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REVIEW ARTICLE

Effectiveness of Tai Chi for health promotion for adults with health conditions: a scoping review of Meta-analyses

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ABSTRACT

Purpose: To complete a scoping review of meta-analyses summarizing evidence of the effectiveness of Tai Chi for adults with health conditions.

Materials and Methods: Meta-analyses were retrieved from Medline, Embase, AMED, CINAHL, SPORTDiscus, PsychINFO, Web of Science, PubMed Health and the Cochrane Library from database inception to early September 2018. Multistage deduplication and screening processes identified full-length, unique, peer-reviewed meta-analyses. Two people independently appraised 42 meta-analyses based on the GRADE system and organized results into 3 appendices subsequently collated into heterogeneous, statistically significant, and statistically insignificant tables.

Results: "High" and "moderate" quality evidence indicates that Tai Chi can significantly benefit adults with health conditions including cancers, chronic obstructive pulmonary disease, coronary heart disease, depression, heart failure, hypertension, low back pain, osteoarthritis, osteoporosis, Parkinson's Disease and stroke. Outcomes included significant improvements in activities of daily living, balance, exercise capacity, gait, mastery, mental health, mobility, motor function, participation in daily life, physical function, quality of life, range of motion, and strength; with reductions in blood pressure, body mass index, depression, disability, dyspnea, falls, fatigue, pain, stiffness, and waist circumference.

Conclusions: Healthcare providers now have information to advise clients with health conditions on the effectiveness of Tai Chi for overall health promotion.

➤ IMPLICATIONS FOR REHABILITATION

- Tai Chi is a form of safe, enjoyable, light-to-moderate aerobic physical activity for adults that is inexpensive to implement in diverse community settings.
- Adults with health conditions require physical activity for prevention of secondary impairments and over-all health promotion.
- This scoping review of meta-analyses elucidates "high" and "moderate" quality evidence of the effectiveness of Tai Chi in improving important outcomes for people with numerous health conditions.
- This information can be useful for healthcare providers who wish to recommend effective community-based physical activity to clients they are serving.

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Tai Ji; PubMed; health promotion; adults; meta-analysis

Introduction

Numerous studies have described the importance of physical activity for promoting general health and well-being and for preventing chronic disease or disability and premature death [1,2]. Health Canada and the Canadian Society for Exercise Physiology (CSEP) have published guidelines for how much physical activity people of varying ages should obtain [3–5]. Adults should engage in 150 min of moderate-vigorous aerobic physical activity per week and muscle and bone strengthening activities using major muscle groups at least twice a week [6,7]. Those with poor mobility should participate in physical activity to enhance balance and reduce the risk of falls [7]. Overall, the CSEP suggests that more physical activity leads to greater health benefits and that various types of physical activity are beneficial, with safety and enjoyment being key [6,7].

Tai Chi is one form of light-to-moderate aerobic physical activity that may be appealing for many adults. It is a form of physical and mental training combining Chinese martial arts and meditative movements [8] involving a series of slowly performed, continuous, and rhythmic movements that put minimal impact on the joints of the body [8,9]. Tai Chi comprises mental concentration, physical balance, muscle relaxation, and breathing that is coordinated with whole-body movement, and is thought to assist in finding balance between one's body and mind [10]. Studies have reported high levels of enjoyment and high adherence rates among participants [11,12]. Tai Chi is relatively easy and inexpensive to implement in diverse community settings, including socioeconomically-disadvantaged and mixed-ethnicity communities with older adults [9,11,12]. Tai Chi is promising in its ability to promote general health and well-being, to prevent chronic disease, and to optimize health among people with chronic disease.

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Supplemental data for this article can be accessed here.

Given the potential that has been associated with Tai Chi for promoting health, Solloway and colleagues [13] conducted a "systematic review of systematic reviews" and compiled an evidence map describing the volume and focus of Tai Chi research. The map identified many patient outcomes on which Tai Chi may have positive effects; nonetheless, the authors identified some limitations to this study which prevented them from drawing firm conclusions [13]. Huston and McFarlane [14] have since published an updated review of the health benefits associated with Tai Chi; however, there were also limitations associated with this study which hinder the confidence readers can have of the results. Specifically, limitations of these two high level overviews include that: i) the two studies are now dated, having reported on research published up to February 2014 [13] and October 2015 [14], ii) only the MedLine database was searched [14], limiting external validity, iii) a mix of both systematic reviews and randomized controlled trials comprised the units of analysis [14], iv) the quality of studies were either not evaluated [13] or evaluations were not conducted in a transparent manner using two independent reviewers [14], and iv) detailed data extraction tables were not provided [13,14]. To build on these preliminary findings, we aimed to use a comprehensive search strategy to collect, initially, only systematic reviews that were inclusive of the most up-to-date research, evaluate the quality of the included studies using transparent organizational methods with two independent reviewers, and provide detailed data extraction tables to support summary tables.

When examining the effects of Tai Chi on health outcomes, content can be separated into subgroups of either individuals with diagnosed health conditions (i.e., in which the focus would be on secondary and tertiary prevention) or individuals for whom no diagnosed health condition exists (i.e., in which the focus would be on primary prevention) [15]. The primary objective of this scoping review was to summarize the current state of knowledge of the effectiveness of Tai Chi for adults with diagnosed health conditions from published, peer-reviewed, unique meta-analyses. Secondary objectives included describing the frequency of meta-analyses published over time, exploring the relationship between the date of publication and the average quality rating of each included manuscript containing both statistically significant and non-significant results, and tracking reports of adverse effects of Tai Chi. The outcomes of this work are expected to be useful to healthcare service providers working with people with various health conditions to enable them to recommend complementary, safe, effective, and enjoyable community-based Tai Chi classes appropriately for the purposes of secondary and tertiary prevention and overall health promotion.

Materials and methods

We used the advanced scoping methods proposed by Levac, Colquhoun, and O'Brien [16]. In addition to identifying the purpose of the work, steps included: identifying relevant studies through comprehensive use of multiple databases and a systematic search strategy; selection of relevant articles; charting data (including a quality appraisal); and collating, summarizing, and reporting results. We are aware of the work being conducted by Colquhoun and colleagues [17] in which they plan to elaborate on their recommendations for quality appraisal in scoping reviews; however, in the absence of new guidelines which were under development at the time we conducted this project, we relied on quality appraisal using the GRADE guidelines [18]. As recommended by Levac et al. [16] we might do a consultation with Taoist Tai Chi ®^{TM} Arts experienced instructors accredited annually by Fung Loy Kok Institute of Taoism at a future date.

