Acupuncture and Herbal Medicine

Clinical research on Tai Chi: a review of health benefits

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Abstract

Tai Chi, a traditional Chinese martial art and health exercise, has gained significant global attention and recognition. The clinical benefits of Tai Chi have been studied extensively in recent decades. We conducted a systematic search of PubMed, Web of Science, EMBASE databases, and the China National Knowledge Infrastructure, identifying and reviewing 241 clinical trials on the benefits of Tai Chi from their inception to June 1, 2023. Most of these studies have consistently demonstrated the positive impact of Tai Chi on balance, cognitive function, mood regulation, sleep quality, pain relief, cardiorespiratory function, and overall health. In the future, the key to fostering the ongoing development of this field lies in comprehensive research on standardized study designs and reporting, the scope of Tai Chi applications, and the core factors influencing its efficacy.

Keywords: Clinical trials, Health-promoting effects, Review, Tai Chi, Taijiquan

Graphical abstract: http://links.lww.com/AHM/A94.

Introduction

Tai Chi, which originated in China, is a traditional martial art. Blending body movements, meditation, and breathing control, Tai Chi has evolved into a representative form of traditional health exercise in China. The deliberate, unhurried movements of Tai Chi, in conjunction with its emphasis on self-awareness, mirror the concepts of balance, harmony, and natural well-being that are deeply ingrained in Chinese culture. Consequently, Tai Chi has garnered substantial global attention and recognition. In recent decades, extensive studies have investigated the clinical benefits of Tai Chi. These studies provide compelling evidence supporting the therapeutic potential of Tai Chi for disease prevention, treatment, and rehabilitation. Notably, it has exhibited remarkable efficacy in alleviating pain, enhancing stability, reducing stress and anxiety, and mitigating inflammation[1–5]. Despite the mounting interest in Tai Chi as a therapeutic intervention and the myriad of retrospective studies exploring its clinical research applications across various disorders, a comprehensive synthesis and review in this field is conspicuously absent. Therefore, this study reviewed the clinical research papers related to the field of Tai Chi for health promotion by searching four databases. The aim of employing bibliometric methods was to organize and summarize research trends and experimental approaches in the Tai Chi realm. This study aimed to provide an overview of clinical research papers on Tai Chi that often involve large sample sizes and detailed reporting.

Methods

Search strategy

A comprehensive search was conducted across three electronic databases, PubMed, Web of Science, EMBASE, and the China Science Citation Database, which is based on the China National Knowledge Infrastructure, to identify relevant literature spanning from the inception of these databases until June 1, 2023. The researchers employed the search terms “Taijiquan” “Tai Chi” “Tai Chi Chuan” “Taichi” and “Tai-ji” with clinical trials as specific filters.

Inclusion and exclusion criteria

The scope of the included literature encompassed all clinical trials that utilized Tai Chi alone or in combination with other therapies in the treatment group. The researchers

Yuke Teng and Weiming Luo contributed equally to this article.

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excluded the literature meeting any of the following conditions: (1) non-clinical trials or duplicates, (2) clinical studies unrelated to the health-promoting effects of Tai Chi, or (3) a single group with a sample size of less than 30 to avoid large sample size gaps between different studies. In instances in which data were unavailable or ambiguously presented, the researchers established direct communication with the corresponding author through phone or email.

Data extraction

Data extraction was carried out by two separate groups (Group I: Jianwei wu, Cong Sun and Group II: Muchen Wang, Xiaoqian Nie) using a predetermined data extraction template. Any discrepancies or variations were resolved through a comprehensive discussion among the authors. The information gathered included details of the corresponding author, publication year, sample size, study population, age, and research outcomes. Two authors (Yuke Teng and Weiming Luo) performed a thorough review and validation of the extracted data.

Results

General information of the included studies

The search yielded 2,217 papers, of which 241 were ultimately included in this study (Figure 1). As shown in Figure 2, the publication trend in health promotion research related to Tai Chi has consistently shown an upward trajectory since the inception of the databases. After arranging the journals in descending order based on the number of publications, it is evident that the *Journal of the American Geriatrics Society* has demonstrated significant interest in this field, with a total of 12 published research papers (Table 1). Similarly, when the authors were ranked by the number of publications in descending order, the most prolific author in this field was F. C. Lee from the Oregon Research Institute (Table 2).

Most of the 241 studies (22%) focused on healthy participants. Approximately 10% of the studies focused on neurodegenerative conditions such as stroke, Parkinson disease, Alzheimer disease, and cognitive impairment. Additionally, 6% of the studies focused on cancer survivors, 5% investigated patients with arthritis, and 9% examined individuals with cardiovascular disease. Moreover, 5% of the studies specifically addressed patients with diabetes and 5% studied menopausal women. In contrast, 13% of the studies did not specify the categories of the study population (Figure 3A).

Among the 241 clinical studies that explored the health-promoting effects of Tai Chi, the distribution of research areas was as follows: 19% focused on balance,

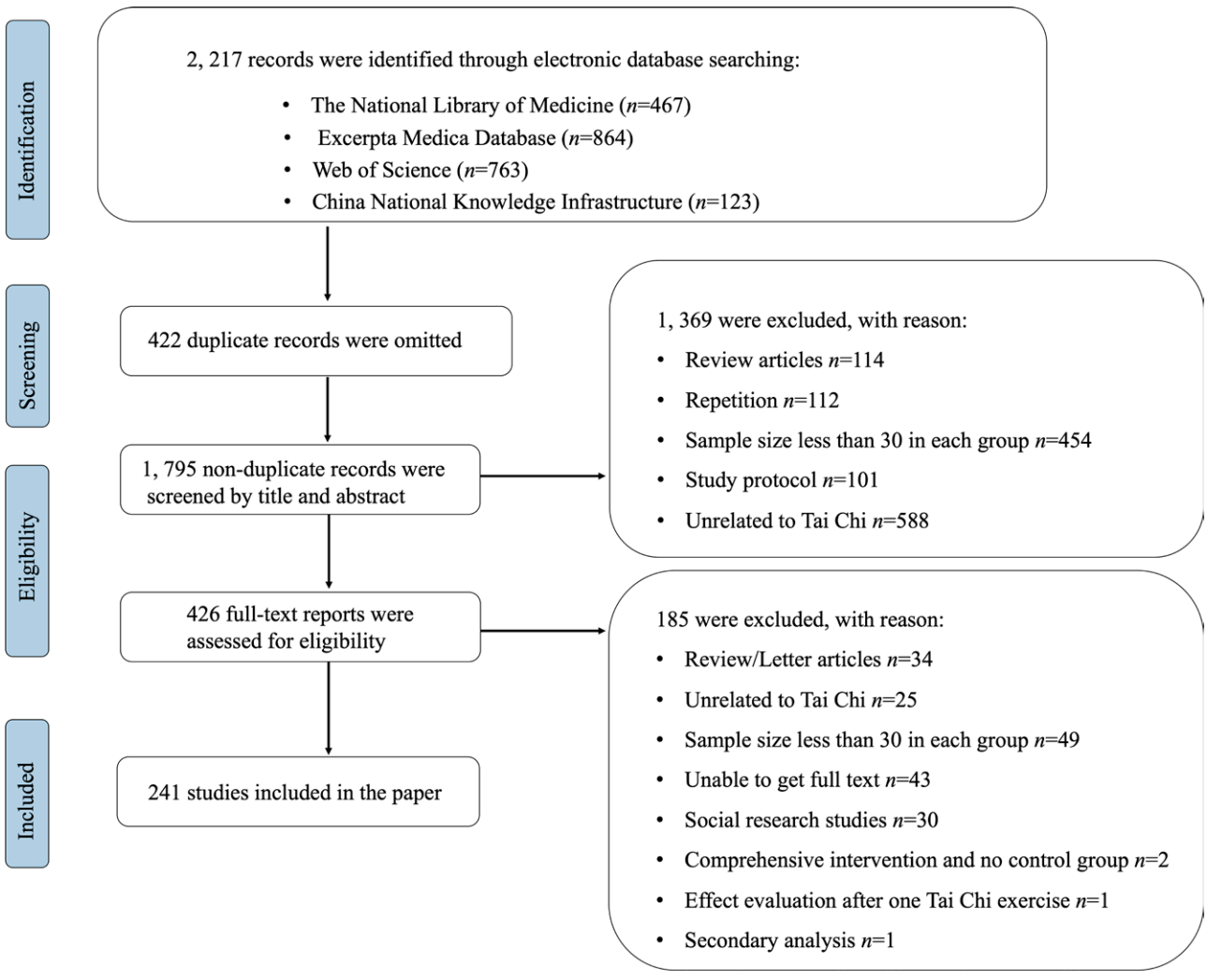

Figure 1. Flowchart of the study selection process.

