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The effectiveness of tai chi in breast cancer patients: A systematic review and meta-analysis

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ABSTRACT

Background and purpose: Tai chi has been suggested as a potential effective intervention for improving function and wellbeing in breast cancer patients. This systematic review evaluated the current evidence for the effectiveness of tai chi in patients with breast cancer.

Methods: Randomized Controlled Trials (RCTs) evaluating the effects of tai chi in breast cancer patients were identified through searches in OVID MEDLINE, AMED, EMBASE, CINAHL, Cochrane Central Register of Controlled Trials, CNKI, VIP, and Wanfang Data, up to June 2019. Meta-analyses were performed for results syntheses.

Results: Sixteen RCTs involving 1268 participants were included in this review. It was demonstrated that tai chi is no different from conventional supportive care interventions in improving fatigue, sleeping quality, depression or body mass index at either 3 months or 6 months; however it significantly improves overall quality of life (QoL) at 3 months. Moreover, tai chi, when offered as an adjunct to conventional therapy, is more effective in improving fatigue at 3 months, and QoL at 3 months and 6 months compared to conventional therapy alone.

Conclusion: Tai chi shows no improvement in fatigue compared with conventional supportive interventions, but it significantly relieves fatigue symptom for breast cancer patients when used with conventional supportive care interventions. Tai chi *versus* conventional supportive care interventions, and as an adjunct to conventional therapy is effective in improving QoL for breast cancer patients.

1. Introduction

Breast cancer is the most common cancer among women worldwide, and the incidence rate increased significantly in the last decade [1–3]. Advancements in early detection and treatment of breast cancer continue to improve the likelihood of survival: the 10-year survival rate in New Zealand is estimated at 92% with regular mammogram [4]. Although it is encouraging, breast cancer survivors experience a variety of side effects from cancer treatment (i.e. surgery, chemotherapy, radiation therapy, and antihormonal therapy), including fatigue [5,6], sleep disturbance [5,7], depression and anxiety [5,8,9], pain [10,11], weight gain [12,13], cardiac toxicity [14,15], and cognitive impairment [16,17]. These side effects negatively impact on the general wellbeing and function of breast cancer survivors, and ultimately affect their quality of life (QoL) [18–20]. While conventional therapies, such as medications, have demonstrated limited effectiveness to address the symptoms of side effects, breast cancer patients have turned their attention to some other treatment modalities, such as complementary and alternative medicine (CAM) [21–23]. Among the CAM treatments, tai chi has become an increasingly popular intervention [24].

Tai chi is an old internal Chinese martial art based upon the fundamental theory of Traditional Chinese Medicine. It is a mind-body, weight-bearing exercise intervention that incorporates slow movement with controlled breathing and mindful meditation. Before our study, at least 5 publications systematically reviewed the primary research of tai chi for patients with breast cancer up to 2015 [25–29]. Their conclusions, limited by the paucity, heterogeneity, and poor quality of the included studies, were conflicting: future high-quality randomized controlled trials (RCTs) with longer follow-up were recommended to provide more reliable evidence [25–28]. Furthermore, the effectiveness of tai chi on outcome measurements other than QoL (e.g. fatigue, sleeping quality, and depression) has yet to be clarified [30]. Since the

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latest systematic review [26], there have been several new studies published, none of which have been systematically reviewed. We thus decided to undertake an updated systematic review and meta-analysis from all available RCTs to evaluate the effectiveness of tai chi for supportive care in patients with breast cancer.

2. Methods

This systematic review was reported in accordance with the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)* statement [31].

2.1. Data sources and search strategy

A comprehensive computerized search was performed by two reviewers (LL and HT) in the following databases: OVID MEDLINE, AMED, EMBASE, CINAHL, Cochrane Central Register of Controlled Trials, China National Knowledge Infrastructure (CNKI), VIP, and Wanfang Data, since the inception of each database up to end of June 2019. Keywords used were (*tai chi* OR *taichi* OR *tai chi chuan* OR *taichichuan* OR *tai ji* OR *taiji* OR *tai ji quan* OR *Chinese martial arts* OR *wushu*) AND (*breast cancer* OR *breast tumor* OR *breast carcinoma* OR *mammary cancer*), with slight modifications for individual searches in each database (relevant Chinese terms for *tai chi* and *breast cancer* were used in Chinese databases including CNKI, VIP, and Wanfang Data). There were no restrictions on publication status or language provided an English and/or Chinese abstract was available. Reference lists of identified studies were manually searched for further articles, and professionals working in the representative field were contacted for unpublished studies.

The following inclusive selection criteria were applied:

I. Study design: RCTs on tai chi for breast cancer;
II. Participants: adult patients diagnosed with breast cancer who received active breast cancer treatment (e.g. surgery, radiation therapy, chemotherapy, or antihormonal therapy);
III. Intervention: tai chi with or without other treatments;
IV. Comparisons: tai chi compared with conventional supportive care interventions; and tai chi plus conventional supportive interventions compared with conventional supportive interventions alone;
V. Outcome measures: fatigue, sleeping quality, QoL, depression, and body mass index (BMI).

2.2. Study selection and data extraction

Two reviewers (LL and HT) independently screened potential studies to determine eligibility. Consensus was reached by discussion, and a third reviewer (GDB) was consulted if disagreements persisted. Data were extracted from each included study independently by the two reviewers (LL and HT), and entered into three standardized spreadsheets recording author(s), publication year and country, study population, details of tai chi interventions, control comparisons, outcome measures, and measurement time-points. Differences were checked by referring to original studies, and disagreement resolved by discussion. Corresponding authors of original studies were contacted if further information was required.

2.3. Quality assessment

The methodological quality of included studies was independently evaluated by two reviewers (LL and HT) using the physiotherapy evidence databases (PEDro) scale [32], which is a valid measure of the methodological quality of clinical trials [33]. Depending on the number of 'Yes' responses (coded as '1' score), a trial was regarded as 'moderate to high quality' if the total score was over 4 (ranging from 5 to 10) [34]. The two reviewers were not blinded during this process. Again, discrepancies were resolved by discussion or judgement from a third reviewer (GDB).

2.4. Data synthesis

Studies were grouped in accordance with the following predefined criteria:

I. Control groups: tai chi compared with other forms of conventional supportive care interventions for breast cancer including usual health care, psychosocial support therapy, cognitive behavior therapy, spiritual growth group, and aerobic exercise forms other than tai chi, such as ba duan jin, yang ge dance, sham qi gong, and walking; and tai chi plus standard rehabilitation training or usual care compared with standard rehabilitation training or usual care alone.
II. Outcome measures: primary outcome measures were fatigue, sleeping quality, and QoL; secondary outcome measures included depression, and BMI.
III. Follow-up time points: at 3 months, and 6 months since the start of tai chi intervention.

Review Manager (RevMan) software 5.1.0 was used to perform meta-analysis of included studies. Data were categorized as continuous and dichotomous variables. Continuous variables were analyzed using weighted mean differences (WMD) with 95% confidence intervals (CIs), or standardized mean differences (SMDs) if different measurement scales were used. Dichotomous variables were analyzed using risk ratio (RR) with 95% CIs. Heterogeneity across studies was tested by the I^2 statistic. The fixed-effects model was used to combine data if heterogeneity was low (I^2 <50%), otherwise the random-effects model was used to pool data (I^2 ≥50%). A funnel plot was used to examine the publication bias if 10 or more studies were pooled.

