution has been needed to resolve this issue (25). Since the 1990s, the US government has actively advocated Tai Chi exercise, which promoted the development of Tai Chi in the USA. Meanwhile, the US government, a few scientific research departments, and universities began to pay more attention to the importance of Tai Chi and increased their financial support for relevant research in an attempt to scientifically confirm the roles of Tai Chi in promoting health (25). For example, in December 1997, Dr. Wolf from Emory University initiated a 4-year study to explore the effects of Tai Chi exercises on falls with the support of the U. Department of Health and Welfare, the National Institute of Aging, and the National Institutes of Health (December 1997 to September 1999 was the recruitment stage of the study, and the next 2 years was the trial stage) (26).

From the perspective of journal category, most of the journals which published papers on Tai Chi research belong to geriatrics and gerontology, sport sciences, integrative complementary medicine, rehabilitation, and general medicine internal. This result shows that studies on Tai Chi involved many fields and received the attention of experts from different disciplines. In the network obtained from the cocitation analysis of journals (*Figure 1A*), each node represents a journal. The larger the node is, the more times the journal has been cited, and the more important the papers published in the journal are (23). From the map, we can see that the top 2 journals are *JAGS* and *APMR*, indicating their centrality in publishing academic papers on Tai Chi and health promotion. Furthermore, papers published in the 2 journals had attracted the attention of most academics in this field. Of them, *JAGS* is an impactful

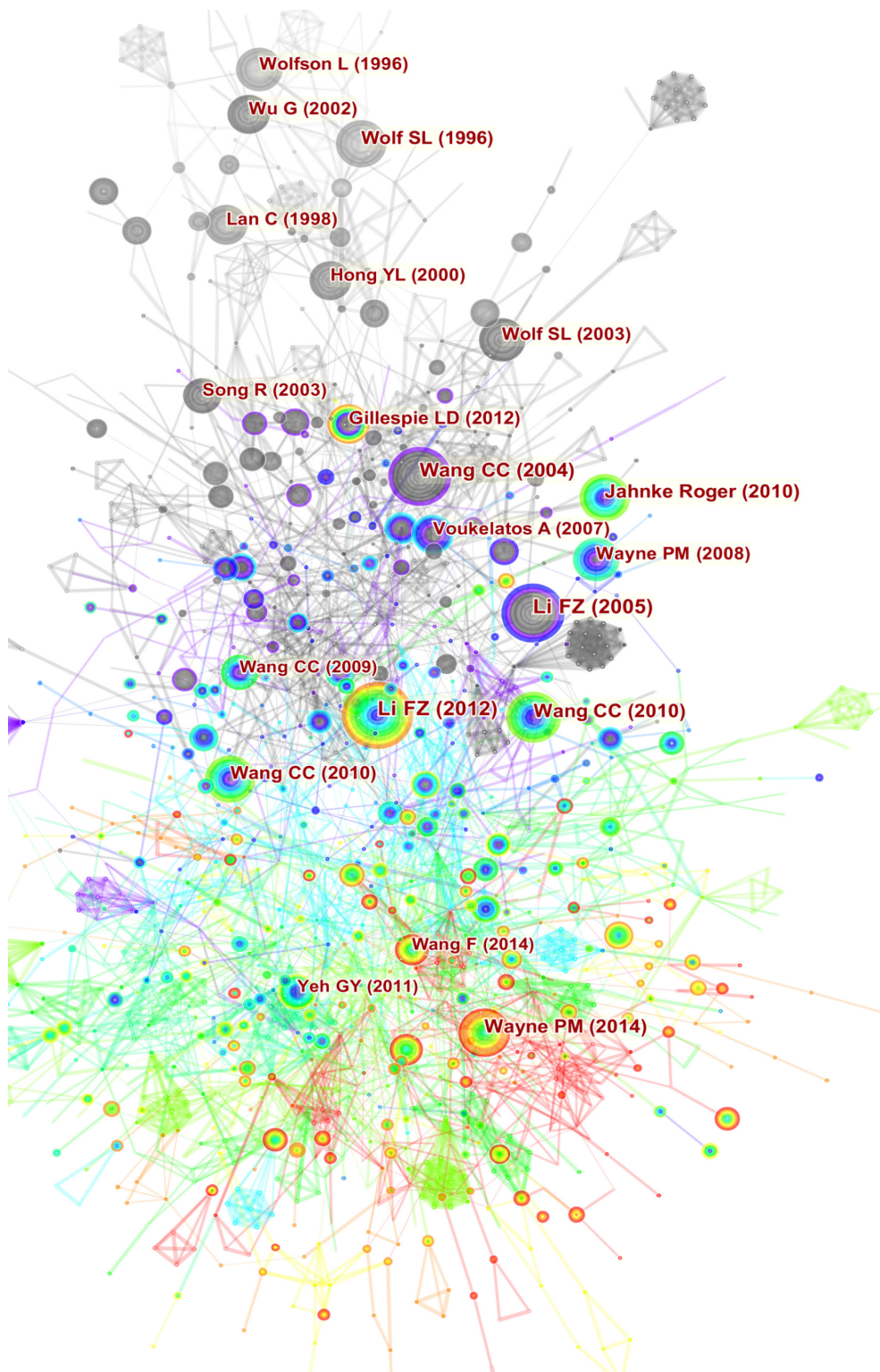


Figure 4 Network map of cocited references.