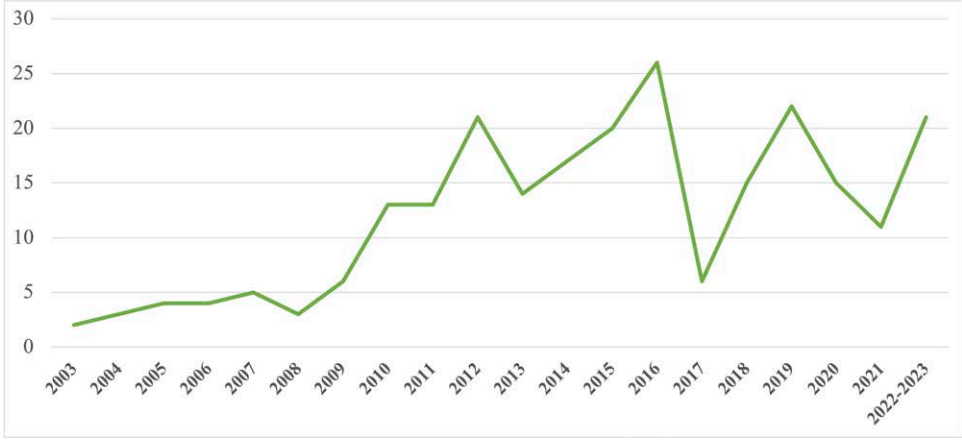

Figure 2. Clinical trials on the health promotion effects of Tai Chi (annual publications).

Table 1

Ranking of journals that published papers on Tai Chi clinical trials

Number	Journal	Number of published articles	Latest impact factor
Science citation index			
1	*Journal of the American Geriatrics Society*	11	6.3
2	*The Journal of Alternative and Complementary Medicine*	7	2.6
3	*Archives of Physical Medicine and Rehabilitation*	5	4.3
4	*Complementary Therapies in Medicine*	4	3.6
5	*The American Journal of Geriatric Psychiatry*	3	7.2
6	*BMC Geriatrics*	3	4.1
7	*PLoS One*	3	3.7
8	*Chinese Journal of Integrative Medicine*	3	2.9
China science citation database			
1	*Chinese Journal of Gerontology*	27	1.3
2	*Chinese Journal of Rehabilitation Medicine*	14	1.6
3	*Chinese Journal of Rehabilitation Theory and Practice*	8	1.7
4	*Chinese Journal of Sports Medicine*	6	1.1
5	*Chinese Journal of Osteoporosis*	3	2.0

while others delved into cognitive function (8%), emotion and sleep quality (10%), chronic pain (8%), and quality of life (8%). An additional 14% of the studies investigated the impact of Tai Chi on cardiorespiratory fitness and safety profiles, and 8% specifically assessed its analgesic effects. Furthermore, 33% of studies investigated other health-promoting benefits associated with Tai Chi (Figure 3B).

Health benefits of Tai Chi

Improving balance

There are 46 studies that have investigated the effects of Tai Chi on balance. The studies' characteristics are presented in Table 3.

In 1996, Wolf et al.[93] published an inaugural study on the impact of Tai Chi on fall risk among older individuals in the "J Am Geriatr Soc." This study demonstrated that 15 weeks of Tai Chi practice was more effective than balance training and health education in reducing blood pressure and fear of falling in older individuals. Subsequently, the enhancement of balance through Tai Chi has ignited substantial interest among researchers worldwide. Numerous studies have been conducted on Tai Chi to bolster balance in healthy older individuals and those with various diseases, delving into its benefits in diminishing the fear of falling, enhancing or restoring balance and stability, and reducing the frequency of falls in daily life. For instance, Li et al.[4] illustrated that a 24-week regimen of twice-weekly, 60-minute Tai Chi practice markedly improved stability and step length in healthy older individuals, surpassing the effects of stretching and resistance training. Another study revealed that stroke patients undergoing 12 weeks of Tai Chi training (comprising 1 hour of group practice per week and 3 hours of self-practice) exhibited enhanced center of gravity excursion, improved healthy side reaction time, and better reliance on integrated vestibular balance control than controls[13].

Table 2

First author's information in clinical trials of Tai Chi

Number	Author	Institution	Number of published articles
Science citation index			
1	Fuzhong Li	Oregon Research Institute	8
2	Michael R. Irwin	University of California	6
3	Chenchen Wang	Tufts Medical Center	3
4	Romy Lauche	Harvard Medical School	3
5	Guohua Zheng	Shanghai pharma university	2
6	Liu Jiao	Fujian University of Traditional Chinese Medicine	2
7	Rhayun Song	Chungnam National University	2
8	Taylor-Piliae, R. E.	University of Arizona	2
China science citation database			
1	Xinhui Yang	Harbin Sport University	3
2	Jingya Li	Sichuan Normal University	2
3	Jing Liu	Shanghai University of Sport	2
4	Xiangjiang Rong	Capital University of Physical Education and Sports	2
5	Rongmei Xu	School of physical Education and Taijiquan	2
6	Zhen Zheng	Chengdu University of traditional Chinese medicine	2

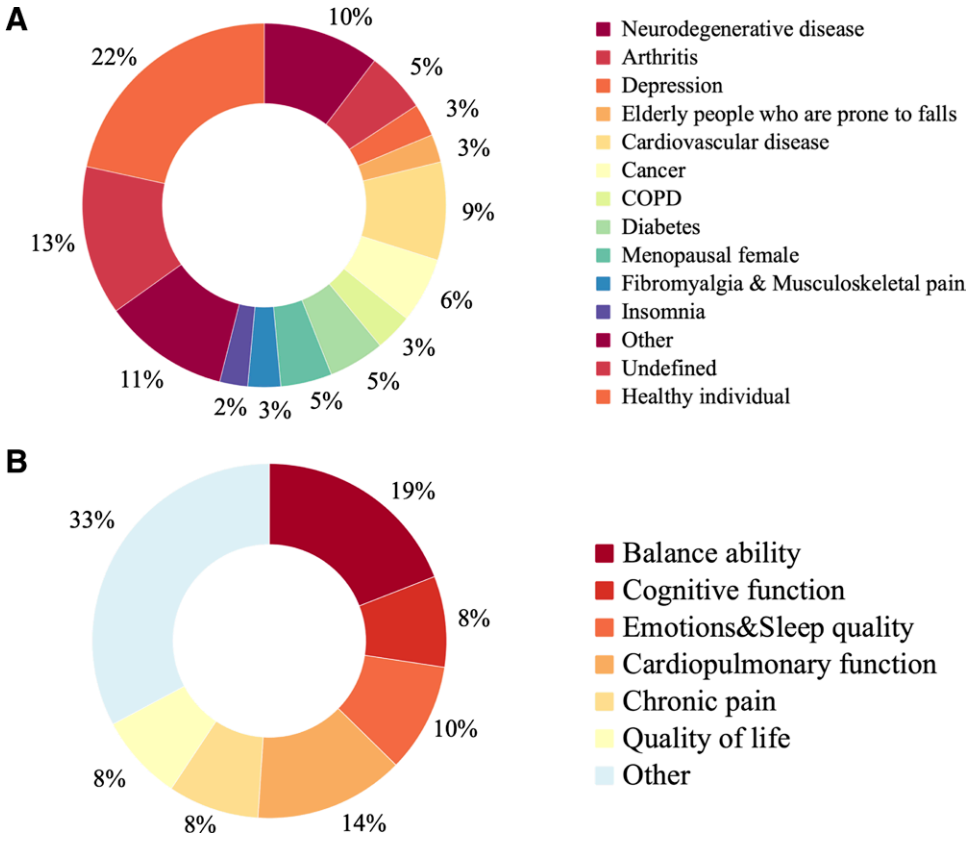

Figure 3. Distribution of disease categories and outcomes assessment of clinical research in Tai Chi. (A) Distribution of subjects included in a clinical study of the health-promoting effects of Tai Chi. (B) Distribution of clinical research areas on the health-promoting effects of Tai Chi. COPD: Chronic obstructive pulmonary disease.

Researchers have also investigated the potential mechanisms underlying the influence of Tai Chi on balance by examining aspects such as neuromuscular adaptation and posture control. For instance, Gatts[94] and Gatts and Woollacott[95] reported that 3 weeks of continuous Tai Chi practice (five sessions per week, each lasting 90 min) significantly reduced the reaction time of the tibialis anterior muscle and mitigated the simultaneous contraction of antagonist muscles. Swift and precise neuromuscular activation is pivotal for Tai Chi to augment balance and reduce the likelihood of slipping or tripping incidents. Solianik et al.[96] uncovered that

Table 3

The study's characteristics of Tai Chi for balance ability, cognitive function, emotion, and sleep improvement