3. Results

3.1. Study selection

The search strategy identified 274 records, of which 195 records were screened for eligibility after duplicates were excluded. A total of 171 records were excluded on the basis of title and abstract, and the full-text of 24 records were reviewed. Finally, 20 articles were included in this review (Fig. 1). Of these 20 articles, 13 were in English [30,35–46], and the other seven in Chinese [47–53]. All articles were published between 2003 and 2017. The four articles published by Mustian et al. [30,43–45] and the two articles published by Irwin et al. [35,39] were each regarded as a single trial in this review due to the same group of participants: only two articles, i.e. one for each group of papers [30,35], were included in data analysis. Thus, 16 RCTs were finally included in this review [30,35–38,40–42,46–53].

3.2. Study characteristics

3.2.1. Participants

Participant characteristics of included RCTs are summarized in Table 1. Sixteen RCTs that enrolled a total of 1268 participants were included in this review. Eight RCTs were conducted in the United States [30,35,36,38,40–42,46], seven in China [47–53], and one in Thailand [37]. Eight RCTs exclusively included breast cancer survivors (breast cancer patients who have completed scheduled treatment except for antihormonal therapy) [30,35–38,41,42,46]; seven trials included participants who were undergoing breast cancer therapy [40,48–53]. Eleven RCTs reported the breast cancer stage of participants [30,36–38,40–42,46,47,50,52]. The baseline physical activity level of participants were reported in six RCTs [30,36,38,41,42,46].

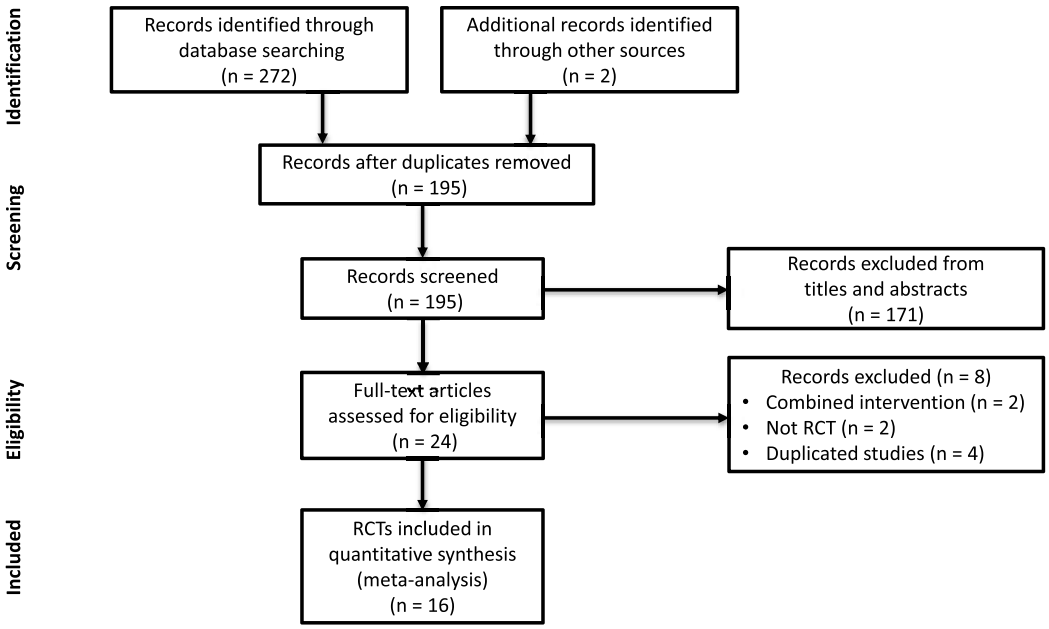

Fig. 1. Flow diagram of literature search.
Abbreviation: RCT, randomized controlled trial.

Table 1
Participant characteristics in the included 16 RCTs.

Author (year)	Country	Number	Age (mean; range)	BC stage	*BC survivors	Time since treatment completion	Treatment received (proportion of participants)				Baseline PA
							Surgery	Chemo-therapy	Radiation therapy	Hormone therapy	
Irwin et al. (2017) [35]	USA	90	NR; 42–83	NR	Yes	≥6 months	11.1%	43.3%	62.2%	31.1%	NR
Wang (2017) [47]	China	86	50.5; 35–63	I-III	NR	N/A	100%	95.3%	32.6%	NR	NR
Larkey et al. (2016, 2015) ([36,38])	USA	87	59; 40–75	0-III	Yes	0.5–5 years	NR	NR	NR	69.0%	11.7 MET hour/ week
Wang et al. (2016) [48]	China	96	NR	NR	No	N/A	100%	NR	NR	NR	NR
Lv et al. (2015) [49]	China	149	48.61; 32–65	NR	No	N/A	100%	NR	NR	NR	NR
Thongteratham et al. (2015) [37])	Thailand	30	NR; NR	0-IIIb	Yes	≥1 year	100%	76.7%	56.7%	60%	NR
Li et al. (2013) [51]	China	57	47.56; 29–68	NR	No	N/A	100%	NR	NR	NR	NR
Robins et al. (2013) [40]	USA	145	50; 27–75	0-IIIa	No	N/A	100%	100%	NR	NR	NR
Xiao et al. (2013) [50]	China	66	NR	0-III	No	N/A	100%	NR	NR	NR	NR
Sprod et al. (2012) [41]	USA	19	53; 43–78	0-IIIb	Yes	≤30 months	100%	84%	61%	56%	<1/week of moderate/ vigorous PA
Wang et al. (2012) [52]	China	185	47.19; 28–65	I-III	No	N/A	100%	96.76%	39.46%	NR	NR
Janelsins et al. (2011) [42]	USA	19	53; 43–78	0-IIIb	Yes	≤30 months	100%	47.4%	94.7%	NR	<1/week of moderate/ vigorous PA
Wang et al. (2010) [53]	China	120	46.49; 28–65	NR	No	N/A	100%	NR	NR	NR	NR
Mustian et al. (2008) [30]	USA	21	52; 33–78	0-IIIb	Yes	≤30 months	100%	84%	61%	56%	<1/week of moderate/ vigorous PA
Galantino et al. (2003) [46]	USA	11	NR; 40–59	II-IV	Yes	≥1 year	NR	NR	NR	NR	<3/week of exercise

Abbreviations: BC, breast cancer; MET, metabolic equivalent of task; N/A, not applicable; NR, not reported; PA, physical activity.
Note: *Breast cancer patients who have completed scheduled treatment except for hormone therapy (e.g. surgery, chemotherapy, radiation therapy).

Table 2
Characteristics of 16 RCTs regarding tai chi for breast cancer.