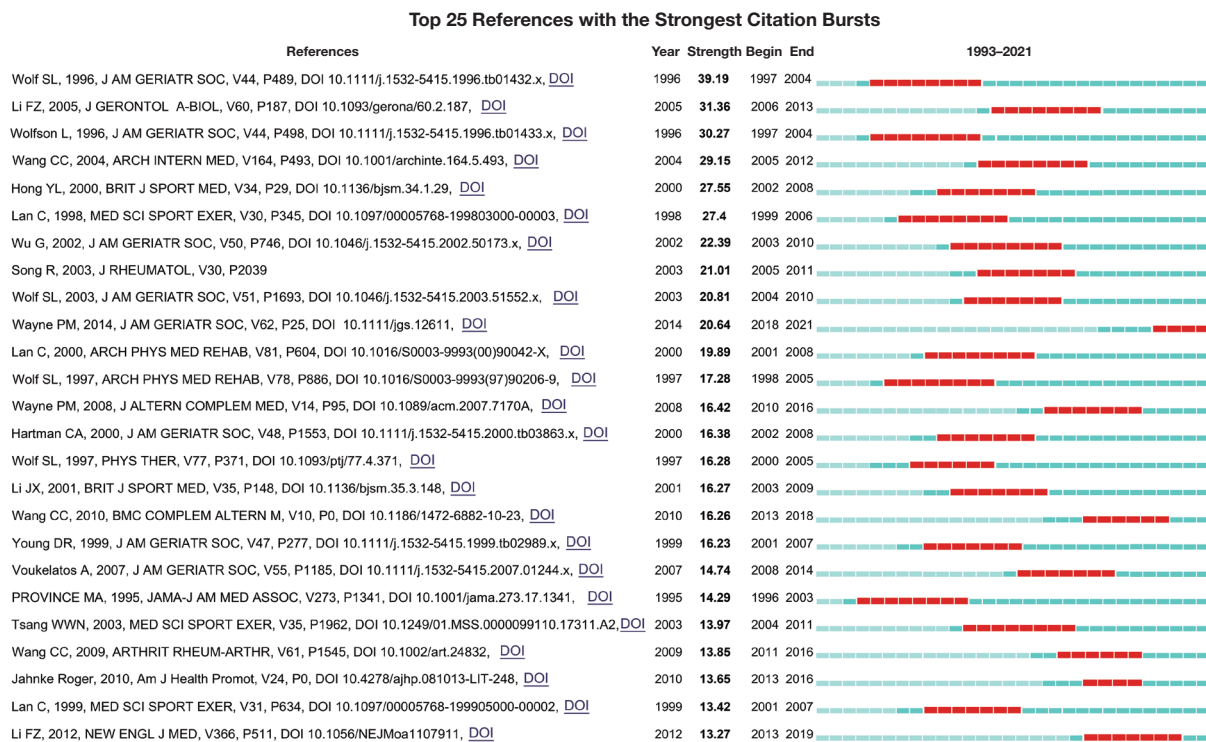


Figure 5 Top 25 references with the strongest citation bursts. The period time in which a reference was found to have a burst is shown as a red line segment, indicating the beginning year and the ending year of the duration of the burst.

journal which has focused on clinical aging research since 1953, while *APMR* is the official journal of the American Congress of Rehabilitation Medicine and has a history of more than 100 years. In addition, some excellent studies focusing on the comprehensive effects of Tai Chi exercises on osteoarthritis and fibromyalgia (FM), as well as on reducing the incidence rate of falls in patients with PD, were published on the world's leading medical journals (27–29). This indicates that Tai Chi practices may have positive effects on chronic disease intervention and health promotion, and might be used as medicine for treating some chronic noncommunicable diseases.

In the network map obtained from cocitation analysis of authors (*Figure 1B*), each node represents an author. The larger the node is, the more times the author has been cited, and the greater is the influence of the author. *Figure 1B* and *Table S1* show that the vast majority of influential authors, such as Li, Wolf, Wang, and Wayne, were from the USA. Li and Wolf were mainly engaged in studying the roles of Tai Chi exercises in improving balance and preventing falls among older adults, as well as in translating effective Tai Chi interventions into community-based falls-

prevention programs (30–32). Research from Wang's group mainly focused on the effects of Tai Chi in treating FM and knee osteoarthritis (28,29,33). The primary purpose of Wayne's study was to evaluate how Tai Chi exercises impact chronic health conditions, as well as exploring mechanisms of observed therapeutic effects from the perspective of physiology and psychology (17,34). Furthermore, 3 Chinese experts, Lan from National Taiwan University Hospital, Tsang from Hong Kong Polytechnic University, and Hong from the Chinese University of Hong Kong, appeared to also be well-known authors in this field, and citations of their papers were among the most numerous.

