The effect of Tai Chi on four chronic conditions—cancer, osteoarthritis, heart failure and chronic obstructive pulmonary disease: a systematic review and meta-analyses

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ABSTRACT
Background Many middle-aged and older persons have more than one chronic condition. Thus, it is important to synthesise the effectiveness of interventions across several comorbidities. The aim of this systematic review was to summarise current evidence regarding the effectiveness of Tai Chi in individuals with four common chronic conditions—cancer, osteoarthritis (OA), heart failure (HF) and chronic obstructive pulmonary disease (COPD).

Methods 4 databases (MEDLINE, EMBASE, CINAHL and SPORTDiscus) were searched for original articles. Two reviewers independently screened the titles and abstracts and then conducted full-text reviews, quality assessment and finally data abstraction. 33 studies met the inclusion criteria. Meta-analyses were performed on disease-specific symptoms, physiological outcomes and physical performance of each chronic condition. Subgroup analyses on disease-specific symptoms were conducted by categorising studies into subsets based on the type of comparison groups.

Results Meta-analyses showed that Tai Chi improved or showed a tendency to improve physical performance outcomes, including 6-min walking distance (6MWD) and knee extensor strength, in most or all four chronic conditions. Tai Chi also improved disease-specific symptoms of pain and stiffness in OA.

Conclusions The results demonstrated a favourable effect or tendency of Tai Chi to improve physical performance and showed that this type of exercise could be performed by individuals with different chronic conditions, including COPD, HF and OA.

INTRODUCTION
Tai Chi, a physical activity which originated in ancient China, involves the interconnected concepts of Yin and Yang. The theory and principle of Tai Chi have been addressed in the literature, which emphasises the fusion of Yin and Yang into a single, ultimate and harmonious manner. Tai Chi is a popular exercise in Chinese society and has drawn increased attention in Western society, especially for older adults. All styles of Tai Chi consist of slow, gentle and flowing movements that involve strengthening, balance, postural alignment, mind concentration, relaxation and breath control. On the basis of these movement traits, Tai Chi is often classified as a low-to-moderate intensity physical activity and is a potentially suitable exercise for individuals in the general population, especially those who are middle-aged or older. Tai Chi has shown multifaceted benefits in improving health-related fitness, lower extremity muscle strength, balance, fall prevention, cardiorespiratory function, mental control and flexibility.

Tai Chi has been used as a complementary therapy in addition to more traditional Western healthcare approaches in several chronic conditions including cancer, cardiovascular diseases and arthritis. It has been shown that Tai Chi improves physiological and psychosocial outcomes in patients with chronic conditions. Given the fact that many middle-aged and older persons have more than one chronic condition, it is important to synthesise the effectiveness of interventions across several comorbidities rather than reporting its effects solely within a single condition. The high prevalence of multimorbidity is demonstrated by a study of 980 Canadians reported that 9 of the 10 individuals had more than one chronic condition; 70% of younger adults (aged 18–44 years) had more than one chronic condition and this prevalence rose to 98% in adults who were 65 years of age and older. Further, loss of function and physical limitations have been identified by patients as problem areas. Since Tai Chi can improve several attributes of fitness, it has potential as an exercise regimen for older individuals with multimorbidity.

We aimed to summarise current evidence regarding the effectiveness of Tai Chi in individuals with four common chronic conditions—cancer, osteoarthritis (OA), heart failure (HF) and chronic obstructive pulmonary disease (COPD)—some of these four chronic conditions may coexist. We included articles on conditions that had Tai Chi applied as an exercise intervention and met the inclusion criteria. Several conditions preliminarily searched for, that is, lung cancer, ischaemic heart disease, did not reveal any reports and thus were not considered in this systematic review. The evidence from this review will inform healthcare practitioners of important considerations when prescribing Tai Chi to people with multimorbidity, especially in older adults. This systematic review addressed the following questions: (1) Is Tai Chi an effective physical activity that improves symptoms, physical function, quality of life and depression in cancer, OA, HF and COPD? (2) Does Tai Chi have similar effects for the same outcome measures across different chronic conditions?
**METHOD**

**Search strategy**

The following electronic databases were searched from their inception until 30 December 2014: MEDLINE, EMBASE, CINAHL and SPORTDiscus. Medical Subject Headings (MeSH) terms were employed to perform the search to retrieve citations and abstracts. “Tai Chi” was combined with each of the four chronic conditions: “cancer,” “osteoarthritis,” “heart failure” and “chronic obstructive pulmonary disease.” The search strategy of each database is listed in online supplementary appendix 1. Additional searches were carried out by scanning the reference lists of related articles.

**Study criteria and selection**

Inclusion criteria for articles were studies that: (1) had participants with cancer or OA or HF or COPD; (2) used any form of Tai Chi, for example, modified Tai Chi or Qigong Tai Chi, as an intervention; (3) had a control group, other treatments or another exercise intervention as a comparison group; (4) reported outcomes of symptoms related to the respective chronic condition or outcomes of exercise training and (5) used a randomised controlled trial (RCT). Studies were excluded if they were not written in English.

Initially, two reviewers independently screened the titles and abstracts retrieved from the four databases. Next, two reviewers independently conducted full-text reviews and finally data abstractions. Disagreements were discussed between the two reviewers at each stage. A third reviewer was consulted to mediate decisions if consensus was not reached.

**Data extraction**

The following information was extracted in data abstraction forms: first author, year of publication, study purpose, participants characteristics, chronic conditions and diagnostic criteria, the details of Tai Chi (type, number of forms, duration, frequency, training length), details of comparison groups and outcomes (preintervention, postintervention and change scores, if available).