		Tai Chi intervention						
Authors	**Population/patients**	**Types**	**Practice duration per time**	**Practice frequency**	**Practice period**	**Control groups**	**Outcomes assessment**	**Conclusion**
The studies characteristics of Tai Chi for balance ability improvement								
Wolf et al.[6]	The elderly	Part of 108-form Tai Chi	15 min	2 times/day	14 weeks	Computer balance train/health education	Strength, flexibility, cardiovascular endurance, body composition, etc	Positive (R)
Wolf et al.[7]	The elderly	Yang style 24-form Tai Chi	60–90 min	2 times/week	48 weeks	Health education	Fall events, falls efficacy scale, the sickness impact profile, etc	Undefined (R)
Li et al.[8]	The elderly	Yang style 24-form Tai Chi	60 min	2 times/week	24 weeks	Stretching exercise	Berg balance scale, dynamic gait index, functional reach, fall calendar, etc	Positive (R)
Li et al.[9]	The elderly	Yang style 24-form Tai Chi	60 min	2 times/week	24 weeks	Stretching exercise	Fall calendar, berg balance scale, dynamic gait index, functional reach, single standing tests, etc	Positive (R)
Sattin et al.[10]	Fall history elderly	Yang style 24-form Tai Chi	60–90 min	2 times/week	48 weeks	Health education	The falls efficacy scale, the activities-specific balance confidence scale, the center for epidemiological studies depression scale, functional reach test, etc	Positive (R)
Lin et al.[11]	The elderly	Chen style Tai Chi & education	60 min	6 times/week	48 weeks	Education	Injurious falls, Tinetti balance scale, etc	Undefined (R)
Voukelatos et al.[12]	Health elderly	Sun style Tai Chi, yang style Tai Chi & mixture of several styles	60 min	1 time/week	16 weeks	Waiting list	Falls calendars, etc	Positive (R)
Au-Yeung et al.[13]	Stroke	Modified of sun style Tai Chi	60 min	4 times/week	12 weeks	Multiple exercise intervention	Dynamic standing balance in the limit of stability test, under 6 integrated sensory tests, etc	Positive (R)
Logghe et al.[14]	The elderly	Yang style Tai Chi	60 min	2 times/week	13 weeks	Usual care	Falls calendar, berg balance scale, falls efficacy scale, the physical activity scale, the Groningen activity restriction scale, etc	Positive (R)
Chyu et al.[15]	Postmenopausal women with osteopenia	Yang style 24-form Tai Chi	60 min	3 times/week	24 weeks	Waiting list	Dynamic and static standing balance, the gait assessment, etc	Positive (R)
Huang et al.[16]	Health elderly	Partial Tai Chi motion & health education	40 min	3 times/week	20 weeks	Tai Chi/health education/blank control	The get-up & go test, falling measure, etc	Positive (R)
Huang et al.[17]	The aged	Partial Tai Chi motion & cognitive behavior therapy	60 min	5 times/week	8 weeks	Cognitive behavioral therapy/blank control	Fear of falling, the geriatric fear of falling measure, etc	Positive (R)

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Table 3
(Continued)

Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Li et al.[4]	Parkinson disease	Partial Tai Chi motion	60 min	2 times/week	24 weeks	Stretching exercise/ resistance exercise	Maximum excursion and directional control, stride length and walking velocity, etc	Positive (R)
Nguyen and Kruse[18]	Health elderly	Yang style 24-form Tai Chi	60 min	2 times/week	24 weeks	Waiting list	The falls efficacy scale, the Pittsburgh sleep quality index, the trail-making test, etc	Positive (R)
Taylor et al.[19]	Fall risk elderly	Modified of sun style 10-form Tai Chi	60 min	2 times/week	20 weeks	Once a week Tai Chi/ low-level exercise program	Timed-up- and-go test, step test, chair stand test, etc	Negative (R)
Tousignant et al.[20]	Fall risk elderly	Partial Tai Chi movements	60 min	2 times/week	15 weeks	Conventional physical therapy	Berg balance scale, the timed up and go test, standing up, walking (3-meter distance), turning and sitting down, and the 5-m walking time, etc	Positive (R)
Yu et al.[21]	Healthy elderly male	Yang style 24-form Tai Chi	60 min	3 times/week	24 weeks	Na	Reaction time, sit-and-reach flexibility, static balance, etc	Positive(B)
Li et al.[22]	Elderly people living alone	Yang style 24-form Tai Chi	60 min	2 times/week	24 weeks	Na	Falls calendars, etc	Positive (B)
Tousignant et al.[23]	Frail old people	Partial Tai Chi movements	60 min	2 times/week	15 weeks	Conventional physical therapy	Falls calendars, etc	Positive (R)
Liu et al.[24]	Health elderly	Partial Tai Chi movements & cognitive behavioral therapy	60 min	8 times/week	8 weeks	Cognitive behavioral therapy	Chinese fall efficacy scale-international, the personal well-being index-Chinese version, etc	Undefined (R)
Quigley et al.[25]	Distal symmetric multiple neuropathy	Partial Tai Chi movements	60 min	1 time/week	10 weeks	Balance train/health education	The berg balance scale, 8 foot up and go test, modified falls efficacy scale, etc	Positive (R)
Song et al.[26]	Healthy elderly female	Chen style Tai Chi	40 min	6 times/week	52 weeks	Dance/walk	Bone density detection, detection of the lower limb muscle strength, detection of the lower limb skeletal muscle content, detection of the balance function, etc	Undefined (R)
Day et al.[27]	The elderly	Sun style Tai Chi	60 min	2 times/week	48 weeks	Flexibility exercise	Falls calendars, etc	Negative (R)
Dogra et al.[28]	Elderly arthritis patients	Yang style Tai Chi	60 min	2 times/week	16 weeks	Na	Timed up-and-go, seated arm curl and chair stand, sit and reach, etc	Positive (B)
Hwang et al.[29]	Fall risk elderly	Yang style Tai Chi	60 min	1 time/week	42 weeks	Lower limb exercise	Falls calendars, four fall measures, the abbreviated injury scale, etc	Positive (R)

(*Continued*)

Table 3
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Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Yıldırım et al.[30]	Healthy adults	Yang style Tai Chi	Yang style Tai Chi	3 times/week	12 weeks	Multiple exercise intervention	Computerized balance assessment, single leg-stance-eyes open, berg balance scale, timed up and go, survey of activities and fear of falling in the elderly, geriatric depression scale, etc	Positive (R)
Li et al.[31]	Healthy adults	Modified of Tai Chi	60 min	2 times/week	24 weeks	Multiple exercise intervention/ stretching exercise	Fall calendar, functional reach, the instrumented timed up & go, the short physical performance battery, etc	Positive (R)
Xie et al.[32]	Stroke	Yun shou	60 min	5 times/week	12 weeks	Balance rehabilitation training	Berg balance scale, single leg stance test, fugl-meyer assessment, timed-up-and-go-test, modified falls efficacy scale, etc	Positive (R)
Gallant et al.[33]	Health elderly	Yang style 8-form Tai Chi	60 min	3 times/week	12 weeks	Na	Timed up and go, functional reach test, the activities-specific balance confidence scale, etc	Positive (B)
Lipsitz. et al.[34]	The elderly	Yang style Tai Chi	Unspecified	2 times/week	52 weeks	Health education	The short physical performance battery, the timed-up-and go, etc	Negative (R)
Yu et al.[35]	Stroke	Yang style 24-form Tai Chi	40 min	3 times/week	12 weeks	Weight support/ conventional therapy	Limit of stability test[35] etc	Positive (R)
Fong et al.[36]	Developmental coordination disorder children	Strength training & Tai Chi	90 min	3 times/week	12 weeks	Strength training/Tai Chi/blank control	Limit of stability test, etc	Positive (R)
Ge et al.[37]	Healthy elderly	Yang style 24-form Tai Chi	60 min	3 times/week	8 weeks	Usual care	Fear of falling scale, the geriatric depression scale, etc	Positive (R)
Zhao et al.[2]	Stroke	Modified of Tai Chi	40 min	3 times/week	12 weeks	Attention training	Fugl-Meyer assessment upper extremity, Wolf motor function test, berg balance scale, trunk impairment scale19, geriatric depression scale-short form, etc	Positive (R)
Li et al.[38]	Parkinson disease	Partial Tai Chi movements	60 min	2 times/week	48 weeks	Brisk walk/no exercise	Berg balance scale, unified pd rating scale, time up and go test, and spatial 3 d gait analysis, etc	Positive (R)
Liu et al.[39]	Healthy elderly	Unspecified	>60 min	>3 times/week	>1 years	Brisk walk/no exercise	Static balance ability test system	Positive (C-S)
Yang and Yu[40]	Healthy elderly	Unspecified	Unspecified	Unspecified	Unspecified	Brisk walk/no exercise	WIN-POD balance function detection system	Positive (C-S)

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Table 3
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Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Wang and Zhang[41]	Healthy elderly	Yang style 24-form Tai Chi	60 min	7 times/week	24 weeks	No exercise	The seven indexes of balance ability are the length of center of gravity shake track, envelope area, center of gravity shake speed, X-axis swing speed, Y-axis swing speed, X-axis offset, and Y-axis offset	Positive (R)
Wang[42]	Healthy elderly	Unspecified	Unspecified	Unspecified	Unspecified	Brisk walk/no exercise	Standing with two eyes open, standing with two eyes closed, standing with one-foot left eye open, standing with one-foot left eye closed, standing with one-foot right eye open, standing with one-foot right eye closed	Positive (R)
Fu and Zhang[43]	Stroke	Yang style 24-form Tai Chi	40 min	6 times/week	32 weeks	Routine exercise/ occupational therapy/ physical factor therapy	Trunk impairment scale, Berg Balance Scale, Functional ambulation category scale, and 10 m maximum walking speed	Positive (R)
Li[44]	Menopause women	Chen style Tai Chi	60 min	5 times/week	52 weeks	Brisk walk/Yoga	Bone mineral density, lower limb skeletal muscle content, lower limb muscle strength and balance	Positive (R)
Yang and Tang[45]	Stroke	6-form Tai Chi & Comprehensive rehabilitation therapy	40 min	3 times/week	8 weeks	Comprehensive rehabilitation therapy	Fugl-Meyer Assessment Scale, Berg Balance Scale	Positive (R)
Li et al.[46]	Parkinson disease	Yang style 24-form Tai Chi	60 min	4 times/week	12 weeks	Usual care	Fugl-Meyer Assessment Scale, Berg Balance Scale, Falls Efficacy Scale-International	Positive (R)
Zhang et al.[47]	Healthy elderly	Yang style 24-form Tai Chi	60–90 min	3–5 times/ week	Unspecified	Square dancing/ power walking/low-frequency exercise	Swing velocity, swing Angle, peripheral area and total swing trajectory length in standing with eyes closed and right foot with eyes open	Positive (C-S)
Hong et al.[48]	Healthy elderly	Simplified Tai Chi	40 min	1 time/week	24 weeks	Health education	Modified Fall Efficacy Scale, Balance ability test	Positive (R)
He et al.[49]	Stroke	6-form Tai Chi	30 min	6 times/week	4 weeks	Comprehensive rehabilitation training	Stability limit test, sit-standing test, Berg Balance Scale, Fugl-Meyer Assessment Scale, functional ambulation category scale	Positive (R)
The studies characteristics of Tai Chi for cognitive function improvement								
Kwok et al.[50]	Healthy college students, health elderly, experienced of practice Tai Chi	Cross-sectional study	/	/	/	Healthy college students	Reaction time, movement time, accuracy, etc	Positive (C-S)