The world is aging, and it is predicted that the number of the aging population worldwide will reach 1.6 billion by 2050 (35). Mounting focus has been placed on the problem of aging. In this study, analysis of keywords showed that the main participants in Tai Chi studies were older adults and that a great number of papers focused on falls, balance, and quality of life. For example, Hartman's study showed that moderate-intensity Tai Chi practices could improve the quality of life of older people with osteoarthritis and proposed that Tai Chi might be an auxiliary method with

safety and effectiveness for treating osteoarthritis (36). In 2005, the US researcher, Li, reported that Tai Chi practice (3 times per week, 6 months) could effectively reduce the number of falls, the fear of falling, and falling risks among older adults (aged 70 years or older). Furthermore, it could also improve physical performance and enhance balance (31).

The time period analysis of key words showed that keywords could be divided into 2 groups: a motor system group (years 1991–2012) and a nervous system group (years 2012–2021). In the former group, the main keywords were “balance”, “fall”, “muscle strength”, “osteoarthritis”, and “rheumatoid arthritis”, among others, all of which have relations with the bones and muscles, and particularly, the motor system. In the latter group, newer terms like “Parkinson’s disease”, “depression”, “dementia”, “Alzheimer’s disease”, and “cognition” appeared, and all of these words have associations with neurons, namely, the nervous system. These results indicated that Tai Chi research has shifted from focusing on motor systems to focusing on the nervous system.

Burstness could be used to seek keywords that increased abruptly over time (24). As displayed in *Figure 3*, the keyword “cognition” had the burst strength of 9.45, and the sudden onset of the word began from 2018 and lasted until 2021. In addition, burstness for references revealed that the paper which burst from 2018 onward and lasted until 2021 was also focused on cognition (17). These results indicated that studies on Tai Chi and cognition might be an emerging trend.

As mentioned in the Results section, research on Tai Chi and health promotion could be roughly divided into 4 knowledge groups:

(I) Preventing falls in older adults: the reported proportion of older adults who fell each year ranges from 14% to 46% worldwide, and for this population, falling has been one of the important causes of injuries, disabilities, and even death (25). Falls and falling-related injuries have placed a substantial economic burden on the healthcare system and pose a major challenge to global public health (37). There is an urgent need to find effective fall-prevention approaches to save public health costs and improve the health of older people (25). As a traditional Chinese health regimen, Tai Chi is suitable for the older adult population. From 1991 to 2006, researchers conducted numerous RCTs, and results showed that Tai Chi exercises could effectively improve balance and reduce falls. Then,

researchers tried to convert Tai Chi exercises into community-based programs, with the purpose of broadly disseminating these programs and effectively implementing them in communities. In 2006, Li *et al.* developed a fall-prevention program called “Tai Chi—Moving for Better Balance” (TCMBB), which was then successfully implemented in 6 community centers from April 2006 to April 2007 (32). To better evaluate the practicality of the TCMBB program, Li *et al.* conducted a large-scale trial from March 2010 to January 2012 and finally concluded that “TCMBB appears exportable and scalable, with potential for clinical and public health effect” (38). Studies by Li *et al.* have laid the foundation for translating Tai Chi intervention into practice. However, in order to maximize the effectiveness of Tai Chi intervention programs, there are still a great number of significant issues that need to be addressed, such as the procurement of support for Tai Chi intervention programs from communities, determining the best way to teach Tai Chi to older adults, and how to ensure exercise frequency, duration, and intensity (25).

(II) Promotion for physical fitness: generally speaking, physical fitness includes 5 components: muscular strength, CRF, muscular endurance, flexibility, and body composition. Among them, CRF is especially important, as numerous studies have shown that individuals with lower CRF have a greater chance of developing diseases, such as hypertension, diabetes, and metabolic syndrome (39–42). Lan reviewed the positive effects of Tai Chi practices on health-related physical fitness, including CRF, self-report physical function, muscular strength and endurance, visual system, proprioceptive system, vestibular system, and quality of life (1). In 2015, Zheng *et al.* conducted a meta-analysis including 20 studies and 1,868 participants and concluded that Tai Chi exercises might improve CRF in healthy adults (7). In addition to studies on the promotion effect of Tai Chi practices on muscle strength, body composition, flexibility, aerobic endurance, and balance (40–42), some researchers also explored the effects on cardiovascular function, including blood pressure, serum cholesterol, and serum lipid (43,44).