Study	Study design	No. of groups	Intervention (No. of participants)	Outcome measures	Measured time-points
Irwin et al. (2017) [35]	Full study	2	1) Tai chi chih (n = 45) 2) Cognitive behavior therapy (n = 45)	I. Sleep quality (PSQI, AISI) II. Fatigue (FSI) III. Depression (IDS) IV. BMI	Baseline; 2 mons; 3 mons; 6 mons; 15 mons
Wang (2017) [47]	Full study	2	1) Tai chi chuan + Standard rehabilitation training (n = 45) 2) Standard rehabilitation training (n = 41)	I. Fatigue (CFS) II. Quality of life (WHOQOL-BREF) III. Sleep quality (PSQI) IV. Depression (SDS)	Baseline*; 1 mon; 3 mons; 6 mons
Larkey et al. (2016) [36]	Pilot study	2	1) Qi gong/tai chi easy (n = 42) 2) Sham qi gong (n = 45)	I. Quality of life (SF-36) II. BMI	Baseline; 3 mons; 6 mons
Wang et al. (2016) [48]	Full study	2	1) Tai chi chuan + Standard rehabilitation training (n = 48) 2) Standard rehabilitation training (n = 48)	Quality of life (FACT-B)	Baseline*; 1 mon; 3 mons
Larkey et al. (2015) [38]	Pilot study	2	1) Qi gong/tai chi easy (n = 42) 2) Sham qi gong (n = 45)	I. Fatigue (FSI) II. Sleeping quality (PSQI) III. Depression (BDI)	Baseline; 3 mons; 6 mons
Lv et al. (2015) [49]	Full study	3	1) Tai chi chuan + Standard rehabilitation training (n = 50) 2) Ba duan jin + Standard rehabilitation training (n = 50) 3) Standard rehabilitation training (n = 49)	Quality of life (SF-36)	Baseline*; 1 mon; 3 mons
Thongteratham et al. (2015) [37]	Pilot study	2	1) Tai chi qi gong plus usual care (n = 15) 2) Usual care (n = 15)	I. Fatigue (FSI) II. Quality of life (FACT-B)	Baseline; 6 wks; 3 mons
Li et al. (2013) [51]	Full study	2	1) Tai chi yun shou + Standard rehabilitation training (n = 29) 2) Standard rehabilitation training (n = 28)	Quality of life (WHOQOL-BREF)	7 ds; 1 mon; 3 mons; 6 mons
Robins et al. (2013) [40]	Full study	3	1) Tai chi (n = NR) 2) Spiritual growth group (n = NR) 3) Usual care (n = NR)	I. Quality of life (FACT-B) II. Depression (CES-D)	Baseline; Post int; 4.5 mons; 6 mons
Xiao et al. (2013) [50]	Full study	2	1) Tai chi chuan + Standard rehabilitation training (n = 33) 2) Aerobics exercise + Standard rehabilitation training (n = 33)	Quality of life (FACT-B)	Baseline†; 3 mons; 6 mons
Sprod et al. (2012) [41]	Pilot study	2	1) Tai chi chuan (n = 9) 2) Psychosocial support therapy (n = 10)	Quality of life (SF-36)	Baseline; 6 wks; 3 mons
Wang et al. (2012) [52]	Full study	3	1) Tai chi chuan + Standard rehabilitation training (n = 63) 2) Yang ge dance + Standard rehabilitation training (n = 51) 3) Standard rehabilitation training (n = 71)	Quality of life (WHOQOL-BREF)	Baseline*; 1 mon; 3 mons; 6 mons
Janelsins et al. (2011) [42]	Pilot study	2	1) Tai chi chuan (n = 9) 2) Psychosocial support therapy (n = 10)	BMI	Baseline; 3 mons
Wang et al. (2010) [53]	Full study	2	1) Tai chi chuan + Standard rehabilitation training (n = 62) 2) Standard rehabilitation training (n = 58)	Quality of life (WHOQOL-BREF)	Baseline*; 1 mon; 3 mons; 6 mons
Mustian et al. (2008) [30]	Pilot study	2	1) Tai chi chuan (n = 11) 2) Psychosocial support therapy (n = 10)	Quality of life (FACIT-F)	Baseline; 3 mons
Galantino et al. (2003) [46]	Pilot study	2	1) Tai chi (n = 6) 2) Walking (n = 5)	I. BMI II. Quality of life (FACT-B) III. Fatigue (BFI)	Baseline; 6 wks

Abbreviations: AISI, Athens insomnia severity index; BDI, Beck depression inventory; BFI, brief fatigue inventory; BMI, body mass index; CES-D, center for epidemiological studies depression scale; CFS, cancer fatigue scale; ds, days; FACIT-F, functional assessment of chronic illness therapy-fatigue; FACT-B, functional assessment of cancer therapy-breast; FSI, fatigue symptom inventory; IDS, inventory of depressive symptoms; int, intervention; mos, months; NR, not reported; PA, physical activity; PSQI, Pittsburgh sleep quality index; SDS, self-rating depression scale; SF-36, short form 36; WHOQOL-BREF, World Health Organization quality of life brief questionnaire; wks, weeks.
Note: *data at 10 days post-operation; †data at 15 days post-operation.

3.2.2. Control interventions

Study characteristics of the included 16 RCTs are presented in Table 2. In six RCTs, tai chi plus standard rehabilitation training was compared to standard rehabilitation training alone [47–49,51–53]. Three RCTs compared tai chi to psychosocial support therapy [30,41,42]. Other exercise forms (e.g. ba duan jin, aerobics exercise, yang ge dance, or sham qi gong [a gentle movement control intervention similar to tai chi but without the focus on breathing and meditative state], and walking) were compared with tai chi in six trials [36,38,46,49,50,52], and cognitive behavior therapy was used as a control arm in one trial [35].

3.2.3. Outcome measures

Five RCTs measured fatigue using Fatigue Symptom Inventory (FSI) [35,37,38], Cancer Fatigue Scale (CFS) [47], or Brief Fatigue Inventory (BFI) [46]. Sleeping quality was measured using Pittsburgh Sleep Quality Index (PSQI) or Athens Insomnia Severity Index (AISI) in three trials [35,38,47]. Five RCTs measured QoL using Functional Assessment of Cancer Therapy-Breast (FACT-B) [37,40,46,48,50]; in addition, four Chinese trials used World Health Organization Quality of Life Brief Questionnaire (WHOQOL-BREF) [47,51–53], and three trials used Short Form 36 (SF-36) to measure QoL [36,41,49]. For secondary outcome measures, depression was measured using four different scales including Inventory of Depressive Symptoms (IDS) [35], Self-rating Depression

Scale (SDS) [47], Beck Depression Inventory (BDI) [38], or Center for Epidemiological Studies Depression Scale (CES-D) [40]. BMI was measured in four trials [35,36,42,46]. The time frame of the outcome measures varied from immediately post intervention to 12 months after the completion of intervention.

3.2.4. Tai chi intervention

The tai chi interventions used in the included trials were highly variable (Table 3). Five Chinese RCTs adopted the 24-form simplified tai chi chuan [47,49,50,52,53], while four trials used the Yang-style tai chi chuan [30,41,42,46]; tai chi chih and Qi gong/tai chi easy were the intervention formats in three trials [35,36,38]. The number of tai chi movements ranged from eight to 38, and the total length of the intervention program varied from 10 weeks to six months. The frequencies of tai chi practicing were weekly 90 or 120 min/session [35,40], 60 min/session for 1–4 sessions/week [30,36–38,41,42,46], 30 min/-session for over 3 sessions/week [49], and 20–30 min/session for two sessions/day [47,48,50–53]. Nine RCTs reported details of the tai chi instructors [30,35–38,41,42,48,51]; among these nine RCTs, trained nurses led the tai chi class in four trials [36–38,51].

3.3. Quality assessment

Results of the quality assessment of the included 16 RCTs are shown in Table 4. Fourteen RCTs were regarded to be of 'moderate to high quality' (a PEDro score ≥5/10) [30,35–38,41,42,47–53]. Fifteen RCTs mentioned randomization [30,35–38,40–42,46–52], and five studies reported appropriate allocation concealment [35,37,41,42,51]. Baseline data were comparable in 15 RCTs [30,35–38,40–42,47–53], and 12 studies provided adequate follow-up [35–38,46–53]. Intention-to-treat analysis was used in seven RCTs [30,35,37,41,49,50,52]. Presentation of the study outcomes (i.e. between-group statistical comparisons, and point measures and measures of variability) were considered satisfied in over 85% studies. Due to the nature of tai chi intervention, none of the included RCTs blinded the tai chi instructors; only two RCTs blinded the participants because of applying sham qi gong as a control arm [36,38], and five trials employed assessors who were blinded to participant group allocation [35–38,47].