(*Continued*)

Table 3
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Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Taylor-Piliae et al.[51]	Healthy adult	Yang style 12 forms Tai Chi	45–90 min	5 times/week	48 weeks	Western exercise	The single-leg-stance test, 30 s timed arm-curl and chair-stand tests, the maximal distance, cardiorespiratory endurance was assessed by treadmill testing, etc	Positive (R)
Lam et al.[52]	MCI	Yang style 24 forms Tai Chi	30 min	3 times/week	12 weeks	Exercise and stretching	Clinical dementia rating, the memory inventory for the Chinese, the can-tones version of Alzheimer disease assessment scale, etc	Positive (R)
Cheng et al.[53]	Alzheimer disease	Yang style 12 forms Tai Chi	60 min	3 times/week	12 weeks	Mahjong/simple handicrafts	Mini-mental state examination, etc	Positive (R)
Zhang et al.[54]	Health elderly	Unspecified	30–60 min	4 times/week	72 weeks	Swimming/running/ square dancing/ without sports	P300 test, scale of elderly cognitive function, Hamilton anxiety scale, Hamilton depression scale, etc	Positive (R)
Sungkarat et al.[55]	Healthy adult	10 forms Tai Chi	50 min	3 times/week	15 weeks	Educational material	The Wechsler memory scale, the block design test, the digit spans forward and backward and trail-making test, etc	Positive (R)
Hsieh et al.[56]	MCI	Virtual reality Tai Chi	60 min	2 times/week	24 weeks	Usual activities	The cognitive abilities screening instrument, etc	Positive (R)
Miller et al.[57]	Tai Chi practice elderly	Cross-sectional study	/	/	/	/	The driving health inventory, the driving scenes test, the mindful attention awareness scale, the vitality plus scale, etc	Positive (C-S)
Siu et al.[58]	MCI	Yang style 24 forms Tai Chi	60 min	2 times/week	16 weeks	Usual activities	The Chinese version of mini-mental state examination, the Hong Kong Chinese version of Lawton's instrumental activities of daily living, etc	Positive (R)
Sungkarat et al.[59]	MCI	10 forms Tai Chi	60 min	3 times/week	24 weeks	Health education	The Wechsler memory scale, the block design test, the digit spans forward and backward and trail-making test, etc	Positive (R)
Huang et al.[60]	MCI	Unspecified	20 min	3 times/week	40 weeks	Routine treatments	The mini-mental state examination, the Montreal cognitive assessment, the trail-making test, etc	Positive (R)
Zou et al.[61]	Older people with cognitive decline and balance disorders	Yang style 24 forms Tai Chi	60/90 min	3/5 times/week	12 weeks	Adapted Chen style forms Tai Chi	The Chinese version of the Montreal cognitive assessment, one-leg standing test, chair stand test, the 6-m walk test, etc	Positive (R)
Hwang et al.[62]	Traumatic brain injury	Yang style 8 forms Tai Chi	50 min	1 Time/week	24 weeks	Computer cognitive training/usual care	The Mattis dementia rating scale, mini-mental state examination, modified telephone interview of cognitive status, trail-making test, etc	Positive (R)

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Table 3
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Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Li et al.[63]	Parkinson disease severity of I to III	Part of yang style Tai Chi	80 min	3 times/week	8 weeks	Regular exercise	The timed up-and-go test, the 50-foot speed test, the functional reach test	Positive (C)
Li et al.[38]	Parkinson disease early stage	Partial Tai Chi movements	60 min	2 times/week	48 weeks	Brisk walking/no exercise rain	Berg balance scale, unified pd rating scale, spatial 3d gait, etc	Positive (R)
Yu et al.[64]	The elderly	Yang style 24 forms Tai Chi	60 min	3 times/week	10 weeks	Brisk walking	The Montreal cognitive assessment, trail-making b–participants, etc	Positive (R)
Chen et al.[65]	T2D and MCI patients	Yang style 24 forms Tai Chi	60 min	3 times/week	24 weeks	No exercise rain	The Montreal cognitive assessment, etc	Positive (R)
Sun et al.[66]	Heart disease/ hypertension patients	Yang style 24 forms Tai Chi & Reading	60 min	2 times/week	12 weeks	recreational activities	Standing with open eyes on one side leg, 5 m fast walking speed, 10 m normal walking speed, left-hand grip strength, Mini-Mental State Examination, Frontal Assessment Battery	Positive (R)
Wang and Sheng[67]	MCI	8 forms Tai Chi	40 min	2 times/week	12 weeks	Health education	Montreal Cognitive Assessment	Positive (R)
Ji[68]	Health elderly	Chen style Tai Chi	40 min	2 times/week	24 weeks	Meditation/aerobics/ sedentary	Event-related potential	Positive (R)
The studies characteristics of Tai Chi for emotion and sleep improvement								
Li et al.[69]	Elderly with sleep disorders	Yang style 8 forms Tai Chi	60 min	3 times/week	16 weeks	Low-impact exercise	Self-rated sleep quality, Pittsburgh sleep quality index, Epworth sleepiness scale less	Positive (R)
Irwin et al.[70]	Health elderly	Modified of 20 forms Tai Chi	40 min	3 times/week	24 weeks	Health education	Pittsburgh sleep quality index, the Beck depression inventory, etc	Positive (R)
Lee et al.[71]	Health elderly	Unspecified	60 min	3 times/week	26 weeks	Normal daily activities	The state self-esteem scale, the Chinese version of the SF-12 health survey, etc	Positive (N)
Caldwell et al.[72]	Undergraduate classes	Chen style Tai Chi	50 min	2 times/week	15 weeks	Recreation	Five facet Mindfulness questionnaire, four-dimensional mood scale, perceived stress scale, self-regulatory self-efficacy scale, Pittsburgh sleep quality indexed	Positive (R)
Lee et al.[73]	Junior school student	Chen style Tai Chi	80 min	1 time/week	10 weeks	Self-study	The perceived stress scale 10-item	Positive (N)
Irwin et al.[74]	Elderly insomnia patients	20 forms Tai Chi	120 min/week	Unspecified	16 weeks	Cognition behavioral therapy/sleep seminar	Insomnia symptomless	Positive (R)
Bao and Jin[75]	Teenager	Yang style 24 forms Tai Chi	60 min	5 times/week	48 weeks	China's 8th edition broadcasting gymnastics	Piers Harris children's self-concept scale, etc	Positive (N)

(*Continued*)

Table 3
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Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Carroll et al.[76]	Elderly insomnia patients	Unspecified	120 min/week	Unspecified	16 weeks	Cognition behavioral therapy/sleep seminar	The Pittsburgh sleep quality index, etc	Positive (R)
Liu et al.[77]	Central obesity patients with depression	Modified of Tai Chi	60–90 min	3 times/week	24 weeks	Waitlist	Center for epidemiologic studies depression scale, the depression anxiety stress scale	Positive (R)
Zheng et al.[78]	College student	Yang style 24 forms Tai Chi	60 min	5 times/week	12 weeks	Non-intervention	Balance ability, lower limb proprioception, flexibility, etc	Positive (R)
Schitter et al.[79]	Healthy adult	Yang-style Tai Chi	60 min	2 times/week	12 weeks	Waiting list	Center for epidemiologic studies depression scale, etc	Positive (R)
Yeh et al.[80]	Chronic heart failure	Yang-style Tai Chi	60 min	2 times/week	12 weeks	Education	Validated instruments of health-related quality-of-life, psychosocial functioning, etc	Positive (R)
Irwin et al.[81]	Insomnia patients with breast cancer	Unspecified	120 min/week	Unspecified	12 weeks	Cognitive behavior therapy	The Pittsburgh sleep quality index, etc	Positive (R)
Liu et al.[82]	Elderly depression	Yang style 24 forms or 42 forms Tai Chi	60 min	3 times/week	24 weeks	No exercise train	Heart rate variability, geriatric depression scale, etc	Positive (R)
Zhang et al.[83]	Subthreshold depression in adolescents	24 forms Tai Chi	90 min	2 times/week	8 weeks	No exercise and no meditation training	Patient health questionnaire, etc	Positive (R)
Liu et al.[84]	Central obesity and depression	Unspecified	90 min	3 times/week	24 weeks	Usual medical care	The medical outcomes study, etc	Positive (R)
Liu et al.[85]	Coronary heart disease	Yang style 24 forms Tai Chi	50–60 min	2 times/day	40 weeks	Routine treatment	The general anxiety disorder 7-item, the patient health questionnaire-9, etc	Positive (R)
Siu et al.[86]	Chronic insomnia in the elderly	Yang style 24 forms Tai Chi	60 min/time	3 times/week	12 weeks	Conventional exercise/no intervention	Actigraphy sleep assessment	Positive (R)
Lavretsky et al.[87]	Geriatric depression	Adapted from "Tai-chi-chih! Joy through movement"	60 min	1 time/week	12 weeks	Health education	The Hamilton rating scale for depression, etc	Positive (R)
Yao et al.[88]	Breast cancer patient	Routine care & yang style 8 forms Tai Chi	60 min	2 times/week	8 weeks	Routine care	The brief fatigue inventory, the Pittsburgh sleep quality index, the hospital anxiety and depression scale-depression, etc	Positive (R)