**Quality assessment**

The quality of included studies was assessed using the Physiotherapy Evidence-Based Database (PEDro) scale, which demonstrates good reliability. The PEDro scale consists of 11 criteria: eligibility criteria, random allocation, concealed allocation, baseline similarity, blinding of participants, blinding of therapists, blinding of assessors, follow-up, intention-to-treat analysis, between-group statistical comparisons, and point measures and measures of variability. One point is given for reporting of each criterion except item 1 (which refers to eligibility criteria) for a maximum score of 10. Two reviewers independently assessed the study quality and disagreements were discussed until consensus was reached.

**Data management and statistical analysis**

Data were analysed using RevMan 5.2 (http://tech.cochrane.org/revman/download). Meta-analyses were performed when at least two studies reported similar outcomes.

For meta-analyses, the mean changes (pre–post intervention) and the SDs of the mean changes of the outcome for the Tai Chi group and the comparison group were inputted into RevMan. Authors of 14 studies were approached to obtain data that were not available in the original paper. Authors of 14 studies scored 1 point on the PEDro scale and were excluded from quantitative syntheses due to missing data.

**RESULTS**

**Study selection**

Searches of electronic databases produced 1102 citations (figure 1). Duplicates were excluded and reference lists yielded an additional five publications. Forty-one full-text articles were identified as potential inclusions after review of titles and abstracts. After full-text reviews, eight reports were excluded due to insufficient information or duplication of a conference proceeding (figure 1). Thirteen articles appeared to be similar in methodology but reported different outcome data in two or more publications. These were counted as individual studies in order to facilitate citation of outcome data. However, these reports were grouped in tables that described quality assessment (table 1) and participant characteristics (table 2). Of note, the search only revealed articles that reported the effect of Tai Chi for patients with breast cancer. Its use was not reported for any other types of cancer.

**Quality assessment**

The median PEDro score for included studies was 5 (IQR 5–6.75) (table 1). Owing to the nature of Tai Chi, blinding of respondents and therapists (PEDro items 5 and 6) is challenging and was not reported in all included studies. One study blinded assessors (PEDro item 7), whereas other studies utilised self-report outcomes, such that the participants were the assessors and hence nullified the possibility of a blinded assessor. Only one study scored 1 point on the PEDro scale and was excluded from quantitative syntheses due to missing data.

**Participants**

Sample sizes of included studies ranged from 11 to 206 (table 2). Breast cancer only included females (290 participants). Male-to-female ratios in the OA, HF and COPD studies were 81/452, 195/76 and 398/92, respectively. Mean ages of the
participants in the cancer, OA, HF and COPD studies were 53.9, 68.8, 68.4 and 72.3 years, respectively. Diagnostic criteria of disease severity were reported in a variety of ways for each condition. For example, three of the five cancer studies used cancer stage to denote cancer severity and recruited patients with cancer stages 0–IV. Two of the nine OA studies reported OA severity using the Kellgren-Lawrence grading scale and participants were rated as grade 2–4, indicative of mild-to-severe OA. Other studies used symptoms as an indicator of OA severity, such as pain intensity on a visual analogue scale (VAS), and scored 4.4 of the 10 points and 48.6 of the 100 points. Four of the five HF studies used the New York Heart Association (NYHA) classification for HF and stated that the participants were in classes I–III, indicative of mild-to-moderate HF severity. Three of the five COPD studies reported forced expiratory volume in 1 s (FEV1) indicative of participants with moderate-to-severe COPD and two studies reported stages of severity.

Characteristics of intervention
Regarding the type of Tai Chi, the Yang style was used in 10 of the 24 studies (2 cancer, 3 OA, 4 HF and 1 COPD). Sun style Tai Chi was used in four OA studies and two COPD studies. Wu style Tai Chi was taught in only two studies (1 OA and 1 HF). The type of Tai Chi was not stated in six studies. The Tai Chi training programme ranged from 6 to 24 weeks and most were of 12-week duration. Session length ranged from 30 to 90 mins and most were of 1 h duration. Tai Chi training was usually offered 2–3 times per week. However, three studies provided Tai Chi once weekly and in one study, participants were asked to attend Tai Chi training every day.

Usual care or waitlist control was the most common comparison group, followed by comparison to another exercise intervention programme. The effectiveness of Tai Chi was compared with that of educational programmes in four studies.
psychosocial therapy as the comparison and one OA study used a non-physical recreational activity as the comparison group.

Outcomes

Walk test

Six-minute walking distance (6MWD) test was performed in cancer, OA, HF and COPD studies (figure 2). Analyses by each chronic condition demonstrated a favourable effect of Tai Chi on 6MWD in HF (SMD=1.58; 95% CI 0.70 to 2.45; p=0.0004) and COPD (SMD=0.37; 95% CI 0.01 to 0.73; p=0.05) studies, and trends towards improvement in one cancer report (p=0.09) and one OA (p=0.11) report.

Muscle strength

Knee extensor strength was assessed in OA, HF and COPD studies (figure 3). The subgroup (each chronic condition) difference was significant (p=0.0009); Tai Chi improved strength even more so than the comparison group in one HF study (SMD=1.14; 95% CI 0.60 to 1.69; p=0.0001) and one COPD study (SMD=1.64; 95% CI 0.90 to 2.39; p=0.0001), but it only showed a trend towards improvement in the OA studies (p=0.13) (figure 3).

Timed Get Up and Go

The aggregated data of the OA studies showed a favourable effect of Tai Chi versus the comparison groups on the Timed Get Up and Go (TUG) test (MD=0.56; 95% CI 0.09 to 1.03; p=0.02). However, the HF study did not provide comparable evidence (p=0.78) (figure 4).

Quality of life

Meta-analyses performed on each chronic condition showed a significant effect of Tai Chi in OA studies (SMD=0.38; 95% CI 0.01 to 0.75; p=0.05), and an improving trend for COPD and HF studies (p=0.08; p=0.18, respectively), whereas the cancer (p=0.62) study did not provide evidence of Tai Chi improving quality of life more so than the comparison groups (figure 5).