We used the GRADE Handbook [18] to rate the quality of evidence in the studies selected for this scoping review. We intentionally avoided a stance of "clever nihilism" [19] by taking a pragmatic approach to our critical appraisals. Specifically, rather than relying on the risk of bias assessments provided by the authors of the selected manuscripts, we used a more balanced approach by carefully considering the impact of various biases in the context of reported studies. We limited our work to completion of the quality appraisals, and did not follow up with making recommendations based on the evidence (nor did we organize tables in order of importance of the outcomes to people in various categories of health conditions). Based on a client-centred perspective [20], both of these final steps require participation of people with the range of health conditions studied to clarify their values and preferences, which was well beyond the scope of the study we undertook.

Data sources and searches

We searched the following databases for published, peer-reviewed, English-language systematic reviews from their inception to September 5, 2018: Medline, Embase, AMED, CINAHL, SPORTDiscus, PsychINFO, Web of Science, PubMed Health and the Cochrane Library. Details of the search strategies are provided in Supplementary Material. Figure 1 contains details of the initial search, which resulted in 2626 records being identified. Because this study used information in the public domain, it is ethics exempt.

Study selection

Deduplication and focus on unique, full-length peer-reviewed records

Zotero (a freely available referencing system database) was used to initiate the deduplication process; however, manual deletion of additional duplicates was also required. In addition, this initial review also deleted records that were older reviews of the same topic from a similar authorship team, duplicate publications in more than one journal, and records that were clearly editorials or commentaries. In our context of wishing to review current best evidence in the form of full-length publications, abstracts, short reports, and evidence briefs were deleted. Finally, with a focus on products going through the full peer-review process, theses and books were excluded. This resulted in 1293 unique publications (Figure 1).

Screening

Given the objective of specifically focusing on evidence related to Tai Chi participation, all articles with titles indicating a more general focus on other interventions ($n = 923$) were deleted, unless Tai Chi was in the title. Other interventions included acupuncture, biofield therapies, chemotherapy, Chinese exercise/herbal medicine/medicine, cognitive behaviour therapy, complementary and alternative approaches, dance, energy therapies, exercise (non-specific), integrative medicine, leisure participation, lifestyle programs, martial arts, meditation, mind-body interventions, mindful practices, non-pharmocologic interventions, occupational therapy, physical activity, physical therapy, psychoneuroimmunology-based interventions, psychological or psychosocial interventions, rehabilitation, relaxation, stress management, wellness programs or yoga.

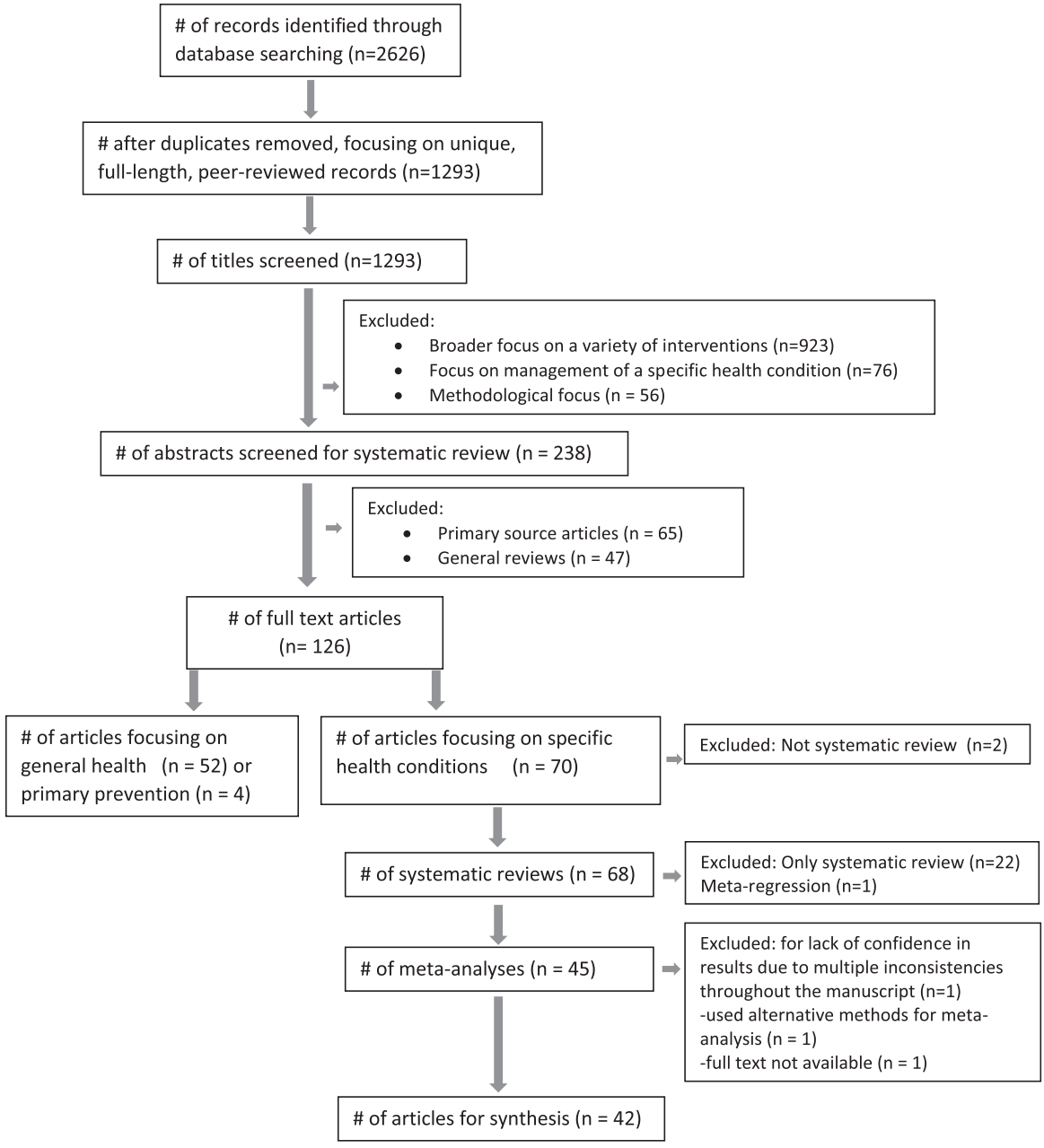

Figure 1. Flow chart of database search and manuscript selection.