(*Continued*)

Table 3
(Continued)

Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Zhang et al.[89]	Breast cancer patient	Yang style 24 forms Tai Chi	60 min	2 times/week	8 weeks	Waiting list	The posttraumatic growth inventory, the perceived stress scale, the self-rating anxiety scale, etc	Positive (R)
Zhao et al.[90]	Stroke	6 forms Tai Chi	30 min	5 times/week	8 weeks	Usual care	Fugl-Meyer motor function assessment, Barthel index, Hamilton Depression Scale	Positive (R)
Zhou et al.[91]	Insomnia	Yang style 24 forms Tai Chi	60 min	6 times/week	24 weeks	NA	Pittsburgh sleep quality index, Serum tumor necrosis factor	Positive (B)
Zhang et al.[92]	Amphetamine-type stimulants are dependent	Unspecified	20–50 min	9 times/week	4 weeks	Audio-visual education	BFS Mood Scale, Exercise-induced Mood questionnaire	Positive (R)

B: before and after self-control study; C: Cohort study; C-S: cross-sectional study; MCI: Mild cognitive Impairment; N: Non-randomized controlled trial; Na: Not applicable; R: RCT; T2D: Type 2 Diabetes.

Tai Chi practice heightened the accuracy of the "go/no-go" task, expedited the speed of pressure center movement in the Laberg stance (both with closed eyes) under single-task and dual-task conditions, and elevated brain-derived neurotrophic factor (BDNF) and irisin levels. These enhancements in sustained attention and the elevation in muscle factor levels could potentially constitute the mechanisms underlying Tai Chi's promotion of balance.

Improving cognitive function

Twenty studies have investigated the effects of Tai Chi on cognitive function. The studies' characteristics are presented in Table 3.

A recent systematic review revealed that Tai Chi practice can significantly enhance global cognitive function in individuals with cognitive impairment, particularly among those with intact executive functioning[97]. A randomized controlled trial demonstrated that compared with traditional exercise, 12 weeks of Tai Chi practice led to superior global cognitive performance and cognitive flexibility in individuals with mild cognitive impairment[98]. Another randomized controlled trial[65] compared the impact of a 24-week intervention involving Tai Chi, conducted three times a week for 60 min per session, with fitness walking to enhance cognitive functionality among older individuals with type 2 diabetes and Mild Cognitive Impairment. These findings from clinical studies provide substantial evidence of the long-term advantages of using Tai Chi practice in enhancing cognitive function among older individuals with diverse disorders.

Parallel to an extensive array of clinical studies, mechanistic studies have also been conducted. For example, one study indicated that Tai Chi practice notably boosts the functional connectivity between the medial prefrontal cortex and medial temporal lobe among healthy older individuals. This suggests that effective cognitive-psychological-physical interventions contribute to maintaining the health and holistic cognition of the aging brain[99]. Studies by Liu et al.[100,101] showed that, in comparison to health education, Tai Chi, Baduanjin, and stationary cycling exercises can better modulate the resting-state functional connectivity of the opioid descending pathway, reward/motivation system, and blood inflammatory markers. The current body of evidence supports the cognitive benefits of Tai Chi; however, the potential enhancing effects of Tai Chi on various cognitive domains, such as executive function, learning and memory, motor perceptual function, language, complex attention, and social cognition, await further investigation.

Regulating emotions and improving sleep quality

There are 24 studies dedicated to the effects of Tai Chi on emotions and sleep quality. The studies' characteristics are presented in Table 3.

In clinical studies, a randomized controlled trial indicated that participants receiving a combination of escitalopram and Tai Chi were more likely to experience a greater reduction in and relief from depressive symptoms than those receiving escitalopram and health education[102]. Additionally, greater improvements were observed in physical and cognitive tests based on the

medical outcomes study (MOS) item short-form health survey. Another study revealed that a 3-month combination of Tai Chi practice and medication treatment outperformed a combination of health education and medication treatment in terms of overall health improvement among individuals with depression. However, no significant between-group differences were noted in emotional or cognitive improvements[87]. As for sleep quality enhancement, a randomized controlled study found that Tai Chi effectively improved insomnia symptoms in breast cancer survivors, with treatment effects comparable to cognitive behavioral therapy – the recommended first-line treatment according to the American Academy of Sleep Medicine[81]. Furthermore, one study found that 12 weeks of Tai Chi practice and regular exercise demonstrated no significant differences in improving objective sleep parameters. Both approaches moderately improved sleep quality in individuals with insomnia, with benefits persisting for up to 24 months[86]. A recent systematic review demonstrated that Tai Chi not only has preventive and therapeutic effects on insomnia but also alleviates depression and anxiety symptoms in patients[103].

Extensive mechanistic studies have investigated the effects of Tai Chi on emotion modulation. A cross-sectional study revealed that during Tai Chi practice, the functional connectivity between the dorsolateral prefrontal cortex and middle frontal gyrus mediates emotional regulation among healthy older individuals, shedding light on how internal experiences affect emotional abilities. Such experiences appear to regulate emotions among long-term Tai Chi practitioners by reducing the functional connectivity within the executive control network[104]. Epigenetic perspectives also reveal the mechanisms of Tai Chi. Epigenetic mechanisms dynamically regulate gene activity without altering DNA sequences, thereby aiding genome adaptation to environmental changes[105]. Mind-body practices, such as Tai Chi, integrate movement and mental tranquility for emotional regulation and health benefits[106]. For example, the antidepressant effects of Tai Chi have been investigated using methylation of the BDNF promoter. Tai Chi intervention reduced methylation and depression, suggesting potential underlying mechanisms[107]. In a cross-sectional study, Tai Chi practitioners exhibited delayed methylation changes compared with controls, implying a positive epigenetic impact[108]. These genetic insights into the mechanisms of Tai Chi are preliminary, and more comprehensive research is warranted because of the exploratory nature of these findings.

Promoting cardiopulmonary function

There are 33 studies dedicated to investigating the effects of Tai Chi on cardiopulmonary function. The studies' characteristics are presented in Table 4.

In 1996, Channer et al.[178] published an initial clinical research article on the use of Tai Chi among patients with acute myocardial infarction. The study revealed that compared with aerobic exercise, Tai Chi could lower systolic and diastolic blood pressure in patients with acute myocardial infarction[178]. Practicing Tai Chi for at least 60 min, five times a week, for 12 weeks or more has demonstrated greater benefits than other exercise programs in terms of reducing blood pressure, increasing nitric oxide levels, and enhancing lipid metabolism[179]. Furthermore, a substantial clinical study involving 1,084 participants demonstrated that 12 weeks of Tai Chi exercises combined with lower extremity muscle training led to improved quality of life and cardiopulmonary function in older patients with chronic heart failure, outperforming the absence of intervention[121]. Beyond cardiovascular disease rehabilitation, researchers have also conducted numerous studies exploring the advantages of Tai Chi on lung function, particularly in aiding the rehabilitation of chronic nonobstructive pulmonary diseases. A meta-analysis highlighted that Tai Chi might have the potential to enhance pulmonary function and physical activity in patients with chronic obstructive pulmonary disease (COPD), offering better improvement in quality of life than controls[180]. These studies collectively affirmed that Tai Chi can enhance diminished cardiorespiratory fitness with no reported side effects and a favorable safety profile.

Alleviating pain

Twenty studies have explored the effects of Tai Chi on pain. The studies' characteristics are presented in Table 4.

