ORIGINAL RESEARCH

Traditional Chinese Exercise for Cardiovascular Diseases: Systematic Review and Meta-Analysis of Randomized Controlled Trials

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Background—Traditional Chinese exercise (TCE) has widespread use for the prevention and treatment of cardiovascular disease; however, there appears to be no consensus about the benefits of TCE for patients with cardiovascular disease. The objective of this systematic review was to determine the effects of TCE for patients with cardiovascular disease.

Methods and Results—Relevant studies were searched by PubMed, Embase, Web of Science, the Cochrane Library, the Cumulative Index to Nursing and Allied Health Literature, and the China National Knowledge Infrastructure. We covered only published articles with randomized controlled trials. The outcome measures included physiological outcomes, biochemical outcomes, physical function, quality of life, and depression. A total of 35 articles with 2249 cardiovascular disease patients satisfied the inclusion criteria. The pooling revealed that TCE could decrease systolic blood pressure by 9.12 mm Hg (95% CI −16.38 to −1.86, P=0.01) and diastolic blood pressure by 5.12 mm Hg (95% CI −7.71 to −2.52, P<0.001). Patients performing TCE also found benefits compared with those in the control group in terms of triglyceride (standardized mean difference −0.33, 95% CI −0.56 to −0.09, P=0.006), 6-minute walk test (mean difference 59.58 m, 95% CI −153.13 to 269.93, P=0.03), Minnesota Living With Heart Failure Questionnaire results (mean difference −17.08, 95% CI −23.74 to −10.41, P<0.001), 36-Item Short Form physical function scale (mean difference 0.82, 95% CI 0.32–1.33, P=0.001), and Profile of Mood States depression scale (mean difference −3.02, 95% CI −3.50 to −2.53, P<0.001).

Conclusions—This study demonstrated that TCE can effectively improve physiological outcomes, biochemical outcomes, physical function, quality of life, and depression among patients with cardiovascular disease. More high-quality randomized controlled trials on this topic are warranted. **(*J Am Heart Assoc*. 2016;5:e002562 doi: 10.1161/JAHA.115.002562)**

Key Words: cardiovascular disease • exercise • meta-analysis • rehabilitation

Cardiovascular diseases (CVDs) are the leading causes of disability and death in the world and in 2010 were considered the main risk factor for the overall global burden of disease.[1,2] According to the World Health Organization,[3] ≈17.3 million people worldwide died from CVD in 2008, and 80% of CVD-related deaths were recorded in low- and middle-income countries. Among CVDs, heart disorder has reportedly claimed 7.3 million lives, whereas stroke has caused 6.2 million deaths. Low-cost, easily accessible, and symptom-free programs are needed to treat and prevent CVD.

Physical inactivity is estimated to be the fourth main risk factor for global mortality.[4,5] Regular exercise is shown to have significant benefits for the maintenance of blood pressure and blood cholesterol.[6–8] The practice and increasing global popularity of traditional Chinese exercises (TCEs), such as tai chi, qigong, and baduanjin, for >2000 years has substantially benefited human health.[9–13] TCE is a low-risk, promising intervention that can help improve physiological outcomes, biochemical outcomes, physical function, quality of life, and depression among patients with CVD.[14–16]

Although TCEs have been widely performed for the prevention and treatment of CVD,[17,18] no consensus has been reached about the benefits of these exercises for the maintenance of physiological outcomes, biochemical outcomes, physical

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An accompanying Data S1 is available at http://jaha.ahajournals.org/content/5/3/e002562/suppl/DC1

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Received August 20, 2015; accepted December 30, 2015.

function, and quality of life or for the prevention of depression among CVD patients. We are also unaware of any systematic reviews that have assessed the effect of TCEs on physiological outcomes, blood cholesterol, quality of life, and depression among patients with CVD.

The effect of TCEs in CVD patients must be determined based on scientific evidence to conserve time and resources. The objective of this systematic review was to determine the effects of TCEs on physiological outcomes, biochemical outcomes, physical function, quality of life, and depression among CVD patients.

Methods

The protocol for our study is registered in the international prospective register of systematic reviews (PROSPERO registration number CRD42013006474).

Search Strategy

Relevant studies published between January 1957 and January 2015 were obtained from the following electronic data sources: PubMed, Embase, Web of Science, the Cochrane Library, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and the China National Knowledge Infrastructure. No language restrictions were imposed, and the search was limited to randomized controlled trials (RCTs). The full electronic search strategies for all databases are provided in Data S1.