(III) Promotion for psychological well-being: it is widely acknowledged that psychological health is as important as physical health. Psychological

illness imposes a huge burden on those involved, reducing work efficiency and increasing medical costs, and thus there is an urgent need to identify cost-effective approaches to improve psychological health (13). Numerous studies have shown that Tai Chi has a positive association with psychological well-being and that Tai Chi can be used as a nonpharmacological therapy for sleep disorders and can perform an auxiliary role in the treatment of depression, anxiety, and other psychological diseases (13,45-49). In 1992, Jin reported that Tai Chi exercises may be associated with the reduction of tension, anxiety, and depression, and that the positive effects of Tai Chi may be similar to those of walking at a speed of 6 km/hour (45). In 2004, the study by Li *et al.* showed that Tai Chi practice could improve sleep duration and latency as well as reduce daytime sleepiness (46), and in 2008, Irwin *et al.* reported that Tai Chi practice might enhance the sleep quality of older adults with moderate sleep complaints (47). In 2011, Lavretsky *et al.* used Tai Chi and escitalopram together to treat geriatric depression, reporting that complementary use of Tai Chi might provide additional improvements of clinical outcomes (48). Wang *et al.* reviewed 40 studies including 3,817 participants and concluded that regular practice of Tai Chi might reduce stress, anxiety, and depression, as well as enhance mood (13). In 2019, Kong *et al.* explored several possible mechanisms by which Tai Chi practice alleviates depression, including reducing stress, altering hippocampal neurogenesis, modulating the brain networks associated with depression, and regulating the inflammatory system (49). Accumulating evidence has suggested that Tai Chi practices may improve psychological health, such as by reducing anxiety, stress, depression, and emotional disorders, and by enhancing self-esteem. However, in order to better understand the considerable value of Tai Chi for treating specific psychological conditions in different groups, more large-scale, high-quality, rigorous, well-controlled, and longer RCTs should be conducted in the future (14).

(IV) Chronic disease intervention: Tai Chi exercise can provide relatively good effects in the intervention of various chronic diseases, including cardiopulmonary diseases, neurological diseases, orthopedic diseases, rheumatological diseases, and cancers (1). In this

paper, we chose knee osteoarthritis, FM syndrome, PD, and cognition impairment as examples for detailed discussions.

Knee osteoarthritis is the main cause of disabilities among older adults (aged 65 years and over), and no particularly effective drugs for treating it currently exist. Commonly, nonsteroidal anti-inflammatory drugs and acetaminophen are used to treat osteoarthritis; however, these drugs may cause severe side-effects (50). In 2000, Hartman reported that Tai Chi exercise could enhance patients' arthritis self-efficacy (36). In 2003, Song reported that Tai Chi practices (12 weeks) could improve balance, arthritic symptoms, and physical functioning among older patients with osteoarthritis (51). In 2009, Wang *et al.* showed that practicing Tai Chi for 12 weeks (twice a week, 60 minutes each time) could reduce pain and improve physical functions, self-efficacy, and health-related quality of life (52). In order to explore the similarities and differences between Tai Chi exercises and standard physical therapy for treating knee osteoarthritis, Wang *et al.* conducted a single-blind RCT that included 204 patients from October 2010 to September 2014 (33). The results showed that after an intervention for 12 weeks, Tai Chi can effectively relieve patient's pain and improve physical function, with the effect being similar to that of physical therapy. In addition, the study showed that Tai Chi intervention could help patients to bolster their self-confidence and overcome fears of pain. Finally, Wang suggested that Tai Chi exercises should be considered a good choice for treating osteoarthritis (33).

FM is a complex syndrome involving chronic and extensive musculoskeletal pain, fatigue, sleep disturbances, and significant physical and psychological harm (29). Currently, there is no cure for FM, and moderate-intensity aerobic exercises are usually recommended for its treatment (53). From July 2007 to May 2009, Wang *et al.* conducted a large-scale RCT at the Tufts Medical Center. Fibromyalgia Impact Questionnaire (FIQ) is a well-validated and frequently used indicator that measures the overall severity of FM in patients (29). The total score of FIQ is from 0 to 100, and higher scores usually mean more severe symptoms. After an intervention for 12 weeks, the FIQ score of the Tai Chi exercises group significantly decreased in comparison with the control. In conclusion, Tai Chi practices might be an effective method for treating FM, and it is worth conducting long-term intervention studies in a larger population in the future (28). Between March 2012 and September 2016, Wang *et al.* conducted a larger RCT with 226 FM patients participating in the trial.

The results showed that both Tai Chi practices and aerobic exercises could reduce the FIQ score, with effects of Tai Chi being more obvious than those of aerobic exercises. Furthermore, a longer duration of Tai Chi intervention showed more improvement (29).

PD is a very common progressive neurodegenerative disease, with symptoms of movement impairment, postural instability, gait dysfunction, and frequent falls (54). With the progression of PD, patients may also experience depression and cognitive decline. In order to fully explore the relationship between Tai Chi exercises and the ability to maintain balance in PD patients, Li *et al.* conducted a large-scale RCT comprising 195 patients. Participants were randomly assigned to 3 groups: a Tai Chi exercises group, resistance training group, and stretching training group. Over 6 months, patients were given exercise interventions (60 minutes per session) twice weekly. The final statistical results revealed that, compared with the other 2 control groups, the Tai Chi exercises group showed more significant improvement in maximum excursion and directional control. During the 24 weeks of trial, a total of 381 falls occurred among 76 participants. The incidence rate of falls (0.22) in the Tai Chi group was lower than that in the resistance training group (0.47) and the stretching exercise group (0.33). The researchers finally concluded that Tai Chi practices could improve the balance ability of patients with moderate to mild PD and reduce the probability of falling (27).