3.4. Effectiveness of tai chi intervention

Table 5 presents the summary results of the effects of tai chi intervention compared with control groups.

3.4.1. Tai chi vs conventional supportive care interventions

3.4.1.1. Fatigue. Two RCTs [35,38] reported changes in fatigue at 3 months, and 6 months since the start of tai chi intervention. No substantial heterogeneity was found between these two studies ($I^2 = 0$). The pooled results failed to suggest that tai chi is more effective in improving fatigue compared with conventional supportive interventions at either the two time-points (MD = −0.46, 95% CI -1.09 to 0.17, and MD = −0.16, 95% CI -0.98 to 0.67 respectively) (Appendix Figures 1A and B).

3.4.1.2. Sleeping quality. Sleeping quality was measured in two RCTs [35,38]. The pooled results indicated that tai chi shows no improvement in sleeping quality compared with control groups at 3 months (MD = 0.26, 95% CI -1.28 to 1.80, $I^2 = 58\%$) (Appendix Figure 2A), or at 6 months (MD = 0.13, 95% CI -1.54 to 1.79, $I^2 = 30\%$) (Appendix Figure 2B).

3.4.1.3. Depression. Depression was assessed in three RCTs [35,38,40]. There was no heterogeneity among these trials ($I^2 = 0\%$). Data analysis showed no statistically significant difference between tai chi and the control groups in improving depression either at 3 months (SMD = 0.22,

Table 3
Treatment parameters of the tai chi intervention in the included 16 RCTs.

Study	Tai chi style	No. of movements	Duration per session	Frequency	Length of program	Instructor
Irwin et al. (2017) [35]	Tai chi chih	20	120 min	1/week	12 weeks	A master's level instructor who had undergone certification by the national tai chi chih association
Wang (2017) [47]	24-form simplified tai chi chuan	24	20 min	2/day	6 months	NR
Larkey et al. (2016, 2015) ([36, 38])	Qi gong/tai chi easy	10	60 min	2/week for Wks 1–2; 1/week for Wks 3-12	12 weeks	A nurse who experienced in leading exercise with cancer patients
Wang et al. (2016) [48]	NR	NR	20 min	2/day	NR	A tai chi expert
Lv et al. (2015) [49]	24-form simplified tai chi chuan	24	≥30 min	≥3/week	≥6 months	NR
Thongteratham et al. (2015) [37]	Tai chi qi gong	18	60 min	≥4/week	12 weeks	A registered nurse who was certified in tai chi qi gong practice and had previous experience leading sessions
Li et al. (2013) [51]	NR	NR	30 min	2/day	NR	Three nurses trained by tai chi expert
Robins et al. (2013) [40]	NR	8	90 min	1/week	10 weeks	NR
Xiao et al. (2013) [50]	24-form simplified tai chi chuan	24	20 min	2/day	NR	NR
Sprod et al. (2012) [41], Janelsins et al. (2011) [42], Mustian et al. (2008) [30]	Yang-style tai chi chuan	15	60 min	3/week	12 weeks	An American College of Sports Medicine certified health and fitness instructor, who was extensively trained in Yang-style tai chi chuan with over 6 years of teaching experience
Wang et al. (2012) [52]	24-form simplified tai chi chuan	24	20 min	2/day	NR	NR
Wang et al. (2010) [53]	24-form simplified tai chi chuan	24	20 min	2/day	NR	NR
Galantino et al. (2003) [46]	Yang-style tai chi	38	60 min	3/week	6 weeks	NR

Abbreviations: NR, not reported; Wks, weeks.

Table 4
Quality assessment of the 16 included RCTs according to the PEDro scale.

Study	1. Eligibility criteria	2. Random allocation	3. Concealed allocation	4. Baseline comparability	5. Blinded subjects	6. Blinded therapists	7. Blinded assessors	8. Adequate follow-up	9. Intention-to-treat analysis	10. Between-group comparisons	11. Point measures and variability	Total score (_/10) (criteria 1 not included)[a]
Irwin et al. (2017) [35]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	**9**
Wang (2017) [47]	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes	**7**
Larkey et al. (2016) [36]	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	**8**
Wang et al. (2016) [48]	Yes	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	**6**
Larkey et al. (2015) [38]	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	**8**
Lv et al. (2015) [49]	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	**7**
Thongteratham et al. (2015) [37]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	**9**
Li et al. (2013) [51]	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	**7**
Robins et al. (2013) [40]	No	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4
Xiao et al. (2013) [50]	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	**7**
Sprod et al. (2012) [41]	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	**7**
Wang et al. (2012) [52]	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	**7**
Janelsins et al. (2011) [42]	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	**6**
Wang et al. (2010) [53]	Yes	No	No	Yes	No	No	No	Yes	No	Yes	Yes	**5**
Mustian et al. (2008) [30]	Yes	Yes	No	Yes	No	No	No	No	Yes	No	Yes	**5**
Galantino et al. (2003) [46]	Yes	Yes	No	No	No	No	No	Yes	No	No	No	3
Sub-item total score (_/16)	15	15	5	15	2	0	5	12	7	14	15	

[a] 'Moderate to high quality' studies (≥5/10) were represented in bold.

Table 5
Summary of pooled results.

Comparison	Outcome measures	Time-point	Studies pooled	Number of patients		SMD (random) [95%CI]	I^2
				Intervention	Control		
Tai chi *vs* Conventional supportive care interventions	Fatigue	3 months	Irwin et al. (2017) [35], Larkey et al. (2015) [38]	85	89	−0.46 [-1.09, 0.17]	0%
		6 months	Irwin et al. (2017) [35], Larkey et al. (2015) [38]	80	83	−0.16 [-0.98, 0.67]	0%
	Sleeping quality	3 months	Irwin et al. (2017) [35], Larkey et al. (2015) [38]	76	82	0.26 [-1.28, 1.80]	58%
		6 months	Irwin et al. (2017) [35], Larkey et al. (2015) [38]	56	60	0.13 [-1.54, 1.79]	30%
	Depression	3 months	Irwin *et* al. (2017) [35], Larkey et al. (2015) [38], Robins et al. (2013) [40]	108	103	0.22 [-0.05, 0.49]	0%
		6 months	Irwin et al. (2017) [35], Larkey et al. (2015) [38]	79	83	0.16 [-0.15, 0.47]	0%
	BMI	3 months	Irwin et al. (2017) [35], Larkey et al. (2016) [36], Janelsins et al. (2011) [42]	83	86	−0.58 [-2.18, 1.01]	0%
	QoL	3 months	Lv et al. (2015) [49], Sprod et al. (2012) [41]	472	480	0.32 [0.07, 0.56]	67%
Tai chi plus conventional therapy *vs* Conventional therapy alone	Fatigue	3 months	Wang (2017) [47], Thongteratha et al. (2015) [37]	60	56	−0.91 [-1.30, −0.53]	0%
	QoL	3 months	Wang (2017) [47], Li et al. (2013) [51], Wang et al. (2012) [52], Wang et al. (2010) [53]	1194	1188	0.34 [0.26, 0.43]	0%
		6 months	Wang (2017) [47], Li et al. (2013) [51], Wang et al. (2012) [52], Wang et al. (2010) [53]	1194	1188	0.40 [0.31, 0.49]	18%

Abbreviations: BMI, body mass index; QoL, quality of life; SMD, standardized mean differences.