Inclusion Criteria

First, the only studies covered were published RCTs. Second, we included articles that discussed patients with CVD including ischemic heart disease or coronary artery disease (eg, heart attack), cerebrovascular disease (eg, stroke), diseases of the aorta and arteries (eg, hypertension), and peripheral vascular disease. Third, we considered only articles that compared an intervention group, that is, a group performing TCEs (eg, tai chi, qigong, baduanjin) with a control group that performed other exercises (eg, strength exercises), that received usual care, or that did not undergo any intervention. Fourth, outcome measures included physiological outcomes (eg, blood pressure, heart rate, peak oxygen uptake), biochemical outcomes (eg, cholesterol and triglyceride [TG]), physical function (eg, 6-minute walk test, timed up and go test), quality of life (eg, Minnesota Living With Heart Failure Questionnaire [MLHFQ], General Health Questionnaire [GHQ], and 36-Item Short Form [SF-36]), and depression (eg, Hamilton Depression Rating Scale [HAMD], Profile of Mood States [POMS] depression scale).

Selection of Studies

Two authors independently used the same selection criteria to screen the titles, abstracts, and full contents of the relevant articles. A study was removed from the selection if the inclusion criteria were not fulfilled. Any disagreements were resolved by discussion. A third author was consulted if a disagreement persisted.

Data Extraction and Management

The following data were extracted: study characteristics (eg, author and year), participant characteristics (eg, age and number of participants), description of interventions, duration of trial period, types of assessed outcomes, and time points. The 2 authors who selected the studies also extracted the data from the included articles. Any disagreement was resolved by discussion, and a third author was consulted if a disagreement persisted.

Quality Assessment

As recommended,[19] we used the Cochrane Collaboration tool for assessing the risk of bias of the included trials. The following information was evaluated: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessments, incomplete outcome data, selective reporting, and other sources of bias.

The trials were graded as unclear, high, or low risk of bias. The methodological quality of each study was independently assessed by 2 review authors. A third author was consulted if any disagreement occurred.

Statistical Analysis

The Review Manager software (RevMan 5.2; Cochrane Collaboration) was used to conduct the meta-analysis. We used the chi-square test and the I^2 statistic to evaluate heterogeneity among the studies. The outcome measures from the individual studies were combined by meta-analysis using a random-effects model. Given that all variables in the included studies were continuous data, we used the standardized mean difference (SMD) or mean difference (MD) and 95% CI to analyze the studies. The MD was used as a summary statistic in meta-analysis when all studies reported the same outcome using the same scale. The SMD was used as a summary statistic in meta-analysis when all studies assessed the same outcome using different scales (ie, the outcome was measured using different units). We considered $P<0.05$ to be statistically significant. Funnel plot asymmetry was used to assess possible publication bias by the Egger's regression test. Sensitivity analysis was conducted by removing each study individually to evaluate the quality and consistency of the results.

If the continuous data were reported as median and interquartile range, the median would be assumed to be equivalent to the mean, and the relationship of interquartile range and the standard deviation would be roughly computed as SD=IQR/1.35.[20] The standard deviation could be obtained from the standard error of a mean by multiplying by the square root of the sample size: $SD=SE\times\sqrt{N}$.[20] In specific cases, we also estimated the means and standard deviations for the data and reported them graphically rather than in a table. The authors of the selected studies were contacted if the standard deviations were not shown in the paper or could not be derived from their data. If the authors contacted did not reply, their articles were excluded.

Results

Search Results

We identified 68 potentially eligible records from the 2824 records obtained from PubMed, the Cochrane Library, Embase, CINAHL, the China National Knowledge Infrastructure, and Web of Science. After reviewing the full content of the papers, 35 articles[21–55] satisfied the inclusion criteria. The remaining 33 articles were excluded for several reasons (eg, participants did not have CVD, studies were not randomized). The process of identifying the eligible studies is outlined in Figure 1. Table 1 summarizes the characteristics of each included study. The 35 articles covered 2249 patients with CVD (15 articles covered patients with heart disease, 13 articles covered those with hypertension, and 7 articles covered those with cerebrovascular disease). The countries or regions of publication were mainly the People's Republic of China (n=17, 48.57%), the United States (n=5, 14.28%), the United Kingdom (n=3, 8.57%), the Republic of Korea (n=3, 8.57%), Japan (n=2, 5.71%), Hong Kong (n=1, 2.85%), Italy (n=1, 2.85%), Taiwan (n=1, 2.85%), New Zealand (n=1, 2.85%), and Israel (n=1, 2.85%).