Depression

Meta-analyses examining each of the chronic conditions only demonstrated a favourable effect of Tai Chi improving depression more so than the comparison groups in the HF studies (SMD=0.56; 95% CI 0.07 to 1.05; p=0.03). Tai Chi showed a non-significant trend in COPD (p=0.09) and OA (p=0.32) studies. Of note, the two cancer studies demonstrated an effect in favour of the other treatment, which included stress management, on depression (SMD=−0.97; 95% CI −1.90 to −0.05; p=0.04) (figure 6).

Symptoms of chronic conditions

Two meta-analyses examined two major symptoms of OA, pain and stiffness. The meta-analyses, regardless of the comparison groups, showed evidence of Tai Chi improving pain (SMD=0.53; 95% CI 0.32 to 0.75; p=0.0001) (figure 7A) and stiffness (SMD=0.59; 95% CI 0.31 to 0.87; p=0.0001) (figure 7B). Subgroup analyses were performed that evaluated the effectiveness of Tai Chi compared with another intervention or compared with no intervention. Positive effects in favour of Tai Chi on pain were shown with either comparison group: other psychosocial therapy versus Tai Chi (p=0.02) or exercise therapy versus Tai Chi (p=0.02; p=0.03).

Table 1 Quality assessment—PEDro score

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1: Eligibility criteria specified; 2: random allocation; 3: concealed allocation; 4: groups similar at baseline; 5: respondents blinding; 6: therapists blinding; 7: assessors blinding; 8: less than 15% dropouts; 9: intention-to-treat analysis; 10: between-group statistical comparisons; 11: point measures and measures of variability data.

COPD, chronic obstructive pulmonary disease; HF, heart failure; OA, osteoarthritis; PEDro, Physiotherapy Evidence-Based Database.
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<th>First author (year)</th>
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<td>17 (20.7)</td>
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<td>WOMAC—pain: TC 6.96 (3.26); Con 7.65 (3.21)</td>
<td></td>
<td>Attention Con</td>
</tr>
<tr>
<td>Tsai (2013)</td>
<td>Knee OA</td>
<td>55 (15/40)</td>
<td>10 (18.2)</td>
<td></td>
<td>Kellgren-Lawrence, n (%): Gr 2: TC 4 (20%); Con 3 (15%); Gr 3: TC 7 (35%); Con 3 (15%); Gr 4: TC 9 (45%); Con 14 (70%)</td>
<td></td>
<td>The wellness education and stretching programme</td>
</tr>
<tr>
<td>Wang (2009)</td>
<td>Knee OA</td>
<td>40 (10/30)</td>
<td>0 (0)</td>
<td></td>
<td>Left ventricular ejection fraction, %: TC 28 (8); Con 29 (7)</td>
<td></td>
<td>Education Con</td>
</tr>
<tr>
<td>Barrow (2007)</td>
<td>HF</td>
<td>65 (53/12)</td>
<td>13 (20)</td>
<td></td>
<td>NYHA symptom class II–III, MLHF mean score: TC 35.1; Con 34.9</td>
<td></td>
<td>Con</td>
</tr>
<tr>
<td>Yeh (2004) &amp; 2008a</td>
<td>HF</td>
<td>30 (19/11)</td>
<td>0 (0)</td>
<td></td>
<td>Left ventricular ejection fraction, %: TC 24 (7); Con 22 (8)</td>
<td></td>
<td>Usual care</td>
</tr>
<tr>
<td>Yeh (2011)</td>
<td>HF</td>
<td>100 (64/36)</td>
<td>4 (4)</td>
<td></td>
<td>Left ventricular ejection fraction, %: TC 28 (8); Con 29 (7)</td>
<td></td>
<td>Education Con</td>
</tr>
<tr>
<td>Yeh (2013)</td>
<td>HF</td>
<td>16 (8/8)</td>
<td>0 (0)</td>
<td></td>
<td>NYHA class III/IV, %: TC 12/50/38; Con 25/63/12</td>
<td></td>
<td>Aerobic Ex</td>
</tr>
<tr>
<td>Caminiti (2011)</td>
<td>HF</td>
<td>60 (51/9)</td>
<td>0 (0)</td>
<td></td>
<td>Ejection fraction, %: TC 33.6 (9); Con 32.8 (12)</td>
<td></td>
<td>Endurance training</td>
</tr>
<tr>
<td>Chan (2013a) &amp; 2013b</td>
<td>COPD</td>
<td>206 (187/19)</td>
<td>48 (23)</td>
<td></td>
<td>Mild=15.5%; moderate=41.7%; severe=42.7%</td>
<td></td>
<td>Ex/Con</td>
</tr>
<tr>
<td>Leung (2013)</td>
<td>COPD</td>
<td>42 (27/15)</td>
<td>4 (9.5)</td>
<td></td>
<td>% pred FEV₁=59 (16); FEV₁/FVC %=47 (13)</td>
<td></td>
<td>Usual medical care</td>
</tr>
<tr>
<td>Yeh (2010)</td>
<td>COPD</td>
<td>42 (27/15)</td>
<td>4 (9.5)</td>
<td></td>
<td>% pred FEV₁=59 (16); FEV₁/FVC %=47 (13)</td>
<td></td>
<td>Usual care</td>
</tr>
<tr>
<td>Niu (2014)</td>
<td>COPD</td>
<td>40 (3/37)</td>
<td>1 (2.5)</td>
<td></td>
<td>FEV₁ (% pred): TC 41.9 (24.60); Con 43.7 (23.08)</td>
<td></td>
<td>Routine medical care</td>
</tr>
<tr>
<td>Ng (2014)</td>
<td>COPD</td>
<td>192 (175/17)</td>
<td>54 (28.1)</td>
<td></td>
<td>TC: mild=20%; moderate=32%; severe=34%; very severe=14%; Con: mild=20%; moderate=49%; severe=27%; very severe=4%</td>
<td></td>
<td>Pulmonary rehabilitation programme</td>
</tr>
</tbody>
</table>

The bold typeface represents values for disease severity are evaluation tools or methods used to determine disease severity.