95% CI -0.05 to 0.49) (Appendix Figure 3A) or at 6 months (SMD = 0.16, 95% CI -0.15 to 0.47) (Appendix Figure 3B).

3.4.1.4. BMI. Three RCTs measured BMI at 3 months [35,36,42]. Pooled data suggested that when compared with control groups, tai chi shows no benefits in improving BMI (MD = −0.58, 95% CI -2.18 to −1.01, I^2 = 0%) (Appendix Figure 4).

3.4.1.5. Quality of life. Three RCTs [36,41,49] assessed QoL using SF-36 scale at 3 months, but one study [36] was excluded from the meta-analysis due to incomplete data; the authors were contacted for details, but did not reply. Based upon the two RCTs [41,49], when compared with conventional supportive interventions tai chi does not have obvious benefits in any of the eight dimensions of the SF-36 scale (Appendix Figure 5). However, when combined the eight dimensions together, it was shown that tai chi is superior to controls in improving participants' QoL (SMD = 0.32, 95% CI 0.07 to 0.56, I^2 = 67%).

3.4.2. Tai chi plus conventional therapy vs conventional therapy alone

For this subgroup, meta-analyses were conducted for the two primary outcome measures including fatigue (at 3 months) and QoL (at 3 months and 6 months) based upon the data available.

3.4.2.1. Fatigue. Two studies [37,47] measured fatigue at 3 months: the additional use of tai chi significantly relieved participants' fatigue (SMD = −0.91, 95% CI -1.30 to −0.53) (Appendix Figure 6).

3.4.2.2. Quality of life. Four studies [47,51–53] reported QoL using the WHOQoL-BREF. Based upon these four RCTs, when compared with standard rehabilitation training alone, tai chi plus standard rehabilitation training improves general QoL at 3 months (SMD = 0.34, 95% CI 0.26 to 0.43) and 6 months (SMD = 0.40, 95% CI 0.31 to 0.49) (Appendix Figures 7A and B). Additionally, tai chi plus standard rehabilitation training had better effectiveness in the five dimensions at 3 months, including overall QoL (SMD = 0.43, 95% CI 0.23 to 0.62), general health (SMD = 0.32, 95% CI 0.12 to 0.51), physical health (SMD = 0.53, 95% CI 0.27 to 0.78), psychological domain (SMD = 0.46, 95% CI 0.26 to 0.66), and social relationships (SMD = 0.22, 95% CI 0.02 to 0.41) (Appendix Figure 7A). At six months, the additional use of tai chi showed superiority in these five dimensions: overall quality of life (SMD = 0.38, 95% CI 0.18 to 0.58), general health (SMD = 0.37, 95% CI 0.17 to 0.57), physical health (SMD = 0.48, 95% CI 0.18 to 0.78), psychological domain (SMD = 0.68 95% CI 0.41 to 0.96), and social relationships (SMD = 0.30, 95% CI 0.10 to 0.50) (Appendix Figure 7B).

4. Discussion

4.1. Summary of the main results

This systematic review evaluated the effectiveness of tai chi for supportive care in patients with breast cancer (included RCTs were published between 2003 and 2017). It showed that there are no significant differences between tai chi and conventional supportive care interventions (i.e. cognitive behavior therapy, sham qi gong, psychosocial support therapy, ba duan jin, and spiritual growth group) for improving fatigue symptom, sleeping quality, depression and BMI at 3 months and 6 months. In contrast, tai chi improves the overall QoL compared to conventional supportive care interventions at 3 months. Most importantly, evidence favored tai chi as an adjunctive therapy over conventional therapy alone in the improvement of fatigue at 3 months, and QoL at 3 months and 6 months.

4.2. Relevance to previous reviews

Prior to this systematic review, five systematic reviews have been published with inconsistent conclusions [25–29]. Two reviews published by Pan et al. [26,27] counted the same trial (conducted by Mustian et al. [30,43,44]) as three independent studies in meta-analyses, thus compromising the review findings. Based upon the published reviews, evidence of effectiveness of tai chi on muscle strength, BMI, and psychosomatic wellbeing was conflicting. While three reviews demonstrated favorable effects of tai chi in improving shoulder function, handgrip strength, elbow flexion and extension, and limb abduction and adduction [26,27,29], interestingly, none of the reviews showed benefits of tai chi in improving participants' QoL. The effectiveness of tai chi on other outcome measures, such as fatigue, sleeping quality, and depression, have yet to be clarified.

This systematic review updated the literature, and comprehensively evaluated the therapeutic value of tai chi for supportive care in breast cancer patients based upon available RCTs. Findings have expanded

previous research on the effectiveness of tai chi on fatigue, sleeping quality and depression, and strengthened conclusions of previous reviews that tai chi does not differ from conventional supportive care interventions (i.e. cognitive behavior therapy, and psychosocial support therapy) in BMI improvement. However, this review found further evidence of effectiveness of tai chi for QoL. Given that our review has shown favorable effects of tai chi in QoL improvement, it is worth exploring the reasons for this result in more detail. Our review included additional studies published after the search dates of the earlier reviews [36,47], and others that were not included in those reviews [49,51], which we classified as 'moderate to high quality'. Another important difference was the fact that in previous reviews, when tai chi was compared with conventional therapy and tai chi plus conventional therapy compared with conventional therapy alone, the two different comparisons were pooled together in result synthesis [29]. Moreover, the outcome measures for assessing QoL with different sub-dimensions were inappropriately combined [26,29]. In our review, we separated out the two comparisons, and only pooled studies with measurement scales of the same sub-dimensions; it was found that tai chi, either used alone or as an adjunct therapy, significantly improves participants' QoL at 3 months and 6 months.

4.3. Implications for future research

Tai chi is a complex, multimodal intervention that incorporates eight physical, cognitive, social, environmental, and ritualistic components (i.e. musculoskeletal strength, flexibility, and efficiency; breathing; concentration, attention, and mindfulness; imagery, visualization, and intention; physical touch and subtle energy; psychosocial interactions; alternative health paradigm and philosophy; rituals, icons; and environment); all of the eight components confer therapeutic effects [54]. Similar to other modalities of CAM, studying tai chi as a form of whole systems (ecologic) framework, rather than deconstruction of tai chi into separate components, can help illustrate a complete and unbiased understanding of the potential therapeutic value of tai chi in health care [54]. It has been suggested that due to the nature of tai chi, randomized, placebo-controlled efficacy trials are not an appropriate research design [54,55]; instead, pragmatic trials comparing tai chi to well-established and credible interventions and/or RCTs comparing tai chi to non- or limited-exercise control groups (e.g. educational interventions) are particularly suitable to tai chi research [55]. In order to facilitate the integration and adoption of tai chi into health care community, future research may evaluate the overall effectiveness of tai chi as it is practiced in a clinical or natural setting.

One limitation of tai chi research, identified in this review (as well as in previous study [55]), is the poor reporting quality of tai chi protocols. Details of tai chi intervention, including time point for initiating practice, practicing styles, number of movements, duration, frequency and length of practice session, and instructor characteristics, are inadequately described. The poor reporting of tai chi intervention poses limitations on research replication and interpretation of individual studies. As reporting guidelines for other forms of CAM, such as acupuncture [56], moxibustion [57], and herbal medicines [58], have been developed, reporting guidelines specific to tai chi research may be accordingly adapted, and should be established. In the interim, future research on tai chi needs to better characterize the tai chi intervention.