Risk of Bias Among the Selected Articles

We assessed the risk of bias in all selected articles (Table 2). All articles used the generation of the allocation sequence (n=35, 100%). Allocation concealment was inadequate in most articles (n=26, 74%). None of the studies blinded their participants or personnel. Eight articles (23%) masked their outcome assessors to the treatment allocation. A low risk of incomplete outcome bias was reported in 31 articles (88.5%), whereas a low risk of selective reporting bias was reported in most articles (n=28, 73.6%).

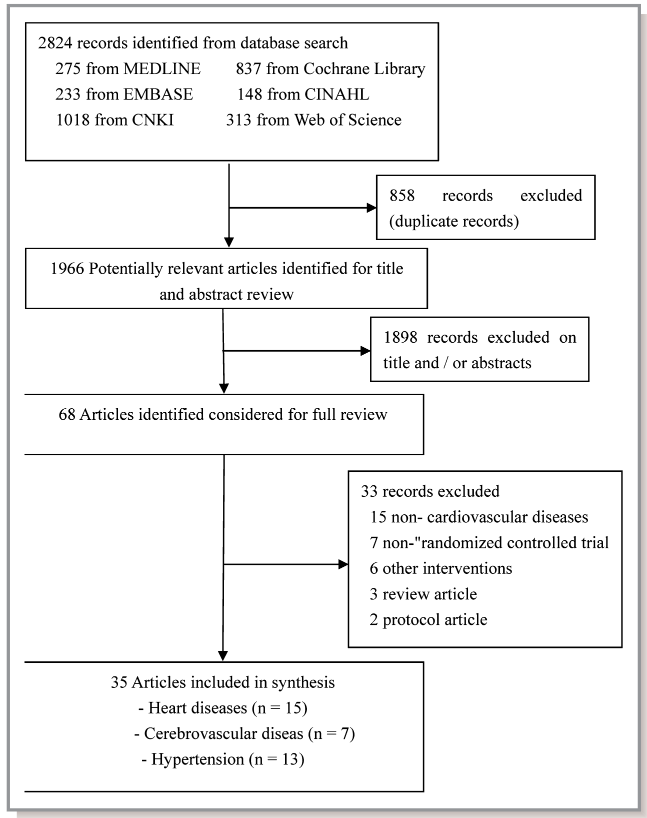

Figure 1. Flow chart of the study selection procedure. CKNI indicates China National Knowledge Infrastructure.

Effects of TCE on Physiological Outcomes

Blood pressure

Sixteen articles* involving 939 patients compared the systolic blood pressures (SBPs) and diastolic blood pressures (DBPs) between patients performing TCEs and those in the control group. Based on a random-effects model, TCE was found to decrease SBP by 9.12 mm Hg (95% CI −16.38 to −1.86, P=0.01; I^2=99%, P<0.00001) and DBP by 5.12 mm Hg (95% CI −7.71 to −2.52, P<0.001; I^2=97%, P<0.00001) among patients performing TCEs compared with those in the control group (Figure 2 and Table 3).

Heart rate

Nine articles** involving 463 patients compared the heart rate between patients performing TCEs and those in the control group. No significant differences were observed between the 2 groups based on a random-effects model (MD −2.39 beats per minute, 95% CI −5.61 to −0.82, P=0.14) (Table 3).

Peak oxygen uptake

Four articles[42,50,52,53] involving 166 patients compared the peak oxygen uptake of patients performing TCEs and those in

*References 21, 24–27, 29, 33–35, 38, 39, 41, 42, 44, 53, 54.
**References 24, 25, 29, 33, 34, 42, 44, 51, 53.