% pred, Per cent predicted; Con, control; COPD, chronic obstructive pulmonary disease; Ex, exercise; FEV₁, forced expiratory volume in 1 s; FVC, forced vital capacity; Gr, grade; HF, heart failure; L/E, lower extremity; MF, male/female; MLHF, Minnesota Living with Heart Failure; NYHA, New York Heart Association; OA, osteoarthritis; PA, physical activity; TC, Tai Chi; VAS, visual analogue scale.
no interventions (SMD=0.51; 95% CI 0.24 to 0.79; p=0.0003) (figure 7A).
Similarly, subgroup analyses showed a favourable effect of Tai Chi on stiffness regardless of the comparison group: other interventions (SMD=0.61; 95% CI 0.25 to 0.97; p=0.0009) and no interventions (SMD=0.57; 95% CI 0.13 to 1.01; p=0.01) (figure 7B).

In COPD studies, meta-analysis showed a non-significant trend of Tai Chi alleviating dyspnoea versus the comparison groups (MD=0.51; 95% CI −0.12 to 1.15; p=0.12) (figure 7C).

Physiological outcomes
The meta-analysis of two HF studies revealed no evidence that Tai Chi improved either systolic blood pressure (SBP) (p=0.80) (figure 8A) or diastolic blood pressure (DBP) (p=0.33) (figure 8B). In addition, the meta-analysis of the other two HF studies reported a non-significant difference in peak oxygen uptake (VO2peak) from Tai Chi compared with either an exercise or a comparison group (p=0.34) (figure 8C).

Figure 2 Forest plot for effects of Tai Chi on 6MWD (6MWD, 6-min walking distance; COPD, chronic obstructive pulmonary disease; HF, heart failure; OA, osteoarthritis).

Figure 3 Forest plot for effects of Tai Chi on knee extensor strength (COPD, chronic obstructive pulmonary disease; HF, heart failure; OA, osteoarthritis).
Meta-analysis of physical function in participants with OA assessed using the WOMAC showed a favourable effect of Tai Chi on improving physical function in participants with OA (SMD=0.70; 95% CI 0.47 to 0.93; p<0.00001) (figure 8D). In addition, Tai Chi improved sit-to-stand times more so than the comparison groups (SMD=0.76; 95% CI 0.12 to 1.40; p=0.02) (figure 8E).

Publication bias
The funnel plot for quality of life did not show asymmetry (figure 9), which indicated no potential publication bias (Egger’s test p=0.55). Funnel plots were not created in other outcomes, and therefore publication bias could not be determined due to the limited number of studies in each outcome measure.48

DISCUSSION
The most important findings of this systematic review and meta-analyses on 33 studies and 1584 participants were that Tai Chi showed favourable effects or modest trends on improving 6MWD, knee extensor strength and quality of life in most or all four chronic conditions: cancer, OA, HF and COPD. Our findings support the results of a previous systematic review that showed the effectiveness of Tai Chi on health outcomes in older patients with chronic conditions.25 These findings also complement previous systematic reviews that only examined the effect of Tai Chi in a single chronic condition.59–62 Moreover, Tai Chi provided greater improvements than comparison groups in other physical performance measures including decreased TUG times and shorter sit-to-stand times in participants with OA.
Finally, Tai Chi was more effective for improving pain and stiffness in OA compared with other interventions or controls.

Meta-analyses demonstrated that Tai Chi was more effective or showed modest trends compared with controls or other intervention groups towards improving the 6MWD in four chronic conditions. The 6MWD is a common primary outcome measure that is considered to evaluate functional exercise capacity. It shows moderate-to-high correlations with outcomes from peak cardiopulmonary exercise tests in participants with cardiac disease and COPD and has also been shown to increase after resistance training in participants with chronic HF. The positive effect and trends of the 6MWD in all four conditions provide evidence that the exercise overload induced by Tai Chi was sufficient to improve functional exercise capacity in these chronic conditions.

Tai Chi improved the knee extensor muscle strength in participants with HF and COPD, but only showed a tendency towards improvement in participants with OA compared with other comparison groups and was not measured in participants with breast cancer. Although participants with knee OA have lower knee muscle strength, this impairment might be less than the weakness demonstrated in participants with HF and COPD and thus a greater overload may be required than that provided by Tai Chi. Hence, Tai Chi appears to improve knee extensor strength in HF and COPD with more marginal benefits in OA. Further study is required to realise its impact on knee extensor strength in cancer survivors.

Other physical performance measures that require knee extensor strength improved more so after Tai Chi compared with other comparison groups in participants with OA. Most notably, TUG and sit-to-stand times showed greater improvements after Tai Chi than comparison groups in participants with OA. These findings may be attributed to the multifaceted training stimuli of Tai Chi that is directed towards improving balance and postural alignment in addition to strength. Although Tai Chi provides a minimal strength training stimulus, its positive influence on TUG and sit-to-stand times provides strong evidence of its clinical impact on important functional measures in participants with OA.

The effect of Tai Chi on quality of life within a particular condition was less consistent. The most positive effects of Tai Chi on quality of life were shown in participants with OA. This is somewhat similar to a systematic review that examined participants with OA that showed improved physical quality of life, but not quality of life related to mental health. The differing results can be explained by the small sample sizes in the previous systematic review, which only included two studies and 84 participants versus 181 respondents in our systematic review. A strong trend was shown in participants with COPD and the inclusion of RCTs that were written in other languages may have resulted in a significant overall effect towards improving quality of life in participants with COPD similar to another systematic review.