In 2000, Hartman et al.[181] published an initial study on the effects of Tai Chi among patients with knee osteoarthritis. Since then, numerous researchers have conducted research on the analgesic and anti-inflammatory effects of Tai Chi in conditions such as knee osteoarthritis, fibromyalgia, nonspecific low back pain, and rheumatoid arthritis. Studies have investigated its impact on bone metabolism and density in middle-aged and postmenopausal women. For instance, Wang et al. provided high-quality evidence for the analgesic benefits of Tai Chi. They found that 12 weeks of Tai Chi substantially improved the clinical symptoms and reduced depressive mood among patients with fibromyalgia, resulting in an elevated quality of life. These effects are notably superior to those of stretching exercises and health education and surpass the threshold for clinical improvement[153]. Additionally, several clinical studies have validated the advantages of Tai Chi in alleviating pain intensity and enhancing physical activity among patients with nonspecific lower back pain[146] as well as in enhancing lower limb muscle function and diminishing cardiovascular disease risks among patients with rheumatoid arthritis[182]. These studies collectively suggest that Tai Chi holds promise in alleviating musculoskeletal pain and elevating the quality of life, making it a suitable option for individuals with limited skeletal muscle activity intensity.

With the progress in clinical research, scholars are delving into the fundamental aspects of the anti-inflammatory and analgesic effects of Tai Chi. Modification of the inflammatory process plays a pivotal role in the health benefits of mind-body therapies such as Tai Chi[183]. Owing to the significant involvement of inflammation in various diseases, studies have investigated the mechanisms of Tai Chi through pathways involving inflammatory cytokines

Table 4

The study's characteristics of Tai Chi for cardiopulmonary function, pain, and quality of life improvement

		Tai Chi intervention						
Authors	**Population/patients**	**Types**	**Practice duration per time**	**Practice frequency**	**Practice period**	**Control groups**	**Outcomes assessment**	**Conclusion**
The studies characteristics of Taijiquan for cardiopulmonary function, improvement								
Thomas et al.[109]	Health elderly	Yang style 24-forms of Tai Chi	60 min	3 times/week	48 weeks	Resistance training exercise/usual level of physical activity	Dual x-ray densitometry body composition, blood pressure, lipids, glycemic and insulin sensitivity indices, etc	Negative (R)
Wolf et al.[110]	Fall history elderly	Part of 24-forms of Tai Chi	60–90 min (home exercise 10–50 min)	2 times/week (home exercise 4–5 times/ week)	48 weeks	Wellness education	Gait speed, functional reach test, time to rise from a chair three times, etc	Positive (R)
Chan et al.[111]	COPD	Breathing regulating Tai Chi	60 min	3 times/week	12 weeks	Breathing and walking	St. George respiratory questionnaire-Hong Kong Chinese version, the multidimensional scale of perceived social support Chinese version, etc	Positive (R)
Huang et al.[112]	Health elderly	Yang style 24-forms of Tai Chi	60 min	3 times/week	20 weeks	Non-attendance	Vascular resistance, etc	Positive (R)
Chang et al.[113]	Cardiovascular disease	Yang style Tai Chi & usual care	90 min	1–3 times/ week	96 weeks	Usual care	Left carotid artery two-dimensional ultrasonographic images, serum total adiponectin concentrations, etc	Positive (R)
Song et al.[114]	Health elderly	Chen style Tai Chi	120 min	2 times/day	48 weeks	Self before and after control	The cardiac pump function indicator, pulmonary ventilation indicator, etc	Undefined (R)
Hsu et al.[115]	Middle-aged and elderly women	Yang style 13-forms of Tai Chi	60 min	3 times/week	12 weeks	Circuit exercise Group/no exercise training	Eight-polar tactile-electrode impedance meter, etc	Positive (R)
Nery et al.[116]	Myocardial infarction	Beijin style Tai Chi	60 min	3 times/week	12 weeks	Stretching exercise	Vo2 peak, cardiopulmonary Exercise testing, etc	Positive (R)
Sun et al.[117]	Hypertension	Unspecified	3 h/week 2 h/week home exercises	Unspecified	48 weeks	Computer education and reading	Blood pressure, blood fat, blood glucose, etc	Positive (R)
Robins et al.[118]	Cardiovascular disease	Modified of Tai Chi	60 min	3 times/week	8 weeks	Waiting list	Fasting glucose, insulin, and lipids, etc	Positive (R)
Polkey et al.[119]	Not using bronchodilators	Yang style 24 forms Tai Chi	60 min	5 times/week	12 weeks	Pulmonary rehabilitation	George's respiratory questionnaire, etc	Positive (R)
Zhu et al.[120]	COPD	Modified of yang style 24 forms Tai Chi	40–50 min	3 times/week	12 weeks	Self-management handbook	6-Minute walk test, modified medical research council scale, etc	Positive (R)

(*Continued*)

Table 4
(Continued)

Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Hao et al.[121]	Older adults with chronic systolic heart failure	Modified of Tai Chi & functional electrical stimulation of lower limb muscles	Unspecified	2 times/week	12 weeks	Functional electrical stimulation of lower limb muscles/Tai Chi/no intervention	Kansas City cardiomyopathy questionnaire, Zung self-rating depression scale, Beck depression inventory, etc	Positive (R)
Li et al.[122]	Coronary heart disease	Yang style 24 forms Tai Chi & conventional treatment and care	60 min	Unspecified	24 weeks	Physical exercise & conventional treatment and care	Left ventricular ejection fraction, SF-36 life quality, self-rating anxiety scale, self-rating depression scale, etc	Positive (R)
Shou et al.[123]	Primary hypertension	Yang style 24 forms Tai Chi	60 min	5 times/week	12 weeks	Health education	The body mass index, blood pressure, blood lipid	Positive (R)
Zheng et al.[124]	Older adults at risk of ischemic stroke	24 forms Tai Chi	60 min	5 times/week	12 weeks	Usual physical activity	Echocardiographic, static lung function, etc	Positive (R)
Jiang et al.[125]	Lung cancer surgery patients	Yang style 24 forms Tai Chi	60 min	7 times/week	12 weeks	Usual care	Inflammatory cytokines, keap1, nrf2 in peripheral blood leukocytes cores, etc	Positive (R)
Yeh et al.[126]	COPD	Yang style Tai Chi	60 min	1–2 times/ week	24 weeks	Education	The chronic respiratory disease questionnaire, the COPD self-efficacy scale, the multidimensional scale of perceived social support, etc	Positive (R)
Kraemer et al.[127]	COPD	Yang-style Tai Chi	60 min	2 times/week	12 weeks	Mind-body breath	6-Minute walk test, multidimensional scale of perceived social support, 30-s chair stand test, the chair sits and reach, etc	Positive (R)
Wen and Su[128]	Hypertension and hyperlipidemia	Wu-style Tai Chi	60 min	3 times/week	6 weeks	Simplified Tai Chi	Blood pressure, blood lipids, etc	Positive (R)
Rong et al.[129]	Health elderly	Unspecified	30 min	3 times/week	More than 5 years	No exercise	Vital capacity, step test index	Positive (C-S)
Zeng et al.[130]	Health elderly	Yang style 24 forms Tai Chi	30–40 min	3 times/week	2 years	No exercise	Blood pressure, body weight, chronic disease incidence and mortality	Positive (R)
Li et al.[131]	COPD	Yang style 24 forms Tai Chi	60 min	7 times/week	24 weeks	Respiratory function training	Lung function, quality of life, mental state, bone density	Positive (R)
Du et al.[132]	COPD	Yang style 24 forms Tai Chi	60 min	2 times/week	12 weeks	Brisk walking/no exercise	Lung function, 6-min walk test, COPD assessment test, Sa 02	Positive (R)
Song[133]	Health elderly	Unspecified	100–140 min	7 times/week	24 weeks	NA	Cardiac pumping function, pulmonary ventilation function and cerebral blood flow resistance	Positive (B)

(*Continued*)

Table 4
(Continued)

Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Xing et al.[134]	COPD	Yang style Tai Chi	60 min	7 times/week	48 weeks	Abdominal breathing and brisk walking/no exercise	FEV1% Estimated value, FEV1/FVC, Maximum air volume per minute	Positive (R)
Li et al.[135]	T2D	Chen style Tai Chi	50 min	7 times/week	24 weeks	Maintain a daily exercise routine	Blood pressure, waist-to-hip ratio, blood glucose, blood lipid, maximum gas volume per minute, forced vital capacity, left ventricular ejection fractions	Positive (R)
Li et al.[136]	T2D	Chen style Tai Chi	60 min	5 times/week	24 weeks	Health education	Fasting blood glucose, VO2 peak	Positive (R)
Yu et al.[137]	Cardiac failure	Yang style 24 forms Tai Chi & medication	40 min	7 times/week	24 weeks	Medication	Cardiac function grade, Brain Natriuretic Peptide, Aldosterone, 6-min walking distance, left ventricular ejection fraction, Minnesota Heart Failure Quality of Life Scale	Positive (R)
Lv et al.[138]	Stable angina	Yang style 24 forms Tai Chi & Conventional therapy	90 min	2 times/week	12 weeks	Conventional therapy	Blood glucose, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, triglyceride, total cholesterol, C-reactive protein, homocysteine, uric acid, VO2 peak, 6-min walking distance	Positive (R)
Yuan et al.[139]	Stable cardiovascular disease	Yang style Tai Chi	30 min	3 times/week	12 weeks	Brisk walking	Hemodynamic changes	Positive (R)
Zhang et al.[140]	Stable coronary artery disease	Yang style 24 forms Tai Chi & Conventional therapy	40 min	5 times/week	24 weeks	Brisk walking/no exercise	VO2 peak, anaerobic threshold, 30-s chair stand test, low-density lipoprotein cholesterol	Positive (R)
Wang et al.[141]	Cardiac failure	Yang style 24 forms Tai Chi & medication	30 min	3–5 times/ week	12 weeks	Medication	Classification of nyha heart function, 6-min walking distance	Positive (R)
The studies characteristics of Tai Chi for pain improvement								
Fransen et al.[142]	Arthritic	Modified of yang style 24-form Tai Chi	60 min	2 times/week	12 weeks	Hydrotherapy classes/waiting list	The Western Ontario and Mcmaster universities osteoarthritis index, etc	Positive (R)
Shen et al.[143]	Arthritic	Yang style 24-form Tai Chi	60 min	2 times/week	6 weeks	Self-control study	Gait kinematics, visual analog scale, the chronic pain self-efficacy scale	Positive (R)
Song et al.[144]	Arthritic	Sun-style 31-form Tai Chi	60 min (home exercise 20 min)	1–2 times/ week (home exercise everyday)	24 weeks	Self-help education	Isokinetic dynamometer, dual-energy x-ray absorptiometry, the survey of activities and fear of falling, etc	Positive (R)