Table 1. Characteristics of Included Studies

Article, Year	Country/ Region	Participant Characteristics, Sample Size	Disease	Intervention	Duration of Trial Period	Outcomes	Time Point
Barrow (2007)[21]	UK	65 participants (G1=32, G2=33). Mean age: G1=68.4 years, G2=67.9 years	Heart failure	G1: Tai chi exercise G2: Standard medical care	Twice a week for 16 weeks	Physiological outcomes (blood pressure), quality of life (MLHFQ), depression (SCL-R depression index)	16 weeks
Blake (2009)[22]	UK	20 participants (G1=10, G2=10). Mean age (SD): G1=46.2 years (11.27), G2=44.5 years (10.52). Mean duration of disease (SD): G1=16.40 years (9.04), G2=14.98 years (13.62)	Brain injury	G1: Tai Chi and qigong exercise G2: No exercise	Once a week for 8 weeks	QOL (GHQ)	8 weeks
Cai (2010)[23]	China	60 participants (G1=30, G2=30). Mean age (SD): G1=60.3 years (10.5), G2=61.3 years (7.4)	Stroke	G1: Baduanjin and health education G2: Health education	4 to 5 times a week for 3 months	QOL (WHOQOL-BREF)	3 months
Caminiti (2011)[24]	Italy	60 participants (G1=30, G2=30). Mean age (SD): G1=73.4 years (2), G2=73.8 years (6). Duration of disease: >3 months	Chronic heart failure	G1: Tai chi exercise plus endurance training G2: Endurance training	4 sessions a week for 8 weeks	Physiological outcomes (blood pressure, heart rate), physical function (6MWT)	12 weeks
Channer (1996)[25]	UK	79 participants (G1=38, G2=41). Age range: 39–80 years	Acute myocardial infarction	G1: Tai chi exercise G2: Aerobic exercise	Twice weekly for 3 weeks then weekly for a further 5 weeks	Physiological outcomes (blood pressure, heart rate)	8 weeks
Chen (2006)[26]	China	40 participants (G1=20, G2=20). Mean age: G1=64.3 years, G2=60.7. Mean duration of disease (SD): G1=8.4 years (4.9), G2=7.8 years (5.4)	Hypertension	G1: Tai chi plus drug G2: Drug	7 times a week for 9 weeks	Physiological outcomes (blood pressure), biochemical outcomes (endothelin)	10 weeks
Chen (2013)[27]	China	68 participants (G1=50, G2=18). Age range: 30–82 years	Hypertension	G1: Conventional treatment and tai chi G2: Conventional treatment	6 times a week for 12 weeks	Physiological outcomes (blood pressure)	12 weeks

Continued

Table 1. Continued

Article, Year	Country/Region	Participant Characteristics, Sample Size	Disease	Intervention	Duration of Trial Period	Outcomes	Time Point
Chen (2013)[28]	China	60 participants (G1=32, G2=28). Mean age (SD): G1=69.3 years (10.6), G2=68.7 years (11.1)	Coronary disease	G1: Conventional treatment and tai chi G2: Conventional treatment	4 times a week for 12 weeks	Biochemical outcomes (TC, TG, LDL-C, HDL-C)	12 weeks
Cheung (2005)[29]	Hong Kong, China	88 participants (G1=47, G2=41). Mean age (SD): G1=57.2 years (9.5), G2=51.2 years (7.4). Mean duration of disease (SD): G1=4.0 years (5.6), G2=3.9 years (5.1)	Hypertension	G1: Qigong exercise G2: conventional exercise	4 hours a week for 16 weeks	Physiological outcomes (blood pressure, heart rate), biochemical outcomes (TC, TG, LDL-C, HDL-C), QOL (SF-36), depression (Beck Depression Inventory)	4 weeks 8 weeks 12 weeks 16 weeks
Ding (2013)[30]	China	90 participants (G1=30, G2=30, G3=30). Mean age (SD): G1=66.2 years (11.6), G2=64.9 years (11.0), G3=66.7 years (13.1)	Percutaneous transluminal coronary intervention	G1: Tai chi exercise G2: Walking G3: No intervention	5 times a week for 6 months	QOL (SF-36)	6 weeks 6 months
Gemmell (2006)[31]	New Zealand	18 participants (G1=9, G2=9)	Braumatic brain injury	G1: TCE (tai chi) G2: No intervention	Once a week for 6 weeks	QOL (SF-36)	6 weeks
Hart (2004)[32]	Israel	152 participants (G1=56, G2=55, G3=41). Mean age (SD): G1=70.8 years (6.3), G2=70 years (6.3), G3=69.6 years (6.1)	Stroke	G1: TCE (tai chi) G2: Hydrotherapy G3: No intervention	Twice a week for 12 weeks	QOL (Duke Health Profile)	6 weeks 12 weeks
Lee (2003)[33]	Korea	58 participants (G1=29, G2=29). Mean age (SD): G1=55.8 years (6.3), G2=57.1 years (7.6)	Hypertension	G1: Qigong exercise G2: No intervention	7 times a week for 10 weeks	Physiological outcomes (blood pressure, heart rate)	10 weeks
Lee (2003)[34]	Korea	58 participants (G1=29, G2=29). Mean age (SD): G1=56.0 years (5.9), G2=56.5 years (7.2)	Hypertension	G1: Qigong exercise G2: No intervention	3 times a week for 10 weeks	Physiological outcomes (blood pressure, heart rate)	10 weeks
Lee (2004)[35]	Korea	36 participants (G1=17, G2=19). Mean age (SD): G1=52.6 years (5.1), G2=54.3 years (5.5)	Hypertension	G1: Qigong exercise G2: No intervention	7 times a week for 8 weeks	Physiological outcomes (blood pressure), biochemical outcomes (TC, TG, HDL-C)	8 weeks