Similarly, articles focusing on management of a specific health condition, without Tai Chi in the title, were also deleted ($n = 76$). Health conditions contained in the titles of these articles that were deleted included Alzheimer's disease, ankylosing spondylitis, chronic pain, balance disorders, cognitive aging or dysfunction, diabetes, diabetic neuropathy, fall prevention, fatigue, fibromyalgia, gait disorders, haemophilia, hip fracture, insomnia, Meniere's disease, menopause, multiple sclerosis, osteoarthritis, osteoporosis, Parkinson's disease, pelvic conditions, peripheral neuropathy, psychiatric conditions, rheumatoid arthritis, somatoform disorders, substance abuse, tinnitus, and vertigo. The final step in initial screening involved deleting records that were methodologic in focus ($n = 56$); these comprised primarily of study protocols, but also included perspectives on difficulties in studying Tai Chi. This resulted in 238 records remaining (Figure 1).

A second stage in the screening of records involved a review of abstracts to select only secondary sources. At this stage, 65 records of manuscripts that were primary sources and 47 records that were general reviews or overviews, rather than systematic reviews, were removed. This resulted in 126 records that appeared to be systematic reviews. Up to this point, screening was done only by the corresponding author. Next, as a means of managing the scope of this project, manuscripts were separated into systematic reviews studying general health outcomes ($n = 52$) and primary prevention ($n = 4$) (scoping review to be completed at a future date) versus specific health conditions ($n = 70$) by the entire authorship team. Hereafter, all screening was done independently by 2 people. These 70 manuscripts were screened to confirm that they were systematic reviews; 2 were removed, leaving 68 manuscripts meeting the initial eligibility criteria (Figure 1).

As we began to evaluate and chart the data of these selected articles, we became acutely aware of the overwhelming task of collating qualitative results; therefore, we decided to focus on meta-analyses. We excluded articles that were systematic reviews

only ($n = 22$) and one article that was a meta-regression, without meta-analyses, resulting in 45 manuscripts. As a final step in managing the still over-whelming amount of results, we decided to focus on results produced in the meta-analyses that did not demonstrate inconsistency (i.e., heterogeneity), thus increasing the "certainty" of current collated knowledge. Finally, we removed those articles that were not internally consistent (and therefore, untrustworthy, $n = 1$) [21], that used alternative methods for meta-analysis ($n = 1$, Liu et al. [22] weighed results based on their non-transparent risk of bias assessment), or that were not available to us in full text format ($n = 1$) [23], leaving a final $n = 42$ for synthesis (Figure 1) [24–65].

Data extraction and quality assessment

Two people independently reviewed and appraised each of the 42 manuscripts. Pairs were each of the 6 first authors with the corresponding author, who reviewed and appraised all selected articles and provided consistency in approach across all appraisals. Any discrepancies in charting or appraisals were settled by consensus. When manuscripts contained results for both total scores and subgroups, only subgroups were charted and only if $\geq$2 studies were included. As an initial step in collating the results, 3 detailed tables were produced, each of which is reported as Supplementary tables.

For the table of heterogeneous results (i.e., p values of the various tests of heterogeneity less than 0.05 and high I^2 values [18], or in the absence of these data, visual interpretation of individual studies' non-overlapping confidence intervals) only the population (health condition), outcome, source, number of participants in experimental and control groups, p value, value of I^2, and results were charted. Based on the well-known heterogeneity of Tai Chi styles and forms, as well as variations in intensity, frequency, and duration of practice [66], details of the Tai Chi intervention were not recorded. Results that were statistically significant (despite inconsistency across studies) were shaded to highlight preliminary evidence of effectiveness.

For the tables of statistically significant and insignificant results (excluding results previously screened for heterogeneity), results were collated in two sections. First, the meta-analyses were described by identifying the source, number of studies, study design(s), number of participants, and details of the intervention in the experimental and control groups, and details of the reporting of adverse events related to Tai Chi [67]. The meta-analyses were then appraised for risk of bias, indirectness, imprecision, and publication bias (all of which could contribute to downgrading of evidence), and other considerations to upgrade, followed by an overall quality appraisal, and recording of the estimate of effect [18].

Most frequently, evidence for risk of bias was presented in individual studies using guidelines from the Cochrane Collaboration tool [68] (low risk of bias, high risk of bias, or unclear), which include items relating to random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias) or selective reporting (reporting bias). With knowledge that attributes of the instructor and expectation of the participants are key ingredients to the practice of Tai Chi [69], it is neither possible nor desirable to blind either instructors or participants; therefore, we did not downgrade for these risks of "bias". Similarly, for self-reported outcomes, we did not consider lack of blinding of the assessor as a source of bias. Otherwise, we used reported information, and GRADE [18] guidelines to judge the risk as "not serious", "serious", or "very serious". In the absence of guidelines from the Cochrane Collaboration we also used data reported using the PEDro [70] and Jadad [71] rating systems. The PEDro scale is out of 11 points. Disregarding two items for blinding of participants and instructors, we rated risk of bias as "not serious" with average ratings $\geq$8, "serious" with average ratings of 6–7, and "very serious" with average ratings of $\leq$5. The Jadad scale is out of 5. We considered average ratings of $\geq$4 as "not serious", 3 as "serious" and $\leq$2 as "very serious". If details of the individual items were available, we used those rather than the summary score.

The main source of *indirectness* found across all meta-analyses was use of outcome measures that had weak or very weak associations with patient-important outcomes, regarded by the GRADE [18] system as "serious" or "very serious" problems. We downgraded physiological, pulmonary, and cardiorespiratory functions by one level; similarly, outcomes of body mass index and bone mineral density were downgraded by one. Outcomes relating to bloodwork or body-produced substances such as cortisol or B-type natriuretic peptide were down-graded two levels, after consideration that they were likely very far from outcomes that patients/clients consider important [18]. For *imprecision*, we did not conduct formal sample size calculations, but rather considered whether larger sample sizes (and therefore tighter confidence intervals) would increase the certainty of either statistically significant or insignificant results. When dichotomous data were reported (such as number of adverse events), we considered the impact of the relatively low number of events. For *publication bias*, we relied on evidence from funnel plots (necessitating a minimum of 5 to 10 studies) and did not make a judgement of concern if authors had unsubstantiated reports from previous authors about "some negative studies" being unpublished. We relied on our extensive database searches to minimize publication bias, given that the English language is a major source of publications world-wide. It was interesting to note that of the 42 manuscripts included in this scoping review, 27, 4, 1, and 1 included searches of Chinese, Korean, Japanese, and Indian databases, further reducing the likelihood of publication bias.