In this review, most of the RCTs conducted in the United States prescribed participants tai chi at 60 min/session, 2 to 3 times weekly for 12 weeks; in contrast, RCTs conducted in China used a tai chi training program at 20 min/session for twice daily (practicing duration unclear). Evaluation of the effectiveness of tai chi requires knowledge of the dosage employed. However, credible treatment guidelines for tai chi with effective parameters have been yet to be identified. Although a growing body of clinical research has demonstrated the positive effects of tai chi when practiced in a short period of time (10–12 week) [55], it is believed that the benefits of tai chi are associated with practicing duration in a dosage-dependent fashion as practitioners' skills improve over time. Consequently, short-term prospective RCTs included in this review may somewhat underestimate the therapeutic effects of tai chi. As acknowledged, it might be not practical for prospective trials to follow up participants in a longer term (e.g. over 5 year); in order to address the long-term benefits of tai chi, future research may be based on well-designed cross-sectional studies, and cohort studies and/or case-control studies recruiting long-term tai chi practitioners [55].

4.4. Implications for future clinical practice

Breast cancer patients frequently experience side effects from cancer therapy, which contribute to becoming sedentary and physically deconditioned. Providing social support environments for breast cancer patients may not be sufficient to address their multiple and complex physical and psychological needs [30]. Exercise has been suggested as an effective and convenient support care intervention for breast cancer patients [59–63]. However, adherence to more conventional forms of exercise, such as walking or cycling, diminishes over time [64]. As generally practiced in groups, tai chi provides significant sources of community-based social support, and results in beneficial psychosocial interactions from other practitioners [54]. A prescription for tai chi serves as an effective alternative mode of physical exercise for individuals in need of an exercise program, which can be practiced in any environment without special equipment. Excellent exercise adherence, attendance rates, and strong desires for long-term practice have been well reported in the RCTs included in this review. In future clinical practice, clinicians can play a vital role in encouraging breast cancer patients to participate in tai chi in order to improve their physical and emotional wellbeing, and overall QoL. Non-government organizations including breast cancer advocacy and support groups have the opportunity to advocate the health benefits of tai chi, and refer their clients to local centers where tai chi classes are offered.

4.5. Limitations of the review

This review may be limited by the inherent heterogeneity of the included RCTs, although efforts have been made to minimize the risk of bias. First, the heterogeneity might be due to different populations, including phase of breast cancer survivorship (breast cancer survivors, or breast cancer patients undergoing adjunct cancer treatment), breast cancer treatment received, and participants' baseline physical activity level. Second, the variances of tai chi parameters used in the included studies and variable methods of application, along with differences in practicing regimes, contribute to the heterogeneity. For these reasons, future well-designed clinical trials with standardized tai chi protocols for a particular subset of breast cancer patients (i.e. breast cancer patients undergoing cancer therapy) are needed to confirm the potential superiority of different tai chi interventions, and determine an optimal treatment protocol for this exercise form.

5. Conclusion

In conclusion, the results of this systematic review suggested that tai chi shows no improvement in fatigue compared with conventional supportive interventions, but it significantly relieves fatigue symptom for breast cancer patients when used with conventional supportive care interventions. Tai chi *versus* conventional supportive care interventions, and as an adjunct to conventional therapy is effective in improving QoL for breast cancer patients.

Declaration of competing interest

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Not applicable.

Appendix. Forest plots of meta-analyses

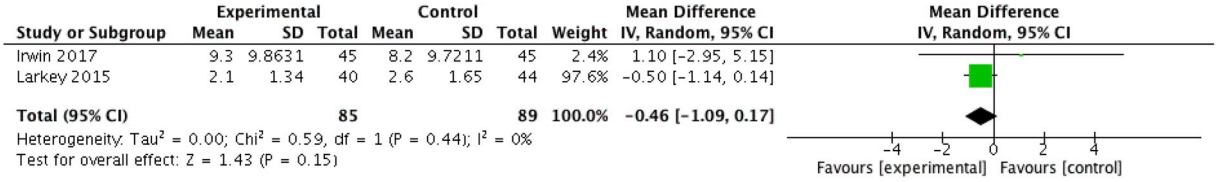

Fig. 1A. Fatigue at 3 months.

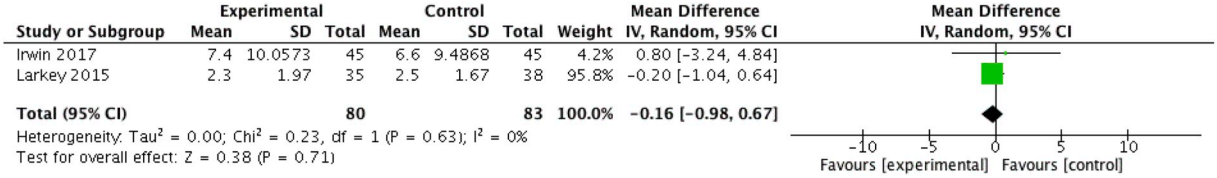

Fig. 1B. Fatigue at 6 months.

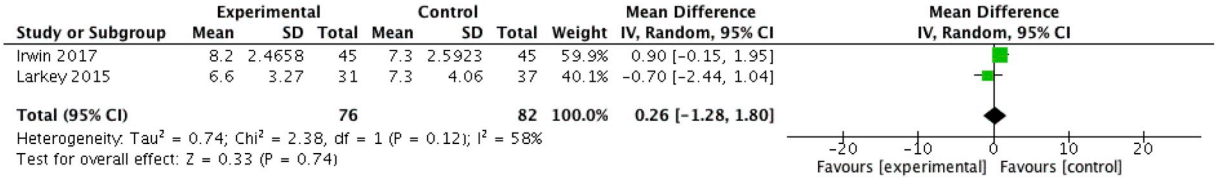

Fig. 2A. Sleeping quality at 3 months.

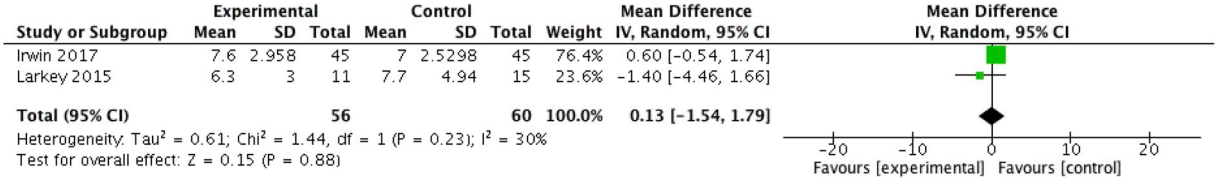

Fig. 2B. Sleeping quality at 6 months.

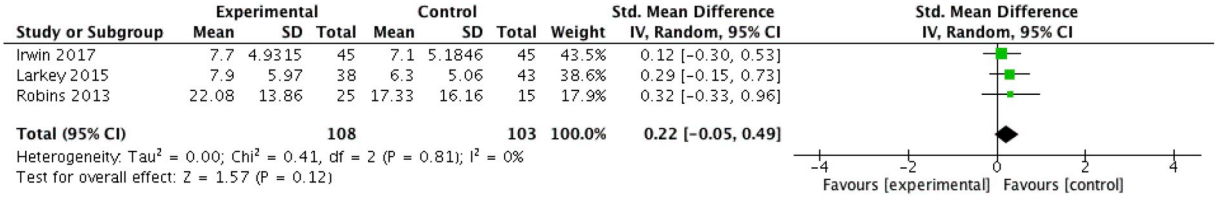

Fig. 3A. Depression at 3 months.