(*Continued*)

Table 4
(Continued)

Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Wang et al.[145]	Fibromyalgia	Yang style 10-form Tai Chi	60 min	2 times/week	12 weeks	Wellness education, stretching for the treatment	Fibromyalgia impact questionnaire score, etc	Positive (R)
Hall et al.[146]	Low back pain	The sun style Tai Chi	40 min	1–2 times/ week	10 weeks	Waiting list	Numerical rating scale, the pain disability index, etc	Positive (R)
Irwin et al.[147]	Health elderly	Adapted from "tai-chi-chih! Joy through movement"	40 min	3 times/week	16 weeks	Health education	Circulating levels of interleukin 6, etc	Positive (R)
Jones et al.[148]	Fibromyalgia	Yang style 8-form Tai Chi	90 min	2 times/week	12 weeks	Health education	The fibromyalgia impact questionnaire, etc	Positive (R)
Romero-Zurita 1 et al.[149]	Fibromyalgia female	Yang style 8-form Tai Chi	60 min	3 times/week	28 weeks	Self-control study	The fibromyalgia impact questionnaire, short-form health survey 36, etc	Positive (R)
Wu et al.[150]	Retired athlete with chronic low back pain	Physical therapy & Chen style Tai Chi	45 min	5 times/week	24 weeks	Physical therapy & swimming, physical therapy & backward walking, physical therapy & jogging, physical therapy & no exercise	Visual analog scale, etc	Positive (R)
Callahan et al.[151]	Arthritis patients	Sun style Tai Chi	60 min	2 times/week	8 weeks	Waiting list	Visual analog scale, etc Scale, the disability scale of the	Positive (R)
Lauche et al.[152]	Chronic nonspecific neck pain	Yang style 13-form Tai Chi	75–90 min	1 time/week	12 weeks	Neck exercises/waiting list	Numerical rating scale, visual analog scale, etc	Positive (R)
Wang et al.[5]	KOA	Yang style Tai Chi	60 min	2 times/week	12 weeks	Standard physical therapy	Western Ontario and Mcmaster universities osteoarthritis index score, etc	Positive (R)
Wang et al.[153]	Fibromyalgia	Yang style Tai Chi	60 min	2 times/week	24 weeks	Aerobic exercise/low-intensity Tai Chi	Fibromyalgia impact questionnaire, etc	Positive (R)
Li et al.[154]	Primary total knee arthroplasty	Yang style 24-form Tai Chi	45 min	5 times/week	12 weeks	Traditional physical exercise	Western Ontario and Mcmaster universities osteoarthritis index score, 6-MIN walk test, knee range of motion, etc	Positive (R)
Liu et al.[101]	KOA	Yang style 24-form Tai Chi	60 min	5 times/week	12 weeks	Baduanjin/stationary cycling/and health education	Knee injury and osteoarthritis outcome score, functional and structural MRI, etc	Positive (R)
Liu et al.[100]	KOA	Yang style 24-form Tai Chi	60 min	5 times/week	12 weeks	Baduanjin, stationary cycling, health education	Knee injury and osteoarthritis outcome score, functional and structural MRI, etc	Positive (R)
Hu et al.[155]	KOA	Unspecified	60 min	3 times/week	24 weeks	Health education	The proprioception of the knee and ankle, etc	Positive (R)
Chen et al.[156]	KOA	Sun style Tai Chi	60 min	2 times/ week	12 weeks	Health education	30 s chair stand, 30 s arm-curl, 2-Min step, single-leg stand, functional reach, 8-foot up-and-go, and 10-m walk tests, etc	Positive (R)

(*Continued*)

Table 4
(Continued)

Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Wang et al.[157]	Healthy women	8-form Tai Chi	40 min	3 times/week	28 weeks	Sham Tai Chi	The pressure pain thresholds of low back, etc	Positive (R)
Xie et al.[158]	Migraine(female)	Modified of yang style 33-form Tai Chi	60 min	5 times/week	12 weeks	Waiting list	Frequency of migraine attack, etc	Positive (R)
The studies characteristics of Tai Chi for quality-of-life improvement								
Greenspan et al.[159]	Elderly female	6-forms of Tai Chi	60–90 min	2 times/week	48 weeks	Wellness education	Sickness impact profile, etc	Positive (R)
Yeh et al.[160]	Heart failure patient	Modified of yang style Tai Chi	60 min	2 times/week	12 weeks	Education	The Minnesota living with heart failure questionnaire, etc	Positive (N)
Day et al.[161]	Preclinically disabled	Modified sun style Tai Chi	60 min	2 times/week	24 weeks	Sitting flexibility training	Late function and disability instrument	Positive (R)
Komelski et al.[162]	Volunteer sample of U.S. Taijiquan and qigong practitioners	Cross-sectional study	/	/	/	Exercise, non-exercise training	Behavioral risk factor surveillance system, etc	Positive (C-S)
Campo et al.[163]	Senior female cancer survivors	Unspecified	60 min	3 times/week	12 weeks	Health education	Mental component summary, physical component summary, etc	Positive (R)
Chan et al.[164]	COPD	Unspecified	60 min	2 times/week	12 weeks	Breathing and walking/usual care	Time interactions in quality of life, George's respiratory questionnaire scale of perceived social support, etc	Positive (R)
Robins et al.[165]	Women with early-stage breast cancer	8-form of Tai Chi	90 min/week	Unspecified	10 weeks	Usual care	The impact of events scale markers, the functional assessment of cancer therapy-breast	Positive (R)
Taylor-Piliae et al.[166]	Survivors of stroke	Yang style 24-forms of Tai Chi	60 min	3 times/week	12 weeks	Strength and range of movement exercises/usual care	36-item short-form health survey, depression scale, depression scale	Positive (R)
Larkey et al.[167]	Breast cancer survivors	Partial Tai Chi movements	30–60 min	1–2 times/week 5 times home exercise	12 weeks	Sham qigong	The fatigue symptom inventory	Positive (R)
Larkey et al.[168]	Breast cancer survivors	Partial Tai Chi movements	30–60 min	1–2 times/week 5 times home exercise	12 weeks	Sham qigong	Medical outcomes survey short form, brief physical activity questionnaire	Positive (R)
Hsu et al.[169]	Wheelchair elderly	Seated Tai Chi	40 min	3 times/week	26 weeks	Usual activity	The WHOQOL-BREF, the geriatric depression scale-short form	Positive (R)

(*Continued*)

Table 4
(Continued)

Authors	Population/patients	Tai Chi intervention				Control groups	Outcomes assessment	Conclusion
		Types	Practice duration per time	Practice frequency	Practice period			
Huang et al.[170]	Breast cancer patients during chemotherapy	Modified of Tai Chi	30 min	3 times/week	12 weeks	Non-sporting Qigong/postsurgical exercise	Edmonton frail scale	Positive (R)
Zhang et al.[171]	Chemotherapy for lung cancer	Yang style 8-form of Tai Chi	60 min	3 times/week	12 weeks	Low-impact exercise	Multidimensional fatigue symptom inventory–short form	Positive (R)
Tajik et al.[172]	Elderly male	Part of 24-form of Tai Chi	30–40 min	3 times/week	8 weeks	Usual daily activities	The Leiden Padua quality of life questionnaire	Positive (R)
Liao et al.[173]	Elderly with mild to moderate depression	Yang style 24-form of Tai Chi	50 min	3 times/week	12 weeks	Health education	WHOQOL-BREF	Positive (R)
Zhu et al.[174]	Substance abuse disorder	Modified of Tai Chi	60 min	5 times/week	12 weeks	Conventional rehabilitation exercises	Blood pressure, vital capacity, quality of life for addicted abusers	Positive (R)
Cheng et al.[175]	Cancer patients	Yang style 24-form of Tai Chi	40 min	3 times/week	12 weeks	High-intensity resistance training/low-intensity resistance training group/routine activities	The cancer-related fatigue, quality of life	Positive (R)
Wang et al.[176]	T2D	Yang style 24-form of Tai Chi	40–60 min	3 times/week	24 weeks	Baduanjin/Usual care	Blood sugar, Blood lipid, Diabetes Specific Quality of Life	Positive (R)
Huang et al.[177]	Elderly patients with sarcopenia	8-form of Tai Chi	40 min	3 times/week	12 weeks	No exercise	Postural control ability, surface electromyogram	Positive (R)

B: Before and after self-control study; C-S: cross-sectional study; COPD: Chronic obstructive pulmonary disease; KOA: Kansas Optometric Association; R: RCT; T2D: Type 2 diabetes.

and cellular markers. You et al.'s[184] research unveiled that a bi-weekly, 12-week Tai Chi regimen significantly reduced β-endorphin levels among older individuals afflicted by chronic pain, in comparison to mild exercise. Another study showed that a 10-month Tai Chi program improved apoptotic pathways linked to cytokines, such as polymerase chain reaction (PCR) and tumor necrosis factor (TNF), thereby alleviating muscle atrophy symptoms compared to health education[3]. Irwin et al.[185] observed that in breast cancer survivors, a 3-month Tai Chi practice decreased interleukin-6 (IL-6) and TNF production in monocytes and the whole-genome transcriptome of peripheral blood mononuclear cells relative to cognitive behavioral therapy for insomnia. These findings partially elucidate the molecular mechanisms of Tai Chi, although human mechanistic research faces limitations that challenge its validation through specific molecular inhibition or stimulation. Future studies should explore the multifaceted molecular mechanisms and innovative research ideas to achieve a deeper understanding.