In addition to the improvement in physical performance measures, symptoms either improved or did not differ after Tai Chi compared with the other treatment or a control group. Pain and stiffness in OA showed greater improvements after Tai Chi and dyspnoea showed a trend towards improvement in participants with COPD. Improved pain and stiffness in participants with OA may be attributed to increases in muscle strength, balance and/or postural alignment. From a clinical perspective, this evidence provides some assurance to the health professional that prescription of Tai Chi to persons living with OA and COPD has the potential to improve functional exercise capacity, but not at the expense of aggravating pain or causing undue dyspnoea.

**Limitations and strengths**

This meta-analysis has some limitations. First, only studies published in English were included due to the lack of two reviewers who were fluent in other languages. Second, with the exception of OA, there were limited numbers of RCTs in the other chronic conditions, especially regarding the availability of raw data. Finally, this meta-analysis was limited to the effects of Tai Chi in patients with OA, COPD, HF, and breast cancer, and it is not possible to generalize these findings to other populations or conditions.

---

**Table 1.**

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Tai Chi</th>
<th>Control</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Cancer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rausch 2007</td>
<td>-3.25</td>
<td>9.81</td>
<td>12</td>
</tr>
<tr>
<td>Robins 2013</td>
<td>-15.4</td>
<td>9.18</td>
<td>43</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>33</td>
<td>100.0%</td>
<td>55</td>
</tr>
<tr>
<td>Heterogeneity: Tau^2 = 0.27; Chi^2 = 2.04, df = 1 (P = 0.15); I^2 = 51%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for overall effect: Z = 2.06 (P = 0.04)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 1.2 OA           |         |         |                                       |
| Alder 2007       | 0.6     | 6.66    | 8                                    | 0.5  | 11.33 | 6                                    | 20.9% | 0.01 [-1.05, 1.07] |
| Fransen 2007     | -0.4    | 8.59    | 56                                    | -0.5 | 6.65  | 41                                    | 45.0% | 0.01 [-0.39, 0.42] |
| Wang 2009        | 7.4     | 7.44    | 20                                    | 0.7  | 7.44  | 20                                    | 34.1% | 0.88 [0.23, 1.54] |
| Subtotal (95% CI)| 84      | 100.0%  |                                       |       |       |                                       |       | 0.31 [-0.30, 0.92] |
| Heterogeneity: Tau^2 = 0.17; Chi^2 = 5.13, df = 2 (P = 0.08); I^2 = 61% |
| Test for overall effect: Z = 0.99 (P = 0.32) |

| 1.3 HF           |         |         |                                       |
| Barlow 2007      | 6.8     | 9.5     | 25                                    | 2.9  | 8.19  | 27                                    | 78.7% | 0.43 [-0.12, 0.99] |
| Yeh 2013         | 1.7     | 3.17    | 8                                    | -1.7 | 3.17  | 8                                    | 21.3% | 1.01 [-0.05, 2.07] |
| Subtotal (95% CI)| 33      | 100.0%  |                                       |       |       |                                       |       | 0.56 [0.07, 1.05] |
| Heterogeneity: Tau^2 = 0.00; Chi^2 = 0.90, df = 1 (P = 0.34); I^2 = 0% |
| Test for overall effect: Z = 2.24 (P = 0.03) |

| 1.4 COPD         |         |         |                                       |
| Leung 2013       | 0.3     | 1       | 19                                    | -1   | 3     | 19                                    | 100.0%| 0.57 [-0.08, 1.22] |
| Subtotal (95% CI)| 19      | 100.0%  |                                       |       |       |                                       |       | 0.57 [-0.08, 1.22] |
| Heterogeneity: Not applicable |
| Test for overall effect: Z = 1.72 (P = 0.09) |

**Figure 6.** Forest plot for effects of Tai Chi on depression (COPD, chronic obstructive pulmonary disease; HF, heart failure; OA, osteoarthritis).
data that could be included in the meta-analyses. Third, the sample sizes of included RCTs were quite small, contributing to limited power in most studies and in the aggregated data examined by meta-analyses. For example, the conflicting findings of the effect of Tai Chi on blood pressure in participants with HF are difficult to interpret because both reports had a small sample size. A fourth limitation is that participants in most studies represented patients who had one primary condition and may have excluded individuals with multimorbidity. Further study examining the effects of Tai Chi on multimorbidity is required to substantiate its benefits in this potentially complex patient group. Finally, the diversity of the type and parameters of Tai Chi in the included studies also limits the ability to make firm conclusions regarding the recommended Tai Chi exercise prescription for each chronic condition.

A key strength of this meta-analysis was the examination of the evidence regarding Tai Chi by reporting the symptoms, physiological and exercise outcomes of four common chronic conditions. Individuals with different chronic conditions may have different mechanisms that contribute to symptoms, impaired physical performance or quality of life. However, in people with multimorbidity, these underlying factors may also be inseparable or difficult to identify. Therefore, this systematic review offers a reasonable starting point to begin the quest for

![Figure 7](http://bjsm.bmj.com/)

**Figure 7** Forest plot for effects of Tai Chi on disease-specific symptoms: (A) pain; (B) stiffness; (C) dyspnoea.
determining alternative exercise protocols, such as Tai Chi, for individuals who live with multimorbidity. Most of the included studies were moderate-to-high quality in terms of methodology (PEDro=4–7). Only one included study had poor quality and was excluded from quantitative syntheses due to missing data. This systematic review provided a quantitative synthesis of important physical performance outcomes, symptoms and quality of life. For some measures, evidence was limited due to the diverse outcome measurements among the conditions and small sample size. More rigorous RCTs with larger sample sizes are required to confirm the inconsistent findings among the included studies. Also, studies that examine patients with a broader range of diagnoses are required. For example, all of the studies examining cancer in this systematic review involved participants with breast cancer. It would be worthwhile to assess the effectiveness of Tai Chi on other types of cancer.