The primary factor potentially upgrading the quality of evidence included a large magnitude of effect. We increased the quality of evidence by one level when the standardized mean difference was greater than 0.80 (interpreted as a "large" effect) [72], the mean difference was 1.5 time the minimal clinically important difference, the relative risk reduction was greater than 50%, or the relative risk was greater than 2 [18]. We increased the quality of evidence by two levels when the standardized mean difference was greater than 1.0, the relative risk reduction was greater than 80%, or the relative risk was greater than 5 [18].

Explanations of downgrading or upgrading are provided in the detailed appendices. We followed GRADE [18] guidelines to establish the overall quality of rating.

Data synthesis and analysis

For the primary objective of this scoping review, we summarized the results of the heterogeneous findings by collating "preliminary evidence of effectiveness" for statistically significant results. For both statistically significant and insignificant findings we collated evidence of "high" and "moderate" evaluations of quality of the evidence, presuming that higher quality evidence is most useful for clinicians upon which to base recommendations for clients. The GRADE system [18] describes "high" quality evidence as

Table 1. Preliminary Evidence of Effectiveness of Tai Chi (i.e., heterogeneous results with statistically significant results; all favoring Tai Chi).

Population	Outcome	Source	Magnitude of statistically significant effects	Interpretation
Cancer (various types)	Cancer related fatigue	Song et al. [61]	SMD (95% CI) = −0.58 (−1.11 to −0.01)	Moderate to large reductions in fatigue
		Zeng et al. [36]	SMD (95% CI) = −0.93 (−1.80 to −0.06)	
		Wayne et al. [65]	SMD (95% CI) = −0.53 (−0.97 to −0.28)	
	Sleep difficulty	Wayne et al. [65]	SMD (95% CI) = −0.49 (−0.89 to −0.09)	Moderate reductions in sleep difficulty
	Quality of life	Wayne et al. [65]	SMD (95% CI) = 0.33 (0.10 to 0.56)	Small improvements in quality of life
		Zeng et al. [36]	MD (95% CI) = 6.6 (2.3 to 10.8)	
Cancer (breast and lung cancer)	Pulmonary function (FVC)	Tao et al. [47]	MD (95% CI) = 339.5 (78.5 to 600.6)	No information available to interpret MD
Chronic Conditions	Sleep	Raman et al. [32]	SMD (95% CI) = 0.89 (0.28 to 1.50)	Large improvements in sleep quality
Chronic heart failure	Bloodwork (B-type natriuretic peptide)	Gu et al. [57]	SMD (95% CI) = −2.43 (−4.52 to −0.34)	Remarkably large reductions in peptide levels
	Exercise capacity	Gu et al. [57]	MD (95% CI) = 58.3 (28.5 to 88.1)	Large effect
			MD (95% CI) = 65.6 (21.6 to 109.5)	
	Physiological function	Gu et al. [57]	MD (95% CI) = 7.7 (3.6 to 11.9)	No information available to interpret MD
	Quality of life	Gu et al. [57]	MD (95% CI) = −10.4 (−14.4 to −6.3)	No information available to interpret MD
		Pan et al. [33]	MD (95% CI) = −14.5 (−23.5 to −5.6)	
COPD	Exercise capacity	Ngai et al. [51]	MD (95% CI) = 27.7 (4.4 to 51.1)	Moderate
		Wu et al. [41]	MD (95% CI) = 40.0 (15.6 to 56.4)	Large
		Guo et al. [50]	MD (95% CI) = 30.9 (6.9 to 54.9)	Moderate
	Health-related quality of life	Wu et al. [41]	MD (95% CI) = −10.0 (−17.6 to −2.5)	Very large
	Predicting survival in COPD	Ngai et al. [51]	MD (95% CI) − 1.0(−3.8 to 1.8)	No information available to interpret MD
	Pulmonary function (FEV_1)	Guo et al. [50]	MD (95% CI) = 0.10 (0.01 to 0.19)	Small to moderate
Coronary heart disease	Depression	Liu et al. [62]	MD (95% CI) = −9.4 (−13.6 to −5.3)	No information available to interpret MD
Essential hypertension	Systolic blood pressure	Wang et al. [31]	WMD = −12.4 (−12.6 to −12.2)	No information available to interpret WMD
		Wang et al. [31]	WMD = −9.3 (−10.9 to −7.8)	
		Lian et al. [56]	SMD (95% CI) = −0.81 (−1.40 to −0.22)	Large reduction in systolic BP
	Diastolic blood pressure	Wang et al. [31]	WMD = −6.0 (−6.2 to −5.9)	No information available to interpret WMD
		Wang et al. [31]	WMD = −7.2 (−7.7 to −6.6)	
		Lian et al. [56]	SMD (95% CI) = −0.84 (−1.18 to −0.50)	Large reduction in diastolic BP
Heart failure	Bloodwork (B-type natriuretic peptide)	Ren et al. [58]	SMD (95% CI) = −1.08 (−1.19 to −0.26)	Very large reduction in peptide levels
	Exercise capacity	Ren et al. [58]	MD (95% CI) = 65.3 (32.6 to 98.0)	No information available to interpret MD
	Quality of life	Ren et al. [58]	MD (95% CI) = −11.5 (−16.1 to −7.0)	Small
	Physiological function	Ren et al. [58]	MD (95% CI) = 11.7 (8.8 to 14.6)	No information available to interpret MD
OA	Pain	Chang et al. [49]	SMD (95% CI) = −0.41 [−0.67 to −0.14]	Approaching moderate reduction in pain
	Physical function	Chang et al. [49]	SMD (95% CI) = −0.74 [−1.34 to −0.15]	Approaching large effect in efficiency of stair climbing
Parkinson's disease	Mobility	Zhou et al. [44]	SMD (95% CI) = −0.73 (−1.35 to −0.10)	Approaching large reduction in TUG times
	Motor function (Unified Parkinson's disease Rating scale III)	Zhou et al. [44]	SMD (95% CI) = −0.75 (−1.22 to −0.28)	Approaching large reduction of motor symptoms associated with Parkinson's Disease
	Quality of life	Ni et al. [37]	SMD (95% CI) = −1.10 (−1.81 to −0.39)	Very large effect on improvement in quality of life
Schizophrenia	Improvement in negative symptoms	Zheng et al. [48]	SMD (95% CI) = −0.87 (−1.51 to −0.24)	Large effect in improving negative symptoms
Stroke	Balance (Berg Balance Scale)	Li et al. [54]	MD (95% CI) = 12.4 (6.7 to 18.1)	Very large improvement in balance
	Daily activities	Li et al. [54]	SMD (95% CI) = 1.21 (0.66 to 1.75)	Very large improvement in ADL
	Motor function (Fugl-Meyer Assessment-lower limbs)	Lyu et al. [63]	MD (95% CI) = 2.8 (1.0 to 4.6)	Small effect

6-MWT: 6 min Walk Test; CI: confidence interval; COPD: chronic obstructive pulmonary disease; FEV_1: Forced expiratory volume in one second; FVC: forced vital capacity; MD: mean difference; min: minutes; n: number per group; N: total number in sample; NR: not recorded; OA: osteoarthritis; *p* value: probability value; SF-36: the Short Form Health Survey 36; SMD: standardized mean difference; TUG: Timed Up and Go Test; WMD: weighted mean difference; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

Table 2. Statistically Significant Results with 'High' Quality Evidence (all favoring Tai Chi).