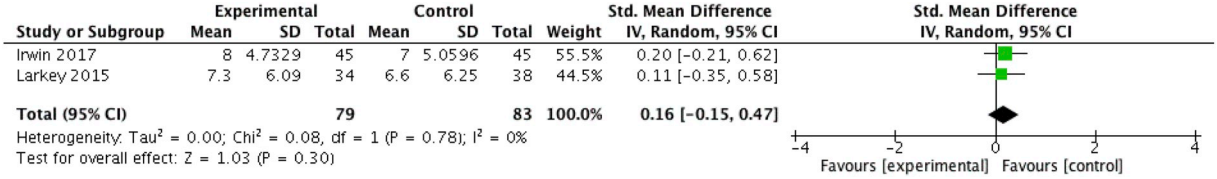

Fig. 3B. Depression at 6 months.

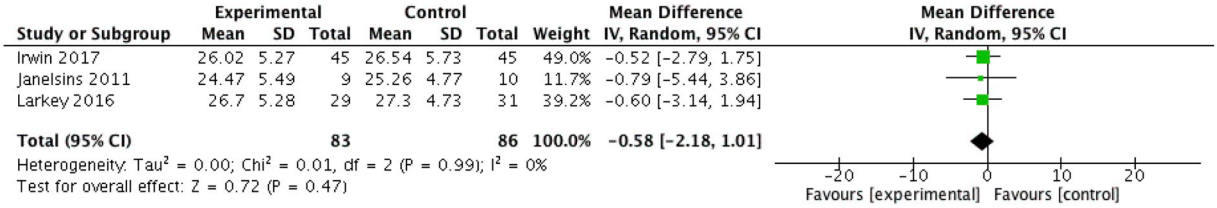

Fig. 4. BMI at 3 months.

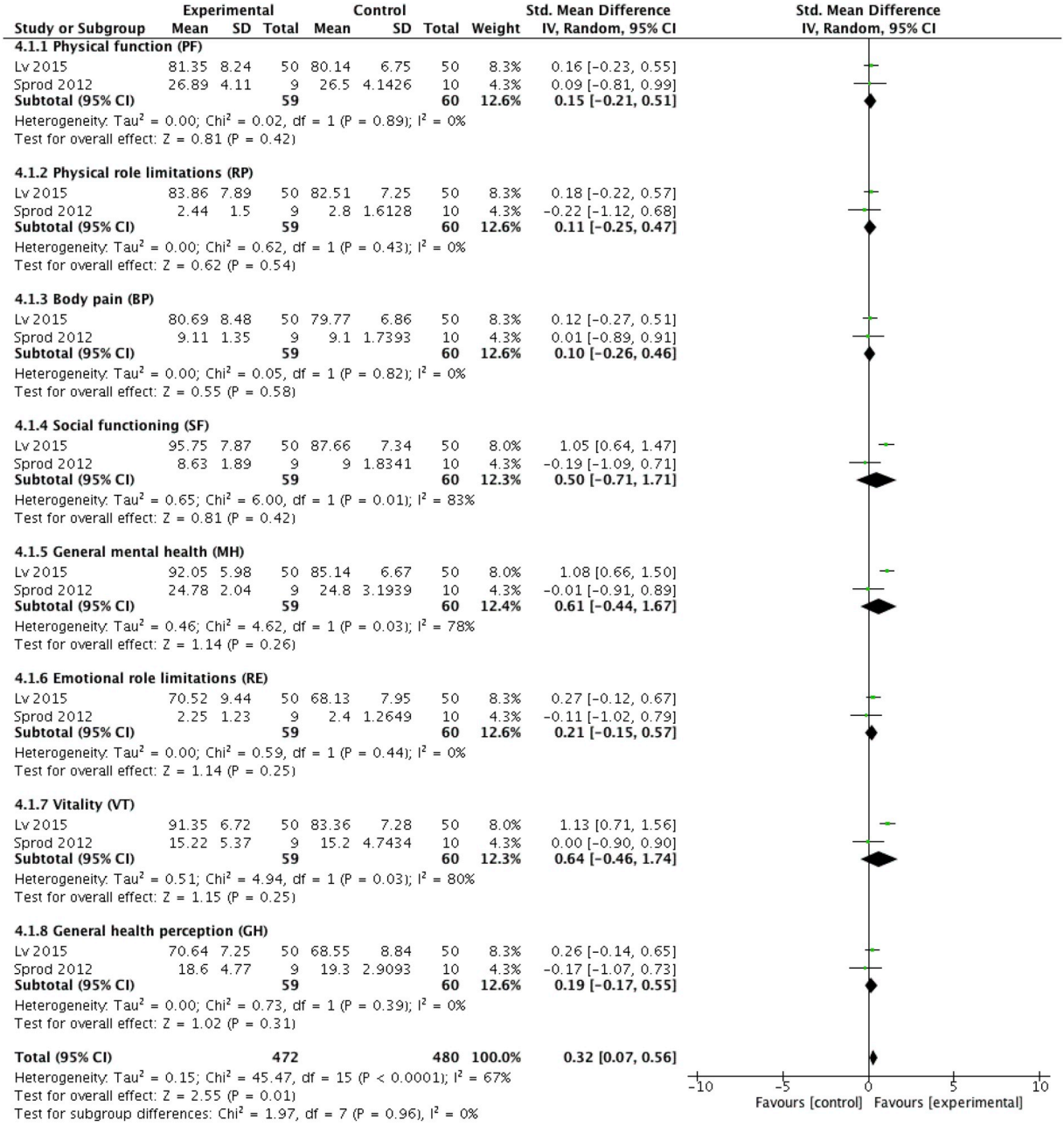

Fig. 5. QoL at 3 months.

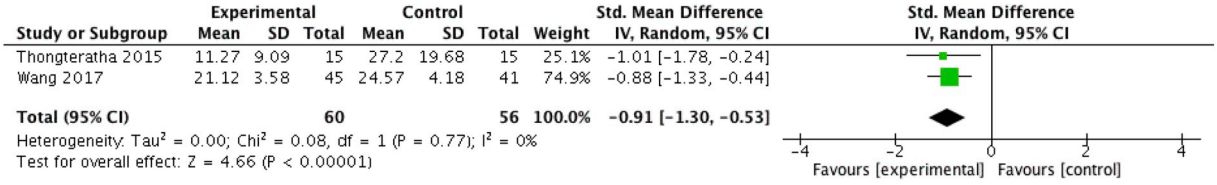

Fig. 6. Fatigue at 3 months.