A. Systolic Blood Pressure (SBP) in HF

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Tai Chi</th>
<th>Control</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Mean Difference (IV, Random, 95% CI)</th>
<th>Mean Difference (IV, Random, 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barlow 2007</td>
<td>2</td>
<td>12.35</td>
<td>25</td>
<td>8</td>
<td>25.35</td>
<td>27</td>
<td>4.21</td>
<td>34.3%</td>
<td>41.2%</td>
<td>-6.00 [(-16.72, 4.72)]</td>
<td>7.60 [(-0.02, 16.28)]</td>
</tr>
<tr>
<td>Cammendi 2011</td>
<td>13.4</td>
<td>2.4</td>
<td>30</td>
<td>6.4</td>
<td>1.3</td>
<td>30</td>
<td>58.8%</td>
<td>31.4%</td>
<td>3.15</td>
<td>0.06 [(-10.88, 4.88)]</td>
<td>0.43 [(-10.98, 11.68)]</td>
</tr>
</tbody>
</table>

Total (95% CI) 55

Heterogeneity: Tau² = 0.04; Ch² = 5.61; df = 1 (P = 0.02); I² = 63.2%

Test for overall effect: Z = 0.26 (P = 0.80)

B. Diastolic Blood Pressure (DBP) in HF

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Tai Chi</th>
<th>Control</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Mean Difference (IV, Random, 95% CI)</th>
<th>Mean Difference (IV, Random, 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barlow 2007</td>
<td>4</td>
<td>10.25</td>
<td>25</td>
<td>8</td>
<td>12.01</td>
<td>27</td>
<td>6.5%</td>
<td>31.5%</td>
<td>3.50</td>
<td>-3.00 [(-10.88, 4.88)]</td>
<td>0.06 [(-10.98, 11.68)]</td>
</tr>
<tr>
<td>Cammendi 2011</td>
<td>5.6</td>
<td>1.4</td>
<td>30</td>
<td>4.3</td>
<td>0.7</td>
<td>30</td>
<td>93.5%</td>
<td>6.5%</td>
<td>1.30</td>
<td>0.06 [(-10.88, 4.88)]</td>
<td>0.06 [(-10.98, 11.68)]</td>
</tr>
</tbody>
</table>

Total (95% CI) 55

Heterogeneity: Tau² = 0.01; Ch² = 1.12; df = 1 (P = 0.29); I² = 0%

Test for overall effect: Z = 0.96 (P = 0.33)

C. Peak Oxygen Uptake (VO²peak) in HF

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Tai Chi</th>
<th>Control</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Mean Difference (IV, Random, 95% CI)</th>
<th>Mean Difference (IV, Random, 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yeh 2004</td>
<td>0.0</td>
<td>0.7</td>
<td>15</td>
<td>8</td>
<td>-0.1</td>
<td>8</td>
<td>36.8%</td>
<td>0.2%</td>
<td>0.80</td>
<td>0.06 [(-10.88, 4.88)]</td>
<td>0.06 [(-10.98, 11.68)]</td>
</tr>
</tbody>
</table>

Total (95% CI) 55

Heterogeneity: Tau² = 0.00; Ch² = 2.24; df = 2 (P = 0.33); I² = 11%

Test for overall effect: Z = 0.96 (P = 0.33)

D. WOMAC function in OA

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Tai Chi</th>
<th>Control</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Mean Difference (IV, Random, 95% CI)</th>
<th>Mean Difference (IV, Random, 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Briemme 2007</td>
<td>10.92</td>
<td>11.92</td>
<td>18</td>
<td>0.9</td>
<td>14.26</td>
<td>13</td>
<td>9.3%</td>
<td>31.6%</td>
<td>9.3%</td>
<td>0.05 [(-0.29, 1.22)]</td>
<td>0.05 [(-0.29, 1.22)]</td>
</tr>
<tr>
<td>Tsai 2013</td>
<td>0.62</td>
<td>12.79</td>
<td>28</td>
<td>3.3</td>
<td>7.03</td>
<td>27</td>
<td>18.8%</td>
<td>53.2%</td>
<td>5.32</td>
<td>0.05 [(-0.29, 1.22)]</td>
<td>0.05 [(-0.29, 1.22)]</td>
</tr>
<tr>
<td>Wang 2009</td>
<td>0.11</td>
<td>286.12</td>
<td>10</td>
<td>286.12</td>
<td>20</td>
<td>18.3%</td>
<td>0.8%</td>
<td>31.6%</td>
<td>0.11</td>
<td>0.05 [(-0.29, 1.22)]</td>
<td>0.05 [(-0.29, 1.22)]</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>66</td>
<td>54</td>
<td>60</td>
<td>40.2%</td>
<td>8</td>
<td>36.8%</td>
<td>0.80</td>
<td>3.65, 5.25</td>
<td>0.05 [(-0.29, 1.22)]</td>
<td>0.05 [(-0.29, 1.22)]</td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 0.01; Ch² = 2.24; df = 2 (P = 0.33); I² = 11%

Test for overall effect: Z = 0.96 (P = 0.33)