Population	Outcome	Source	Magnitude of statistically significant effects	Interpretation
Breast cancer	Elbow extension	Pan et al. [43]	SMD (95% CI) = 1.29 (0.74 to 1.84)	Very large effect
	Fatigue	Song et al. [61]	SMD (95% CI) = −0.81 (−1.13 to −0.48)	Large effect
Cancer (Tai Chi vs physical exercise)	Fatigue	Song et al. [61]	SMD (95% CI) = −0.49 (−0.76 to −0.22)	Moderate effect
Cancer (Tai Chi vs psychological support)	Fatigue	Song et al. [61]	SMD (95% CI) = −0.84 (−1.34 to −0.35)	Large effect
Cancer (Tai Chi ≥8 wks)	Fatigue	Song et al. [61]	SMD (95% CI) = −0.81 (−1.13 to −0.48)	Large effect
Chronic Health Conditions (OA, Rheumatoid Arthritis, fibromyalgia)	Depression	Wang et al. [40]	MD (95% CI) = −6.0 (−7.1 to −4.9)	No information is available to interpret MD
COPD (Tai Chi ≤3 mo)	Health-related quality of life – Mastery dimension	Ngai et al. [51]	MD (95% CI) = 0.9 (0.3 to 1.5)	Large effect
COPD	Health-related quality of life	Yan et al. [30]	MD (95% CI) = 1.0 (0.2 to 1.7)	Large effect
		Wu et al. [41]	MD (95% CI) = 1.0 (0.2 to 1.7)	Large effect
COPD	Health-related quality of life – Dyspnea dimension	Guo et al. [50]	MD (95% CI) = 0.9 (0.5 to 1.3)	Large effect
COPD	Health-related quality of life – Fatigue dimension	Guo et al. [50]	MD (95% CI) = 0.8 (0.4 to 1.1)	Large effect
Heart failure	Exercise capacity	Chen et al. [45]	SMD (95% CI) = 1.58 (0.70 to 2.45)	Very large effect
Low back pain	Pain	Kong et al. [46]	SMD (95% CI) = −0.81 (−1.11 to −0.52)	Large effect
	Pain	Hall et al. [52]	SMD (95% CI) = −0.84 (−1.27 to −0.42)	Large effect
OA (Tai Chi vs attention control)	Pain	Kong et al. [46]	SMD (95% CI) = −0.60 ((−1.08 to −0.12)	Moderate effect
OA (Tai Chi vs wait list control)	Pain	Kong et al. [46]	SMD (95% CI) = −0.42 (−0.72 to −0.12)	Small-moderate effect
OA (Tai Chi after 6–10 wksl)	Pain	Kong et al. [46]	SMD (95% CI) = −0.50 (−0.83 to −0.17)	Moderate effect
OA	Quality of life	Lauche et al. [34]	SMD (95% CI) = 0.88 (0.42 to 1.34)	Large effect
OA	Pain	Kang et al. [26]	SMD (95% CI) = −1.18 (−1.82 to −0.54)	Very large effect
	Physical function	Kang et al. [26]	SMD (95% CI) = −1.20 (−1.74 to −0.67)	Very large effect
OA (Tai Chi < 12 wks)	Physical function	Yan et al. [26]	SMD (95% CI) = −0.71 (−1.16 to −0.25)	Moderate-large effect
OA (Tai Chi = 12 wks)	Physical function	Yan et al. [29]	SMD (95% CI) = −0.72 (−1.12 to −0.31)	Moderate-large effect
OA (Tai Chi vs other intervention)	Physical function	Chen et al. [45]	SMD (95% CI) = 0.83 (0.44 to 1.23)	Large effect
Osteoporosis	Pain	Kong et al. [46]	SMD (95% CI) = −0.83 (−1.37 to −0.28)	Large effect
Parkinson's disease	Balance	Yang et al. [38]	SMD (95% CI) = 1.22 (0.80 to 1.65)	Very large effect
		Zhou et al. [44]	SMD (95% CI) = 0.85 (0.51 to 1.20)	Large effect
	Mobililty	Yang et al. [38]	SMD (95% CI) = 1.06 (0.68 to 1.44)	Very large effect
	Rate of falls	Winser et al. [64]	OR (95% CI) = 0.47 (0.29 to 0.77)	53% risk reduction
Stroke	Balance	Lyu et al. [63]	MD (95% CI) = 5.2 (3.4 to 7.1)	Large effect
		Li et al. [54]	MD (95% CI) = 6.1 (5.4 to 6.9)	Large effect
	Daily activities ability	Li et al. [54]	SMD (95% CI) = 1.17 (0.82 to 1.52)	Very large effect
		Lyu et al. [63]	MD (95% CI) = 10.0 (6.8 to 13.0)	Very large effect
	Mobility	Winser et al. [64]	OR (95% CI) = 0.21 (0.09 to 0.48)	79% risk reduction

CI: confidence interval; COPD: chronic obstructive pulmonary disease; MD: mean difference; mo: months; OA: osteoarthritis; OR: odds ratio; SMD: standardized mean difference; TUG: Timed Up-and-Go test); vs: versus; wks: weeks.

Table 3. Statistically Significant Results with 'Moderate' Quality Evidence (all favoring Tai Chi).