Cognition refers to the process by which people acquire or apply knowledge. It includes feeling, perception, memory, thinking, imagination, and language. Age-related cognitive decline is an emerging global public health problem (17). In the USA, approximately 5.4 million older adults (aged 70 years and over) experience mild cognitive impairment (MCI), and 3.4 million experience dementia (17,55). By studying the network of cocited references (*Figure 3*) and analyzing original literature, we found that since 2010, a growing number of researchers began to explore the effects of Tai Chi practices on cognition. In 2010, Taylor-Piliae's study showed that Tai Chi exercises had positive effects on physical and cognitive functions. After intervention for 24 weeks, compared with the control group, Tai Chi practitioners performed better in cognitive function, and the positive effect lasted for 12 months. Taylor-Piliae's study represents the first formal research on Tai Chi exercise and cognitive function (56). Chang was the first to explore the influence of Tai Chi practice on older people with cognitive impairment, with the results indicating that regular participation in Tai Chi exercises could delay cognitive

decline among older adults (57). In 2014, a meta-analysis and systematic review was conducted by Wayne from Harvard University. Analysis showed that Tai Chi exercise might be a safe nonpharmacological therapy to enhance the cognitive function of older adults (17). As mentioned in the Results section, this paper had a citation burst with the strength of 20.64 (*Figure 5*), which lasted until 2021. Liu *et al.* conducted a meta-analysis including 33 RCTs with a total of 1,808 participants in 2021. They concluded that Tai Chi exercises might play a positive role in improving cognition among middle-aged and older people with cognitive impairment (15). However, in order to draw more-definitive conclusions, more large-scale, longer, well-designed, and methodologically sound trials should be performed in the future. Additionally, an increasing number of researchers have begun to pay attention to how Tai Chi exercises affect the cognitive function of older adults, or in other words, to explore the internal mechanisms involved (55,58,59).

Noticeably, since its initial outbreak in China in late 2019, the COVID-19 virus has spread rapidly around the world and has caused an ongoing pandemic (60). As a result of COVID-19 home confinement, sedentary behavior, physical inactivity, and negative emotions in the general population have remarkably increased (61). A growing number of studies are being carried out to verify the efficacy and safety of Tai Chi on COVID-19 during the rehabilitation period (18). For example, Solianik's study explored the effect of a Tai Chi intervention (10 weeks) on psychoemotional state, cognition, and motor learning among older people (aged 60–78 years) during the COVID-19 pandemic and suggested that Tai Chi exercise is effective in improving mental and physical functioning in this group under pandemic conditions (62). Shu's systematic review and meta-analysis suggested that Tai Chi with a high exercise amount could be used as a complementary intervention for patients with COVID-19 (63). Lee's study showed that the virtual program (Tai Chi for Arthritis and Fall Prevention Program) was a viable alternative for older persons who are socially isolated because of COVID-19 home confinement (64). Xu explained the positive role of Tai Chi exercise in responding to the COVID-19 pandemic and hoped to introduce it as an effective intervention for individuals to cope with COVID-19 (61). Finally, Castro *et al.* advocated Tai Chi as an effective and appropriate rehabilitation tool for persons affected by COVID-19 (65).

Although studies into Tai Chi are now flourishing, and many examples of this research are valuable and laudable,

in the future, a few issues of Tai Chi research should be carefully considered.

- (I) High-quality trials: Tai Chi studies with methodological weaknesses are not uncommon, and the results of such studies are not convincing (66-68). For clinical trials of Tai Chi research, some studies did not involve an appropriate intervention or did not have an appropriate comparison group (67,68) and many did not employ an RCT design (66,67), which is regarded as the gold standard for evaluating the efficacy of Tai Chi (69). In order to yield high-quality evidence, rigorous design and methodology should be used in Tai Chi research. As previously mentioned, well-controlled randomized trials with appropriate control groups are highly recommended (69). Meanwhile, the number of participants should be sufficient, and outcome measurements should be reliable and validated. In addition, for the control design, an additional exercise (comparison) could be used to identify the unique contributions of Tai Chi, just as in the excellent studies conducted by Li and Wang (29,70,71).
- (II) Advanced technologies: advanced technologies including electromyography (EMG), electrocardiogram (EKG), electroencephalogram (EEG), motion capture, respiration sensors, magnetic resonance imaging (MRI), and others should be used in Tai Chi research for better understanding the effects of Tai Chi and to help researchers design and optimize interventions for specific diseases.
- (III) Mechanistic research: numerous RCTs and meta-analyses have shown the positive effects of Tai Chi exercises on health promotion; however, little is known about the mechanisms underlying its therapeutic action. Therefore, studies aiming to discover and elucidate the mechanisms for how Tai Chi exercise improves all kinds of clinical health outcomes should be conducted in the future.
- (IV) Translation: when an intervention shows efficacy in RCTs, the next step is to translate it into practice (25). Currently, a great number of studies remain focused on demonstrating the effectiveness of Tai Chi practice as an intervention method, but little thought has been given to how Tai Chi can be disseminated to the intended recipients, how to attract program participants, and how to ensure maintenance and