E. Sit-to-stand time in OA

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Tai Chi</th>
<th>Control</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Mean Difference (IV, Random, 95% CI)</th>
<th>Mean Difference (IV, Random, 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tsai 2013</td>
<td>2.18</td>
<td>3.75</td>
<td>28</td>
<td>2.24</td>
<td>5.37</td>
<td>27</td>
<td>37.5%</td>
<td>2.1%</td>
<td>0.04</td>
<td>0.05 [(-0.29, 1.22)]</td>
<td>0.05 [(-0.29, 1.22)]</td>
</tr>
<tr>
<td>Wang 2009</td>
<td>12.03</td>
<td>7.41</td>
<td>19</td>
<td>7.37</td>
<td>19.0%</td>
<td>19</td>
<td>30.9%</td>
<td>50.6%</td>
<td>51.2%</td>
<td>0.05 [(-0.29, 1.22)]</td>
<td>0.05 [(-0.29, 1.22)]</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>47</td>
<td>46</td>
<td>46</td>
<td>46.8%</td>
<td>46.8%</td>
<td>46</td>
<td>46.8%</td>
<td>46.8%</td>
<td>46.8%</td>
<td>0.05 [(-0.29, 1.22)]</td>
<td>0.05 [(-0.29, 1.22)]</td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 0.50; Ch² = 5.80; df = 1 (P = 0.02); I² = 83%

Test for overall effect: Z = 1.57 (P = 0.11)

1.1.2 TC vs no intervention

Hartmenn 2000 | 0.8 | 1.85 | 18 | -0.5 | 2.46 | 15 | 31.6% | 0.59 | -0.11, 1.20 |

Total (95% CI) 65

Heterogeneity: Tau² = 0.21; Ch² = 5.90; df = 2 (P = 0.05); I² = 66%

Test for overall effect: Z = 2.31 (P = 0.02)

Test for subgroup differences: Ch² = 0.17; df = 1 (P = 0.68); I² = 0%
In conclusion, the results provided evidence regarding a favourable effect or tendency of Tai Chi on improving the performance of 6MWD, knee extensor strength and quality of life in people with cancer, OA, HF and COPD. Additionally, the meta-analyses showed the favourable effects of Tai Chi versus other interventions or no treatment on several disease-specific symptoms, including pain and stiffness. Taken together, Tai Chi demonstrates improvement in functional exercise capacity in individuals with different chronic conditions without aggravating symptoms of pain and dyspnoea. To summarise, Tai Chi appears to provide an adequate exercise stimulus and it could be a suitable exercise to prescribe for people with several comorbidities that include COPD, HF and OA.

**Contributors** Y-WC and WDR contributed to the conception and design of this systematic review. Y-WC conducted the search and analysed the data. Y-WC, MAH, KLC, KP and WDR extracted the data and completed the methodological quality assessment. Y-WC was primarily responsible for writing the manuscript. MAH, KLC, KP and WDR critically revised the manuscript.

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**Competing interests** None declared.

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**REFERENCES**


**What are the findings?**

- Tai Chi can improve some physical performance outcomes in four chronic conditions (cancer, osteoarthritis, heart failure and chronic obstructive pulmonary disease) but not at the expense of worsening pain or dyspnoea.
- Tai Chi may provide a suitable exercise stimulus for people with several comorbidities.

**How might this impact on clinical practice in the future?**

- It is possible to consider prescribing Tai Chi in people with multimorbidity.
- Tai Chi is an exercise that is suitable to improve physical performance in middle-aged and older adults.
- Tai Chi can be a complementary therapy in some chronic conditions.

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![Figure 9](http://bjsm.bmj.com/first-published-as-10.1136/bjsports-2014-094388-on-17-september-2015/downloaded-from) Funnel plot for quality of life.
Review


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Tai Chi linked to improved physical capacity in certain common long term conditions

Could be useful exercise for older people with several co-existing chronic ailments, suggest researchers

The ancient Chinese exercise Tai Chi is linked to improved physical capacity among older adults with certain common long term conditions, indicates a pooled analysis of the available evidence, published online in the British Journal of Sports Medicine.

Among people with breast cancer, heart failure, osteoarthritis and chronic obstructive pulmonary disease (COPD), these improvements were not at the expense of worsening pain or breathlessness, the findings show.

Tai Chi consists of slow, gentle, flowing movements that aim to boost muscle power, balance, and posture. It also includes mindfulness, relaxation, and breath control.

The researchers wanted to find out how effective Tai Chi was in long term conditions that are common among older adults. So they trawled electronic research databases for relevant studies published up to 2014, on the use of Tai Chi in people with cancer, osteoarthritis, heart failure, and COPD.

They wanted to find out if Tai Chi relieved symptoms, and improved physical capacity and quality of life in all four long term conditions.

Out of 1102 articles, 33, involving 24 studies and 1584 participants, were suitable for inclusion; 21 studies were included in the pooled analysis.

The average age of participants ranged from the mid 50s to the early 70s, while the average length of the Tai Chi training programme was 12 weeks, with most sessions lasting an hour. Tai Chi training was usually offered two to three times weekly.

The results showed that Tai Chi was associated with trends, or definite improvement, in physical capacity and muscle strength in most or all four long term conditions.

This included improvements in the six minute walking test; muscle strength, as measured by bending and stretching the knees; the time it takes to get up and move known as the TUG test; and quality of life.

Tai Chi was also associated with an improvement in the symptoms of pain and stiffness in osteoarthritis and in breathlessness in COPD. And it was associated with improved sit to stand times among patients with osteoarthritis.

This is an observational study so no definitive conclusions can be drawn about cause and effect, added to which the only cancer included in the analysis was breast cancer.

But the findings back those of previous research, and provide a reasonable starting point to look at the value of exercise programmes, such as Tai Chi, for people with several co-existing long term conditions, say the researchers.