Population	Outcome	Source	Magnitude of statistically significant effects	Interpretation
Arthritis	Pain	Hall et al. [52]	SMD (95% CI) = −0.66 (−0.85 to −0.48)	Moderate-large effect
	Disability	Hall et al. [52]	SMD (95% CI) = −0.66 (0.85 to −0.46)	Moderate-large effect
Breast cancer	Shoulder abduction	Pan et al. [43]	SMD (95% CI) = 0.58 (0.08 to 1.09)	Moderate effect
	Shoulder adduction	Pan et al. [43]	SMD (95% CI) = 0.77 (0.25 to 1.29)	Moderate – large effect
	Elbow flexion	Pan et al. [43]	SMD (95% CI) = 0.75 (0.24 to 1.27)	Moderate-large effect
	Handgrip strength	Pan et al. [43]	SMD (95% CI) = 0.61 (0.10 to 1.12)	Moderate effect
Cancer–lung	Fatigue	Song et al. [61]	SMD (95% CI) = −0.50 (−0.83 to −0.18)	Moderate effect
Cancer (Tai Chi ≤8 wks)	Fatigue	Song et al. [61]	SMD (95% CI) = −0.36 (−0.63 to −0.08)	Small-moderate effect
Cancer (Tai Chi ≥180 min/wk)	Fatigue	Song et al. [61]	SMD (95% CI) = −0.52 (−0.83 to −0.22)	Moderate effect
Cancer	Depression	Wayne et al. [65]	SMD (95% CI) = −0.27 (−0.44 to −0.11)	Small effect
	Mental health	Zeng et al. [36]	MD (95% CI) = 2.4 (1.8 to 3.0)	Moderate effect
	Quality of life: Emotional well-being	Yan et al. [39]	SMD (95% CI) = 0.24 (0.02 to 0.45)	Small effect
	Vitality	Zeng et al. [36]	MD (95% CI) = 1.6 (0.6 to 2.5)	Moderate effect
Coronary heart disease	Quality of life	Liu et al. [62]	SMD (95% CI) = 0.73 (−0,39 to 1.08)	Moderate-large effect
COPD	Dyspnea	Yan et al. [30]	MD (95% CI) = −0.86 (−1.4 to −0.3)	Small to moderate
COPD (Tai Chi <3 mo)	Exercise capacity	Guo et al. [50]	MD (95% CI) = 16.0 (2.9 to 29.2)	Small to moderate
COPD (Tai Chi >3 mo)	Exercise capacity	Ngai et al. [51]	MD (95% CI) = 36.0 (1.4 to 10.6)	Moderate to large
COPD (Tai Chi ≥12 mo)	Exercise capacity	Guo et al. [50]	MD (95% CI) = 24.6 (2.3 to 47.0)	Moderate
COPD	Exercise capacity	Yan et al. [30]	MD (95% CI) = 34.2 (21.3 to 47.2)	Moderate to large
		Ding et al. [35]	MD (95% CI) = 25.2 (12.0 to 38.4)	Moderate
		Ding et al. [35]	MD (95% CI) = 22.1 (4.8 to 39.3)	Small to moderate
		Chen et al. [45]	SMD (95% CI) = 0.37 (0.01 to 0.73)	Small-moderate effect
	Health-related quality of life	Yan et al. [30]	MD = −3.7 (−7.1 to −0.4)	Small to moderate
		Wu et al. [41]	MD = −3.5 (−6.1 to −1.0	Small to moderate
	Health-related quality of life – Symptoms dimension	Yan et al. [30]	MD = −3.8 (−7.4 to −0.3)	Small to moderate
Depression	Depressive symptoms	Chi et al. [27]	SMD (95% CI) = −0.27 (−0.52 to −0.02)	Small effect
Essential hypertension	Blood Pressure (classified into groups)	Wang et al. [31]	RR (95% CI) = 3.39 (1.81 to 6.34)	Large effect
	Body Mass Index	Lian et al. [56]	SMD (95% CI) = −0.38 (−0.73 to −0.06)	Small-moderate effect
	Waist circumference	Lian et al. [56]	SMD (95% CI) = −0.53 (−0.74 to −0.32)	Moderate effect
OA	Mobility	Chen et al. [45]	MD (95% CI) = 0.6 (0.1 to 1.0)	Small effect
OA (>10 wks of Tai Chi)	Pain	Kong et al.[46]	SMD (95% CI) = −0.57 (−0.86 to −0.27)	Moderate effect
OA (<12 wks of Tai Chi)	Pain	Yan et al. [29]	SMD (95% CI) = −0.49 (−0.90 to −0.08)	Moderate effect
OA (12 wks of Tai Chi)	Pain	Yan et al. [29]	SMD (95% CI) = −0.52 (−0.95 to −0.09)	Moderate effect
OA	Pain	Kang et al. [26]	SMD (95% CI) = −0.47 (−0.79 to −0.14)	Moderate effect
		Lauche et al. [34]	SMD (95% CI) = −0.72 (−1.00 to −0.44)	Moderate-large effect
OA (Tai Chi vs no intervention)	Pain	Chen et al. [45]	SMD (95% CI) = 0.51 (0.2 to 0.79)	Moderate effect
OA (Tai Chi vs other intervention)	Pain	Chen et al. [45]	SMD (95% CI) = 0.55 (0.09 to 1.01)	Moderate effect
OA	Participation in daily life	Chang et al. [49]	SMD (95% CI) = −0.63 (−0.98 to −0.27)	Moderate effect
	Physical function	Kang et al. [26]	SMD (95% CI) = −0.60 (−0.93 to −0.28)	Moderate effect
	Physical function	Lauche et al. [34]	SMD (95% CI) = −0.72 (−1.01 to −0.44)	Moderate-large effect
OA (>12 wks Tai Chi)	Physical function	Yan et al. [29]	SMD (95% CI) = −0.45 (−0.85 to −0.04)	Moderate effect
OA (Tai Chi vs no intervention)	Physical function	Chen et al. [45]	SMD (95% CI) = 0.62 (0.31 to 0.92)	Moderate effect
OA	Quality of Life	Chen et al. [45]	SMD (95% CI) = 0.38 (0.01 to 0.75)	Small-moderate effect
OA	Stiffness	Lauche et al. [34]	SMD (95% CI) = −0.59 (−0.99 to −0.19)	Moderate effect
OA (12 wks of Tai Chi)	Stiffness	Yan et al. [29]	SMD (95% CI) = −0.47 (−0.83 to −0.12)	Moderate effect
OA (Tai Chi vs no intervention)	Stiffness	Chen et al. [45]	SMD (95% CI) = 0.57 (0.13 to 1.01)	Moderate effect
OA (Tai Chi vs other intervention	Stiffness	Chen et al. [45]	SMD (95% CI) = 0.61 (0.25 to 0.97)	Moderate effect
Parkinson's disease	Balance	Yang et al. [38] [55]	SMD (95% CI) = 0.74 (0.38 to 1.10)	Moderate-large effect
	Balance	Song et al. [55]	SMD (95% CI) = 0.54 (0.36 to 0.73)	Moderate effect
	Depression	Song et al. [55]	SMD (95% CI) = −0.46 (−0.80 to −0.12)	Moderate effect
	Number of falls	Song et al. [55]	SMD (95% CI) = −0.40 (−0.68 to −0.13)	Small to moderate effect

(*continued*)

Table 3. Continued.