institutionalization. Therefore, more studies aimed at narrowing the research-to-practice gap are urgently needed. For example, Li *et al.* developed a falls-prevention program called TCMBB which was implemented in community-based organizations such as seniors centers (32). Research showed that the TCMBB program was practical to disseminate and could be effectively implemented and maintained in communities (38,72).

Conclusions

In this paper, 1,936 pieces of literature collected from WoS between 1991 and 2021 were imported into CiteSpace V for analysis. For the research of Tai Chi and health promotion, China had the highest number of published articles, followed by the USA and Australia. The majority of influential authors were from the USA and included Li, Wolf, Wang, and Wayne. Analysis of keywords showed that Tai Chi research mainly focused on older adults, which is consistent with the fact that most of these articles belonged to the categories of geriatrics and gerontology. Next, we have answered 3 key questions raised in the Introduction. Scientific research on Tai Chi and health promotion can be roughly divided into 4 knowledge groups: preventing falls in older adults, promotion for physical fitness, promotion for psychological well-being, and chronic disease intervention (Q1). Effects of Tai Chi on cognitive function are emerging trends in this field (Q2). Finally, high-quality trials, advanced technologies, mechanistic research, and translation should be carefully considered for Tai Chi research in the future (Q3). This paper may provide potentially valuable and helpful information for academics in the research field of Tai Chi and health promotion, as well as give meaningful guidance and suggestions for future studies.

Acknowledgments

Funding: This work was supported by the Natural Science Research for Colleges and Universities of Anhui Province of China (No. KJ2019A0498, No. KJ2020A0058), Anhui Provincial Key Laboratory of Molecular Enzymology and Mechanism of Major Diseases, Anhui Normal University (No. fzm202013) and funding from National Training Base for Social Sports Instructors of Anhui Province, Anhui Normal University (No. 110-061654).

Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <https://apm.amegrouppublishers.com/article/view/10.21037/apm-22-843/coif>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Cite this article as: Wang A, Ju Y, Bi C. Scientometric analysis of researches on Tai Chi and health promotion based on literatures from 1991 to 2021. *Ann Palliat Med* 2022;11(12):3648-3662. doi: 10.21037/apm-22-843

Table S1 Co-citation analysis of authors

Count	Cited author	Institution	Country	Representative paper	Journal
470	Li FZ	Oregon Research Institute	USA	Tai chi and postural stability in patients with Parkinson's disease	New England Journal of Medicine
409	Wolf SL	Emory University	USA	Reducing frailty and falls in older persons: an investigation of tai chi and computerized balance training	Journal of the American Geriatrics Society
338	Wang CC	Tufts University	USA	A randomized trial of tai chi for fibromyalgia	New England Journal of Medicine
323	Lan C	National Taiwan University Hospital	China	Tai chi chuan to improve muscular strength and endurance in elderly individuals: a pilot study	Archives of Physical Medicine and Rehabilitation
252	Wayne PM	Harvard University	USA	Effect of tai chi on cognitive performance in older adults: systematic review and meta-analysis	Journal of the American Geriatrics Society
195	Tinetti ME	Yale University School of Medicine	USA	Preventing falls in elderly persons	New England Journal of Medicine
170	Tsang WWN	Hong Kong Polytechnic University	China	Effects of tai chi on joint proprioception and stability limits in elderly subjects	Medicine and Science in Sports and Exercise
162	Wu G	University of Vermont	USA	Evaluation of the effectiveness of tai chi for improving balance and preventing falls in the older population	Journal of the American Geriatrics Society
140	Yeh GY	Harvard University	USA	Effects of tai chi mind-body movement therapy on functional status and exercise capacity in patients with chronic heart failure: a randomized controlled trial	The American Journal of Medicine
134	Lee MS	Korea Institute of Oriental Medicine	Korea	Tai chi for osteoarthritis: a systematic review	Clinical Rheumatology
134	Li JX	University of Ottawa	Canada	Changes in muscle strength, endurance, and reaction of the lower extremities with tai chi intervention	Journal of Biomechanics
131	Taylor-Piliae RE	University of Arizona	USA	Change in perceived psychosocial status following a 12-week tai chi exercise programme	Journal of Advanced Nursing
128	Lord SR	University of New South Wales	Australia	The effect of group exercise on physical functioning and falls in frail older people living in retirement villages	Journal of the American Geriatrics Society
124	Hong YL	Chinese University of Hong Kong	China	Balance control, flexibility, and cardiorespiratory fitness among older tai chi practitioners	British Journal of Sports Medicine
107	Gillespie LD	University of Otago	New Zealand	Interventions for preventing falls in older people living in the community	Cochrane Database of Systematic Reviews