Improving quality of life

Nineteen studies explored the effects of Tai Chi on the quality of life. The study characteristics are presented in Table 4.

A pilot study indicated that Tai Chi, as an adjunctive intervention in standard care, could alleviate fatigue, sleep disturbances, and depression symptoms, thereby enhancing the quality of life of patients with breast cancer[186]. Another study showed that a 12-week Tai Chi or resistance exercise, conducted three times a week for 40 min, improved fatigue levels and enhanced the quality of life among patients with gastric, lung, and breast cancers[175]. A randomized controlled trial showed that Tai Chi practice for a total of 24 sessions over a 3-month period significantly prevented chemotherapy interval thrombosis, reduced peripherally inserted central venous catheter (PICC)-related complications, improved self-management ability, and improved quality of life in long-term PICC home-dwelling patients compared with physical training[187]. These studies suggest that Tai Chi may be an appropriate means of long-term self-management, especially for frail patients.

Prospect and implication

"Integration of Sports and Medicine" represents a novel approach aimed at addressing the healthcare requirements of individuals across their entire lifespan. This approach opens new avenues for Tai Chi to strengthen its role in health maintenance and the promotion of rehabilitation. This review reveals that promoting balance, improving cognitive function, regulating mood and sleep, improving cardiopulmonary function, relieving pain, and enhancing quality of life are the hot spots of clinical research on the health-promoting effects of Tai Chi. Research targeting the older individuals, chronically diseased, neurologically diseased, and cardiovascular patients may be a future trend in the field.

Clear reporting and detailed research proposal design are key to improving the quality of research

Presently, research on the health-promoting effects of Tai Chi still grapples with issues related to low quality, as nearly all systematic reviews on Tai Chi have consistently reported evidence of low or moderate quality[188–190]. Primarily, there is a lack of clarity regarding the reporting of clinical trial types, research hypotheses, and sample size calculations, despite the fact that clinical research in this domain spans over two decades. This reflects the inadequate emphasis placed on research standardization within this field, which serves as a primary contributor to the consistently subpar quality of Tai Chi clinical studies. Second, considerable uniformity prevails in the intervention protocols, with only a few studies tailoring intervention approaches to specific disease characteristics. This has resulted in a deficient rationalization of intervention protocols and undue replication of methods across various individual studies. An analysis revealed that the most commonly used intervention design in clinical Tai Chi studies was 60 min of practice three times a week for 12 weeks, regardless of whether the study population consisted of healthy subjects or patients[191]. Intervention programs must be refined to achieve the goal of integrating Sports and Medicine. There is a pressing need to develop exercise prescriptions suitable for individuals with diverse medical conditions. This approach should be refined by adapting intervention protocols to suit various diseases. Insufficient cross-pollination among research teams may be a major cause of these challenges. Researchers well-versed in physical education who understand the intricacies of Tai Chi might lack comprehensive knowledge of the clinical research design paradigms and norms. However, clinicians and researchers might lack a sufficient understanding of Tai Chi. Thus, the formation of research teams with multidisciplinary backgrounds is highly advisable to advance the quality of research in this field.

Exploring and expanding the application scope of Tai Chi for health promotion using evidence-based medicine methods

Current research predominantly concentrates on uncovering the advantages of Tai Chi in areas such as promoting balance, enhancing cognitive function, improving sleep and mood regulation, boosting cardiovascular fitness, alleviating pain, and enhancing the quality of life. However, along with the pursuit of improved research quality in these domains to provide more robust evidence, there is a pressing need to explore and broaden the application scope of Tai Chi in health promotion. Achieving this involves the development of more refined intervention protocols and customization of interventions based on disease subtypes. However, it entails the integration of Tai Chi into a broader array of diseases, particularly chronic conditions that present challenges for cure but are not immediately life-threatening. Moreover, future research should focus on elucidating the core factors that influence the efficacy of Tai Chi interventions, encompassing factors such as the practice environment, methodologies, and other relevant variables. In an active intervention approach, the quality of the intervention is closely linked

to proficiency, concentration, and dedication. This entails addressing both the internal and external facets. The delineation of the pivotal elements contributing to Tai Chi's therapeutic effects holds immense significance for elevating the efficiency of Tai Chi interventions and their practical clinical applications.

The combination and application of traditional Chinese medicine therapy

Traditional Chinese medicine comprises five primary treatment methods: guidance, acupuncture, moxibustion, massage, and herbal medicine. Among these, Tai Chi is the only active therapeutic technique that has evolved from the practice of guidance. Tai Chi employs specific movements synchronized with breathing and mindful awareness to stimulate self-regulation, enhance blood circulation, modulate neural excitability, and restore internal and external equilibria and harmony. This proactive self-intervention reduces reliance on medical professionals, alleviates strain on healthcare resources, and has significant practical and strategic value. Acupuncture, moxibustion, and massage involve stimulating specific acupuncture points to activate the body's self-regulatory mechanisms, thereby achieving an internal and external balance for disease treatment. Acupuncture has emerged as one of the most widespread external treatments in Traditional Chinese Medicine. The extensive development of acupuncture has been based on its straightforward and efficient nature. In contrast, herbal medicines adjust imbalances in the body through the internal ingestion or external application of medicinal substances. They are widely used in China and Asian region. Herbal medicine is the preferred choice for individuals for whom external treatments are unsuitable. These therapeutic methods emphasize a holistic approach that prioritizes comprehensive well-being, encompassing the physical, mental, and spiritual aspects. By balancing the internal and external factors within the body, they serve both preventive and curative functions. Traditional therapies not only possess individual merits but also complement each other, boasting good tolerability and safety. A combination of these methods yields more effective results. For example, selecting appropriate treatments or employing combinations of different therapies at various disease stages can significantly enhance the short- and long-term efficacies of traditional Chinese medicine, thereby alleviating healthcare pressure.

In summary, Tai Chi has a history spanning hundreds of years as a health-promoting exercise that makes substantial contributions to health maintenance and aids recovery. It has noteworthy significance in disease prevention, health preservation, and supplementary rehabilitation therapy. Over the past two decades, clinical Tai Chi research has evolved from a nonexistent status to a wide spectrum of subjects, spanning healthy individuals and diverse patient populations. This evolution has transitioned from mere health promotion to exploration of the underlying mechanisms. This progress has yielded copious scientific evidence elucidating the health-promoting effects of Tai Chi. Looking ahead, the key to nurturing the continued advancement of this field lies in comprehensive research that encompasses standardized study designs and reporting, the extension of Tai Chi's application scope, and the core determinants influencing its efficacy. This should involve high-quality, multicenter, large sample clinical studies and open, transparent details of Tai Chi interventions to enhance the reproducibility of research in this field. Collaboration with professionals from different fields is vital for innovative development. This collective effort will contribute to firmly establishing Tai Chi as an enduring tool for self-health management, playing an integral role in safeguarding human health throughout the entirety of life. Additionally, the integrated application of Tai Chi, acupuncture, and herbal medicine should also be regarded as significant. Rigorous experimental designs, accurate data recording, and detailed practice guidelines will contribute to the comprehensive application of traditional Chinese medical therapies. Policy-level support should strengthen international collaboration and communication, enhance public health education through promotions and lectures, and promote the integration of traditional Chinese medicine into daily life.

Conflict of interest statement

Fanrong Liang is the editorial board member of this journal. The other authors declare no conflict of interest.

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Author contributions

Teng Yuke and Luo Weiming designed the study and drafted the manuscript. Wu Jianwei and Li Zhengjie revised the study design and the manuscript. Wang Muchen, Wu Jinghan, Nie Xiaoqian, and Sun Cong participated in the design of the search strategy and data extraction. Zhou Jun, Liang Ziyan, and Liu Baiyang formed the data synthesis and analysis plan. Zhang Furong, Liu Tianyu, Zhao Shi and Xiaofan Yang suggested revisions to the manuscript. All authors have read and approved the publication of the final manuscript.

Ethical approval of studies and informed consent

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Data availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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