Population	Outcome	Source	Magnitude of statistically significant effects	Interpretation
	Mobility	Ni et al. [37]	MD (95% CI) = −0.8 (−1.3 to −0.2)	Small effect
		Song et al. [55]	SMD (95% CI) = −0.34 (−0.58 to −0.10)	Small-moderate effect
		Winser et al. [64]	MD (95% CI) = −2.1 (−3.3 to −1.0)	Small to moderate effect
	Motor Function	Yang et al. [38]	SMD (95% CI) = −0.57 (−1.11 to −0.04)	Moderate effect
		Mazzarin et al. [53]	SMD (95% CI) = −0.47 (−0.78 to −0.18)	Moderate effect
		Song et al. [55]	SMD (95% CI) = −0.44 (−0.61 to −0.28)	Small-moderate effect
	Quality of life	Song et al. [55]	SMD (95% CI) = −0.39 (−0.61 to −0.17)	Small-moderate effect
	Stride length	Ni et al. [37]	SMD (95% CI) = 0.56 (0.03 to 1.09)	Moderate effect
Stroke	Daily activities ability	Lyu et al. [63]	MD (95% CI) = 10.0 (6.8 to 13.0)	
	Gait	Li et al. [59]	SMD (95% CI) = −0.26 (−.50 to −0.03)	Small effect
	Mobility	Lyu et al. [63]	MD (95% CI) = 0.6 (0.4 to 0.8)	No information available to interpret MD
		Lyu et al. [63]	MD (95% CI) = 2.6 (1.8 to 3.4)	Small to moderate effect
	Motor function	Lyu et al. [63]	MD (95% CI) = 4.5 (1.9 to 7.1)	No information to interpret MD for al. limbs
		Lyu et al. [63]	MD (95% CI) = 8.3 (4.7 to 11.8)	Moderate effect

6-MWT: 6 min Walk Test; CI: confidence interval; COPD: chronic obstructive pulmonary disease; MD: mean difference; min: minutes; mo: months; OA: osteoarthritis; RR: relative risk; SMD: standardized mean difference; vs: versus; wk: week; wks: weeks.

providing a very good indication of the likely effect, associated with knowledge users being very confident in the results; "moderate" quality evidence provides a good indication of the likely effect and is associated with moderate confidence. For the secondary objectives, we tallied the frequency of publications by year, calculated a Spearman's rho correlation between the order of the date of publication (year and month, when known, from earliest to most recent) and average quality rating for each systematic review, and reported on documentation of adverse events.

Results

Primary objective

Detailed data extraction tables are contained in Supplementary Tables S1, S2 and S3 for heterogeneous, statistically significant, and statistically insignificant results, respectively. Table 1 contains a summary of results with preliminary evidence of effectiveness (i.e., heterogeneous results with statistically significant findings). The greatest certainty of results (i.e., findings that are not heterogeneous and statistically significant) for outcomes with either "high" or "moderate" ratings for quality of evidence are summarized in Tables 2 and 3. Supplementary Table S4 summarizes the statistically insignificant results of findings with either "high" or "moderate" quality ratings. All of the statistically significant results favoured the Tai Chi intervention, except for one result in a meta-analysis of people with cancer, reporting on the outcome of depression; in this one case (quality rating "moderate"), depression was significantly lower in the control group, which received spiritual growth care [45]. Of the remaining 117 results favoring Tai Chi 98 (84%) received quality ratings of either "high" or "moderate". In contrast, 69 (68%) of the 101 insignificant results received quality ratings of either "very low" or "low", with poor methodologic quality contributing to lack of power. The most recent evidence for "high" and "moderate" quality ratings, ordered by magnitude of effect, is summarized in Table 4.

Secondary objectives

The frequency of meta-analyses by year of publication was one for each of 2008, 2010, 2011, nine in 2013, seven for each of 2014, 2016, and 2017, three for 2015, and six to early September 2018. The correlation between the order of publication and the average quality rating of 41 studies that contained either statistically significant or insignificant results was 0.16 ($p = 0.31$). Of the 42 systematic reviews, 20 did not mention adverse events at all and 17 reported "no adverse events", but specific data were not provided; therefore, it was unclear if they were not reported in the original studies or if this outcome was investigated and none were found. Three meta-analyses reported minor, transient adverse events, including low back pain and upper back pain among people with low back pain, and muscle soreness and foot, knee, or shoulder pain among participants with osteoarthritis, all of which subsided over time or were alleviated with correction of the form. Two meta-analyses documented more significant adverse events of ankle sprains, pain, falls, and dizziness among participants with Parkinson's Disease.

Discussion

"High" and "moderate" quality evidence indicated that Tai Chi practice can significantly benefit adults with various health conditions including cancers, COPD, coronary heart disease, depression,

Table 4. Summary of most recent 'high' and 'moderate' quality evidence by magnitude of effect.

Magnitude of Effect	Population and outcome 'high' quality evidence	Population and outcome 'moderate' quality evidence
Very Large (SMDs ≥1.0–1.58)	Heart failure – exercise capacity Stroke – mobility Breast cancer – elbow extension Stroke – daily activities ability	
Large (SMDs ≥ 0.80 < 1.00)	Cancer (general) – reduced fatigue Low back pain – reduced pain Osteoarthritis – physical function Osteoporosis – reduced pain Parkinson's Disease - reduced falls Breast cancer – reduced fatigue Chronic Obstructive Pulmonary Disease – quality of life dimensions of increased mastery and reduced dyspnea and fatigue Stroke - balance	Hypertension – reduced blood pressure
Moderate – Large (SMDs ≥ 0.65 < 0.80		Breast cancer – shoulder adduction Breast cancer – elbow flexion Coronary Heart Disease – quality of life Arthritis – reduced pain Arthritis – reduced disability Chronic Obstructive Pulmonary Disease – exercise capacity
Moderate (SMDs ≥ 0.50 < 0.65)	Osteoarthritis – reduced pain	Osteoarthritis – participation in daily life Breast Cancer - Handgrip strength Breast cancer – shoulder abduction Osteoarthritis – reduced stiffness Parkinson's Disease – stride length Parkinson's Disease – balance Hypertension – reduced waist circumference Lung Cancer – reduced fatigue Cancer – mental health Stroke – motor function
Small – Moderate (SMDs ≥ 0.30 < 0.50		Parkinson's Disease – reduced depression Parkinson's Disease – motor function Parkinson's Disease – quality of life Hypertension – reduced body mass index Osteoarthritis – quality of life Parkinson's Disease – mobility Chronic Obstructive Pulmonary Disease – overall quality of life and symptoms dimension
Small (SMDs > 0.20 < 0.30)		Cancer – depression Depression – depressive symptoms Stroke – gait Cancer – Emotional well-being Osteoarthritis – mobility