Table S2 Most cited references

Citation counts	Year	Reference	Knowledge group
97	2012	Li FZ, 2012, NEW ENGL J MED, V366, P511, DOI 10.1056/NEJMoa1107911	Chronic disease intervention
91	2005	Li FZ, 2005, J GERONTOL A-BIOL, V60, P187, DOI 10.1093/gerona/60.2.187	Preventing falls of the elderly
77	2004	Wang CC, 2004, ARCH INTERN MED, V164, P493, DOI 10.1001/archinte.164.5.493	Chronic disease intervention
74	2014	Wayne PM, 2014, J AM GERIATR SOC, V62, P25, DOI 10.1111/jgs.12611	Promotion for psychological well-being
69	2010	Wang CC, 2010, BMC COMPLEM ALTERN M, V10, P0, DOI 10.1186/1472-6882-10-23	Promotion for psychological well-being
66	2010	Jahnke Roger, 2010, Am J Health Promot, V24, P0, DOI 10.4278/ajhp.081013-LIT-248	Promotion for physical fitness
63	2010	Wang CC, 2010, NEW ENGL J MED, V363, P743, DOI 10.1056/NEJMoa0912611	Chronic disease intervention
62	1996	Wolf SL, 1996, J AM GERIATR SOC, V44, P489, DOI 10.1111/j.1532-5415.1996.tb01432.x	Preventing falls of the elderly
58	2012	Gillespie LD, 2012, COCHRANE DB SYST REV, V0, P0, DOI 10.1002/14651858.CD007146.PUB2	Preventing falls of the elderly
53	2008	Wayne PM, 2008, J ALTERN COMPLEM MED, V14, P95, DOI 10.1089/acm.2007.7170A	Chronic disease intervention
52	2000	Hong YL, 2000, BRIT J SPORT MED, V34, P29, DOI 10.1136/bjism.34.1.29	Promotion for physical fitness
49	2002	Wu G, 2002, J AM GERIATR SOC, V50, P746, DOI 10.1046/j.1532-5415.2002.50173.x	Preventing falls of the elderly
49	2007	Voukelatos A, 2007, J AM GERIATR SOC, V55, P1185, DOI 10.1111/j.1532-5415.2007.01244.x	Preventing falls of the elderly
49	2003	Wolf SL, 2003, J AM GERIATR SOC, V51, P1693, DOI 10.1046/j.1532-5415.2003.51552.x	Preventing falls of the elderly
48	1996	Wolfson L, 1996, J AM GERIATR SOC, V44, P498, DOI 10.1111/j.1532-5415.1996.tb01433.x	Preventing falls of the elderly
47	2003	Song R, 2003, J RHEUMATOL, V30, P2039	Chronic disease intervention
47	1998	Lan C, 1998, MED SCI SPORT EXER, V30, P345, DOI 10.1097/00005768-199803000-00003	Promotion for physical fitness
46	2009	Wang CC, 2009, ARTHRIT RHEUM-ARTHR, V61, P1545, DOI 10.1002/art.24832	Chronic disease intervention
46	2014	Wang F, 2014, INT J BEHAV MED, V21, P605, DOI 10.1007/s12529-013-9351-9	Promotion for psychological well-being