“Tai Chi can improve some physical performance outcomes in four chronic conditions…but not at the expense of worsening pain or dyspnoea [breathlessness],” they write, adding that it “may provide a suitable exercise stimulus for people with several comorbidities,” and could be used as a complementary therapy in some long term conditions.
Appendix 1

Search strategy (Medline and Embase)

Concept: Tai Chi
1. Tai Ji/
2. exp Martial Arts/
3. (tai chi chuan or tai chi or tai ji quan or tai ji or tai-ji or tajiquan or t’ai chi or taiji).tw.
4. or/1-3

Concept: cancer
5. Neoplasms/
6. (tumor* or cancer* or neoplasm* or neoplasia).tw.
7. 5 or 6
8. 4 and 7
9. Limit 8 to English language

Concept: OA
10. Osteoarthritis/
11. (degenerative adj1 arthritides).tw.
12. (arthritis adj1 degenerative).tw.
15. (osteoarthritide or osteoarthroses or osteoarthrosis deformans or osteoarthrosis or osteoarthritis).tw.
16. or/10 -15
17. 4 and 16
18. Limit 17 to English language

Concept: Heart failure
19. heart failure/
20. (heart failure adj1 right sided).tw.
21. (heart failure adj1 left sided).tw.
22. (cardiac failu? or heart failure or myocardial failure).tw.
23. (heart failure adj1 congestive).tw.
24. (heart adj1 decompensation).tw.
25. or/19-24
26. 4 and 25
27. Limit 26 to English language
Concept: COPD
28. pulmonary disease, chronic obstructive/
29. (chronic obstructive adj1 pulmonary disease*).tw.
30. (chronic airflow obstruction*).tw.
31. (chronic obstructive adj1 (lung or airway)).tw.
32. (COPD or COAD).tw.
33. (airflow obstruction* chronic).tw.
34. lung diseases, obstructive/
35. (lung disease* adj1 obstructive).tw.
36. (pulmonary disease* adj1 obstructive).tw.
37. exp lung disease/
38. (lung adj1 disease*).tw.
39. (pulmonary adj1 disease*).tw.
40. Bronchitis, chronic/
41. (chronic bronchi*).tw.
42. exp pulmonary emphysema/
43. (emphysema*).tw.
44. (hyperlucent lung*).tw.
45. or/28-44
46. 4 and 45
47. Limit 46 to English language
Search strategy (Cinahl)
Concept: Tai Chi
1. MH "Tai Chi"
2. tai chi chuan or tai chi or tai ji quan or tai ji or tai-ji or taijiquan or t’ai chi or taiji
3. 1 or 2

Concept: cancer
4. MH "Neoplasms"
5. tumor* or cancer* or neoplasm* or neoplasia
6. 4 or 5
7. 3 and 6
8. Limit 7 to English language

Concept: OA
9. MH "Osteoarthritis+
10. degenerative N1 arthritides
11. arthritis N1 degenerative
12. degenerative N2 arthritides
13. degenerative N2 arthritis
14. osteoarthritide or osteoarthroses or osteoarthrosis deformans or osteoarthrosis or osteoarthritis
15. or/9-14
16. 3 and 15
17. Limit 16 to English language

Concept: HF
18. MH "Heart Failure"
19. heart failure N1 right sided
20. heart failure N1 left sided
21. cardiac failu# or heart failure or myocardial failure
22. heart failure N1 congestive
23. heart N1 decompensation
24. or/18-23
25. 3 and 24
26. Limit 25 to English language

Concept: COPD
27. MH "Pulmonary Disease, Chronic Obstructive+"
28. chronic obstructive N1 pulmonary disease*
29. chronic airflow obstruction*
30. chronic obstructive N1 (lung or airway)
31. COPD or COAD
32. airflow obstruction* chronic
33. MH "Lung Diseases, Obstructive+
34. lung disease* N1 obstructive
35. pulmonary disease* N1 obstructive
36. MH "Lung Diseases"
37. lung N1 disease*
38. pulmonary N1 disease*
39. MH "Bronchitis, Chronic"
40. chronic bronchi*
41. MH "Emphysema"
42. emphysema*
43. hyperlucent lung*
44. or/27-43
45. 3 and 44
46. Limit 45 to English language
Search strategy (SportDiscus)
Concept: Tai Chi
1. Tai Chi
2. tai chi chuan or tai chi or tai ji quan or tai ji or tai-ji or taijiquan or t’ai chi or taiji
3. 1 or 2

Concept: cancer
4. Neoplasms
5. tumor* or cancer* or neoplasm* or neoplasia
6. 4 or 5
7. 3 and 6
8. Limit 7 to English language

Concept: OA
9. Osteoarthritis
10. degenerative N1 arthritides
11. arthritis N1 degenerative
12. degenerative N2 arthritides
13. degenerative N2 arthritis
14. osteoarthritide or osteoarthroses or osteoarthrosis deformans or osteoarthrosis or osteoarthritis
15. or/9-14
16. 3 and 15
17. Limit 16 to English language

Concept: HF
18. heart failure
19. heart failure N1 right sided
20. heart failure N1 left sided
21. cardiac failu# or heart failure or myocardial failure
22. heart failure N1 congestive
23. heart N1 decompensation
24. or/18-23
25. 3 and 24
26. Limit 25 to English language

Concept: COPD
27. pulmonary disease, chronic obstructive
28. chronic obstructive N1 pulmonary disease*
29. chronic airflow obstruction*
30. chronic obstructive N1 (lung or airway)
31. COPD or COAD
32. airflow obstruction* chronic
33. Lung Diseases, Obstructive
34. lung disease* N1 obstructive
35. pulmonary disease* N1 obstructive
36. Lung Diseases
37. lung N1 disease*
38. pulmonary N1 disease*
39. Bronchitis, Chronic
40. chronic bronchi*
41. Emphysema
42. emphysema*
43. hyperlucent lung*
44. or/27-43
45. 3 and 44
46. Limit 45 to English language