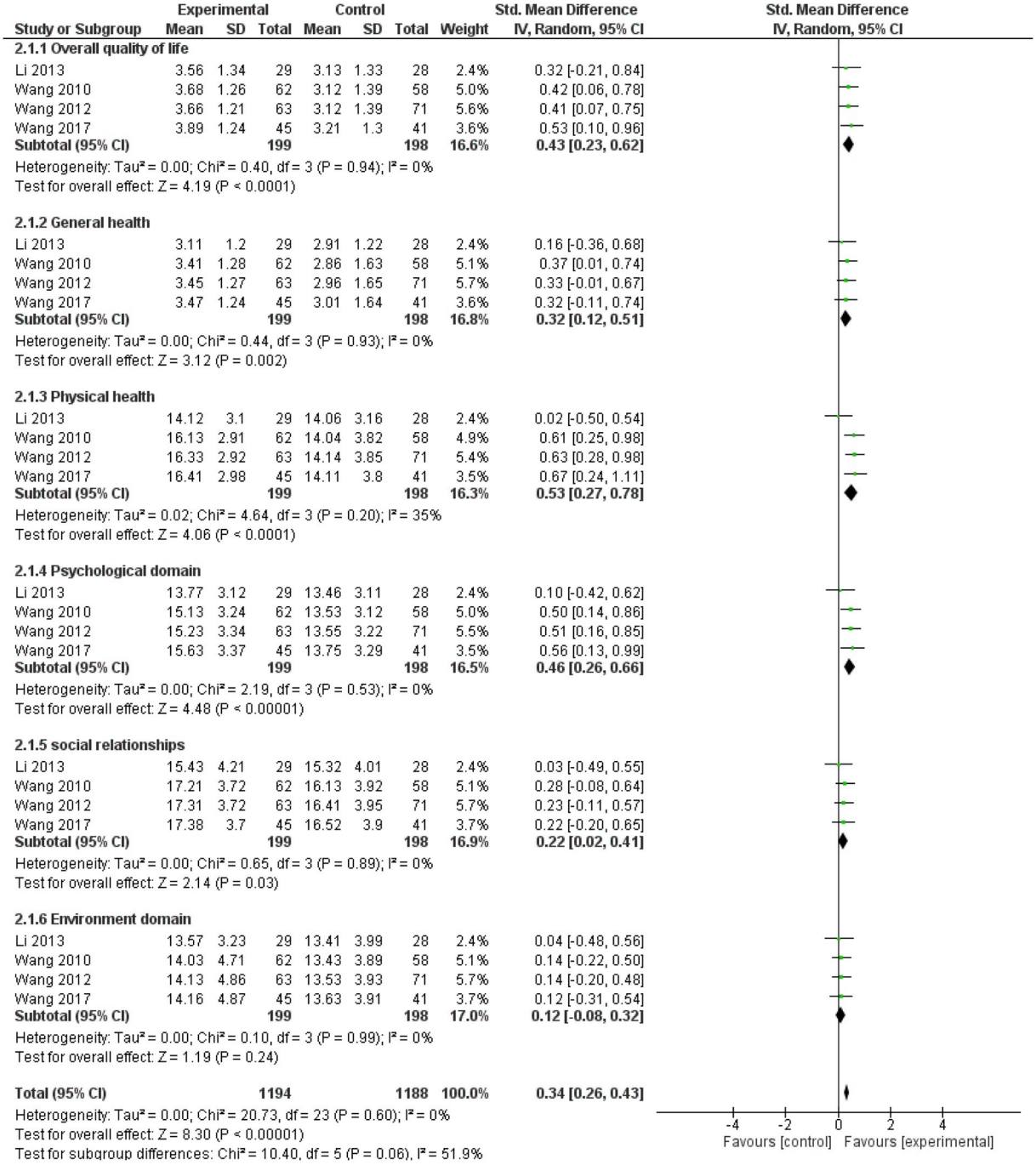

Fig. 7A. QoL at 3 months.

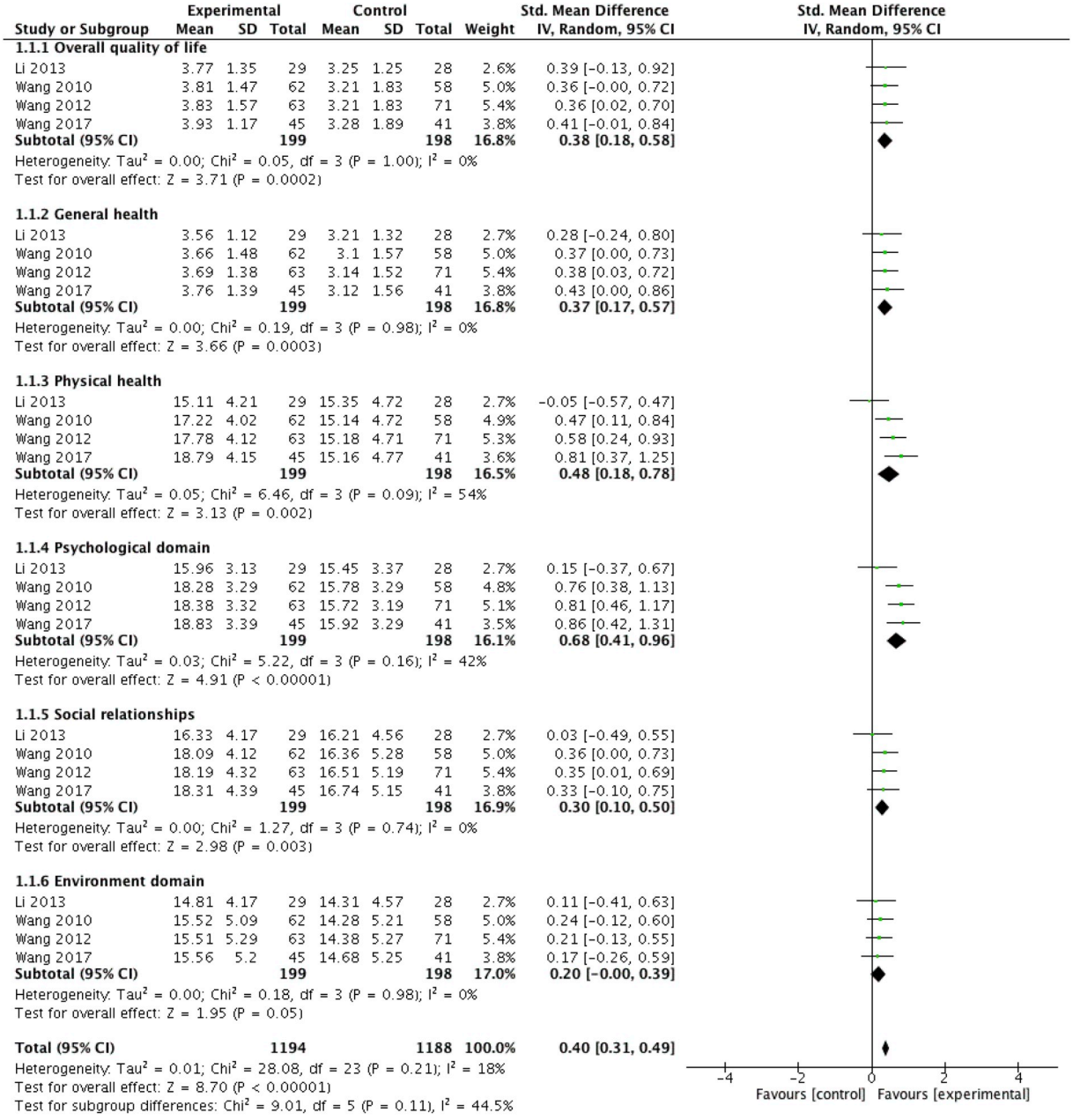

Fig. 7B. QoL at 6 months.

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Authors' contributions

LL: review concept and design, literature search and selection, data extraction and methodological quality assessment, data analysis and interpretation, drafting and revision; HT: literature search and selection, data extraction and methodological quality assessment, data analysis and interpretation, drafting and revision; SY, HY, GDB: revision. All authors read and approved the final manuscript.

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