Table S3 Significant literatures in each knowledge group

Knowledge groups	First author	Year	Title of paper	Journal	Impact factor (2020 Journal Citation Reports)	Cited times (source: Web of Science)
Preventing falls of the elderly	Wolf SL	1996	Reducing frailty and falls in older persons: an investigation of tai chi and computerized balance training	Journal of the American Geriatrics Society	5.562	714
	Wolfson L	1996	Balance and strength training in older adults: intervention gains and tai chi maintenance	Journal of the American Geriatrics Society	5.562	340
	Wolf SL	2003	Intense tai chi exercise training and fall occurrences in older, transitionally frail adults: a randomized, controlled trial	Journal of the American Geriatrics Society	5.562	207
	Li FZ	2005	Tai chi and fall reductions in older adults: a randomized controlled trial	Journals of Gerontology Series A-Medical Sciences	6.053	393
	Voukelatos A	2007	A randomized, controlled trial of tai chi for the prevention of falls: the central Sydney tai chi trial	Journal of the American Geriatrics Society	5.562	170
	Li FZ	2008	Translation of an effective tai chi intervention into a community-based falls-prevention program	American Journal of Public Health	9.308	80
	Li FZ	2013	Implementing an evidence-based fall prevention program in an outpatient clinical setting	Journal of the American Geriatrics Society	5.562	25
	Li FZ	2018	Effectiveness of a therapeutic tai ji quan intervention vs a multimodal exercise intervention to prevent falls among older adults at high risk of falling	JAMA-Internal Medicine	21.873	38
Promotion for physical fitness	Lai JS	1995	Two-year trends in cardiorespiratory function among older tai chi chuan practitioners and sedentary subjects	Journal of the American Geriatrics Society	5.562	114
	Lan C	1996	Cardiorespiratory function, flexibility, and body composition among geriatric tai chi chuan practitioners	Archives of Physical Medicine and Rehabilitation	3.966	122
	Lan C	1998	12-month tai chi training in the elderly: its effect on health fitness	Medicine & Science in Sports & Exercise	5.411	217
	Lan C	1999	The effect of tai chi on cardiorespiratory function in patients with coronary artery bypass surgery	Medicine & Science in Sports & Exercise	5.411	89
	Hong YL	2000	Balance control, flexibility, and cardiorespiratory fitness among older tai chi practitioners	British Journal of Sports Medicine	13.8	216
	Lan C	2004	The aerobic capacity and ventilatory efficiency during exercise in qigong and tai chi chuan practitioners	American Journal of Chinese Medicine	4.667	54
	Zheng GH	2015	Cardiorespiratory fitness in healthy adults: a systematic review and meta-analysis	PLoS ONE	3.24	34
	Promotion for psychological well-being	Jin PT	1992	Efficacy of tai chi, brisk walking, meditation, and reading in reducing mental and emotional stress	Journal of Psychosomatic Research	3.006
Chou KL		2004	Effect of tai chi on depressive symptoms amongst Chinese older patients with depressive disorders: a randomized clinical trial	International Journal of Geriatric Psychiatry	3.485	85
Li FZ		2004	Tai chi and self-rated quality of sleep and daytime sleepiness in older adults: a randomized controlled trial	Journal of the American Geriatrics Society	5.562	187
Irwin MR		2008	Improving sleep quality in older adults with moderate sleep complaints: a randomized controlled trial of tai chi chih	Sleep	5.849	142
Wang CC		2010	Tai chi on psychological well-being: systematic review and meta-analysis	BMC Complementary and Alternative Medicine	3.659	181
Lavretsky H		2011	Complementary use of tai chi chih augments escitalopram treatment of geriatric depression: a randomized controlled trial	American Journal of Geriatric Psychiatry	4.105	137
Wang F		2014	The effects of tai chi on depression, anxiety, and psychological well-being: a systematic review and meta-analysis	International journal of behavioral medicine	2.229	128
Kong J		2019	Treating depression with tai chi: state of the art and future perspectives	Frontiers in Psychiatry	4.157	14
Chronic disease intervention	Hartman CA	2000	Effects of t'ai chi training on function and quality of life indicators in older adults with osteoarthritis	Journal of the American Geriatrics Society	5.562	138
	Song R	2003	Effects of tai chi exercise on pain, balance, muscle, strength, and perceived difficulties in physical functioning in older women with osteoarthritis	Journal of Rheumatology	4.666	215
	Wang CC	2009	Tai chi is effective in treating knee osteoarthritis: a randomized controlled trial	Arthritis Care & Research	4.794	181
	Wang CC	2016	Comparative effectiveness of tai chi versus physical therapy for knee osteoarthritis	Annals of Internal Medicine	25.391	68
	Hackney ME	2008	Tai chi improves balance and mobility in people with Parkinson disease	Gait & Posture	2.84	153
	Li FZ	2012	Tai chi and postural stability in patients with Parkinson's disease	New England Journal of Medicine	91.245	451
	Li FZ	2014	A randomized controlled trial of patient-reported outcomes with tai chi exercise in Parkinson's disease	Movement Disorder	10.338	48
	Wang CC	2010	A randomized trial of tai chi for fibromyalgia	New England Journal of Medicine	91.245	248
	Wang CC	2018	Effect of tai chi versus aerobic exercise for fibromyalgia: comparative effectiveness randomized controlled trial	BMJ-British Medical Journal	39.89	52
	Taylor-Piliae RE	2010	Effects of tai chi and western exercise on physical and cognitive functioning in healthy community-dwelling older adults	Journal of Aging and Physical Activity	1.961	104
	Nguyen MH	2012	A randomized controlled trial of tai chi for balance, sleep quality and cognitive performance in elderly Vietnamese	Clinical Interventions in Aging	4.458	85
	Mortimer JA	2012	Changes in brain volume and cognition in a randomized trial of exercise and social interaction in a community-based sample of non-demented Chinese elders	Journal of Alzheimer's Disease	4.472	150
	Li FZ	2014	Tai ji quan and global cognitive function in older adults with cognitive impairment: a pilot study	Archives of Gerontology and Geriatrics	3.25	33
	Tao J	2016	Increased hippocampus-medial prefrontal cortex resting-state functional connectivity and memory function after tai chi chuan practice in elder adults	Frontiers in Aging Neuroscience	5.75	61
Tao J	2017	Tai Chi Chuan and Baduanjin practice modulates functional connectivity of the cognitive control network in older adults	Scientific Reports	4.379	50	