heart failure, hypertension, low back pain, osteoarthritis, osteoporosis, Parkinson's Disease, and stroke. Outcomes included significant improvements in activities of daily living, balance, exercise capacity, gait, mastery, mental health, mobility, motor function, participation in daily life, physical function, quality of life, range of motion, and strength, with significant reductions in blood pressure, body mass index, depression, disability, dyspnea, falls, fatigue, pain, stiffness, and waist circumference. Additional preliminary evidence from heterogeneous results includes potential benefits for people with cancer and other chronic conditions with respect to improved sleep and reduction of symptoms of people with schizophrenia. High quality evidence suggests no effects of Tai Chi on the emotional dimension of quality of life for people with COPD. Since 2013, there is a relatively stable rate of publication of meta-analyses reporting the effects of Tai Chi on adults with health conditions. The quality of evidence of outcomes relating to the effectiveness of Tai Chi has been steady since the inception of meta-analyses in 2008. The stable rates of publication and quality of evidence attest to sustained interest in and evidence supporting the effectiveness of Tai Chi. Adverse events were inconsistently reported and, for the most part, minor, in keeping with what is expected in engaging in activities of daily living.

Strengths of our work include that we conducted a search on multiple databases (thus minimizing threats of publication bias) up to the beginning of September 2018, providing a greater number of relevant meta-analyses than previous research [13,14]. Furthermore, we evaluated each meta-analysis with transparent methods by two independent raters and presented detailed data extraction tables prior to preparation of summary tables and "bottom line" results. Limitations include that there is unavoidable over-lap in the original studies described in the selected meta-analyses for similar health conditions, as was also noted by Solloway and colleagues [13]. We counteracted this by summarizing only the most recent evidence in the "bottom line" results (in Table 4), assuming that more recently published meta-analyses contained the most comprehensive research literature available. Additionally, only the corresponding author participated in the deduplication and initial screening processes; however, she has more than 30 years of experience as a researcher. Although we do not perceive this to be a weakness, we found it necessary to modify the GRADE guidelines, which are more appropriate for studies in medicine than rehabilitation. Specifically, given the vast diversity of styles and forms of Tai Chi, as well as tremendous variation in frequency, intensity, and duration of practice, as well as methods of instruction, across studies, we elected to use the

heterogeneity criterion as an initial screen of results (considering any statistically significant results to be preliminary evidence only). Because of the nature of Tai Chi, it is neither possible nor desirable to blind instructors and participants [69]; therefore, we did not downgrade for bias based on lack of blinding. It is possible that results of a future scoping review would be different if the guidelines that are under development alluded to by Colquhoun et al. [17] will be used in a future similar attempt. Finally, a limitation of much of the meta-analytic literature on this topic is that adverse events were rarely reported. We agree with others [67] that poor and inconsistent reporting of adverse events limits the conclusions that can be drawn on the safety of Tai Chi.

Compared to the study by Solloway et al. [13], there has been an accumulation of quality evidence supporting the effectiveness of Tai Chi. Our work advances the known effectiveness of Tai Chi by including at least 20 more recently published meta-analyses than contained in Huston and MacFarlane's report [14]. Additionally, the quality evaluation used in our study [18] was more rigorous than that done by Huston and MacFarlane [14], who used an assumption of more systematic reviews equating to stronger support; however, this cannot be taken with confidence because of the known overlap of primary studies in sequential systematic reviews on a topic. Our study also differs from the previous literature, as we used meta-analyses instead of systematic reviews, for greater interpretation and clarity of the magnitude of effects of Tai Chi in various health conditions. Our study is also unique in reporting links between specific health conditions and relevant outcomes, which is useful for clients in making decisions about taking up Tai Chi practice for possible health benefits.

Our study highlights "high" and "moderate" quality evidence of effectiveness for specific subgroups of people with a variety of health conditions and outcomes to provide relative certainty for healthcare providers to consider referral of clients to community-based Tai Chi programmes. Tai Chi is an option for adjunctive physical activity that is relatively safe, enjoyable, and appropriate for life-long practice. Additionally, Tai Chi programmes could be a viable alternative for those not responding to traditional rehabilitation approaches. A benefit of recommending Tai Chi for clients with selected health conditions is the application of intervention through the biopsychosocial model [73], as Tai Chi potentially provides connection both to oneself and with the surrounding world, socialization, a shift in focus towards function, and benefits to the body, mind, and spirit [74].

Given the heterogeneity of how Tai Chi can be practiced, future research should focus on identifying the most effective style, form, and dosage of Tai Chi. In addition, most studies are of relatively short duration. The expectation is that benefits of Tai Chi accrue over a period of years, rather than months, as practitioner skill increases [69]. Although our work focuses on evidence primarily from randomized controlled trials, we agree with Wayne and Kaptchuk's [69] position that other methods ought to be used to ascertain evidence for the effectiveness of Tai Chi. Because it is not possible to randomly allocate people to places of intention, belief, and expectancy, which are all integral to the practice of Tai Chi [69], designs such as pragmatic trials, community-based prospective cohort studies conducted in ecologically valid settings, cross-sectional studies of long-term practitioners, and qualitative studies ought to be used to understand the complex, multi-dimensional aspects of Tai Chi [69]. We also concur that studies should investigate effect modifiers of expectancy- and belief-related characteristics that are likely significant contributors to outcomes [69]. Based on our study, future systematic reviews and meta-analyses should be conducted in areas of improving sleep and mental health conditions, as well as other health conditions not identified in our scoping review, with durations of Tai Chi intervention longer than 8 to 12 weeks, as time and intensive practice are required to perform forms of movement that provide optimal health benefits.

Conclusion

The results of our study enable healthcare providers to recommend complementary, safe, effective, and enjoyable community-based Tai Chi classes for people with various health conditions for the purposes of secondary and tertiary prevention and overall health promotion.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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