Continued

Table 1. Continued

Article, Year	Country/Region	Participant Characteristics, Sample Size	Disease	Intervention	Duration of Trial Period	Outcomes	Time Point
Li (2012)[36]	China	68 participants (G1=36, G2=32). Age range: 38–76 years	Stroke	G1: Tai chi exercise G2: Strength exercise	Twice weekly for 5 weeks	Depression (HAMD)	5 weeks
Lin (2012)[37]	China	60 participants (G1=30, G2=30). Mean age (SD): G1=66.47 years (8.26) G2=64.90 years (8.87)	Coronary artery bypass grafting	G1: Baduanjin G2: Conventional exercise	4–5 times a week for 23 weeks	QOL	8 weeks 20 weeks
Luo (2006)[38]	China	84 participants (G1=44, G2=40). Mean age (SD): G1=44.74 years (12.1), G2=44.86 years (13.05)	Hypertension	G1: Tai chi plus drug G2: Drug	7 times a week for 6 months	Physiological outcomes (blood pressure)	6 months
Mao (2006)[39]	China	62 participants (G1=51, G2=11). Mean age: G1=62.2 years, G2=63.3	Hypertension	G1: Tai chi exercise G2: Drug	6 times a week for 8 weeks	Physiological outcomes (blood pressure), biochemical outcomes (endothelin, no)	8 weeks
Ning (2010)[40]	China	50 participants (G1=26, G2=24). Mean age (SD): G1=53.9 years (6.4), G2=53.5 years (6.7)	Coronary disease	G1: Tai chi exercise G2: Drug	2 or 3 times a week for 6 months	Biochemical outcomes (TC, TG)	8 weeks
Pan (2009) [41]	China	48 participants (G1=24, G2=24). Mean age (SD): G1=62.1 years (5.8), G2=61.4 years (7.1)	Hypertension	G1: Baduanjin exercise plus drug G2: Drug	5 times a week for 24 weeks	Physiological outcomes (blood pressure), biochemical outcomes (TC, TG, HDL-C)	24 weeks
Sato (2010)[42]	Japan	20 participants (G1=10, G2=10). Mean age (SD): G1=68 years (5), G2=68 years (4). Mean duration of disease (SD): G1=19 months (15), G2=21 months (13)	Coronary disease	G1: Tai chi exercise plus conventional rehabilitation G2: Conventional rehabilitation	4 times a week for 1 year	Physiological outcomes (peak oxygen uptake, blood pressure, heart rate)	1 year
Taylor-Piliae (2012)[43]	USA	28 participants (G1=16, G2=12). Mean age (SD): G1=72.8 years (10.1), G2=64.5 years (10.9). Mean duration of disease (SD): G1=58.3 months (46.7), G2=47.9 months (42.5)	Chronic stroke	G1: Tai chi G2: Usual care	Once a week for 8 weeks	Physical function (Short Physical Performance Battery), QOL (SF-36)	8 weeks

Continued

Table 1. Continued

Article, Year	Country/Region	Participant Characteristics, Sample Size	Disease	Intervention	Duration of Trial Period	Outcomes	Time Point
Tsai (2003)[44]	Taiwan, China	76 participants (G1=37, G2=39). Mean age (SD): G1=50.5 years (7), G2=62.7 years (4)	Hypertension	G1: TCE (tai chi chuan) G2: Sedentary life controls	3 times a week for 12 weeks	Physiological outcomes (blood pressure, heart rate), biochemical outcomes (TC, TG, LDL-C, HDL-C)	12 weeks
Wang (1989)[45]	China	100 participants (G1=50, G2=50). Age range: 45–65	Hypertension	G1: Qigong exercise plus drug G2: Drug	7 times a week for 1 year	Biochemical outcomes (TC, TG, LDL-C, HDL-C)	1 year
Wang (2010)[46]	Japan	34 participants (G1=17, G2=17). Age: >50 years	Cerebral vascular disorder	G1: TCE (tai chi) G2: Rehabilitation exercise	Once a week for 12 weeks	QOL (GHQ), depressing (GHQ)	12 weeks
Wang (2012)[47]	China	69 participants (G1=36, G2=33). Mean age (SD): G1=55.8 years (3.54), G2=51.2 years (7.8)	Stroke	G1: Tai chi exercise G2: Conventional exercise	2 times a week for 3 months	QOL (SF-36) and depression (HAMD)	6 months
Wang (2013)[48]	China	60 participants (G1=30, G2=30). Mean age (SD): G1=55.25 years (11.13), G2=54.86 years (12.05)	Percutaneous transluminal coronary intervention	G1: Conventional treatment and tai chi G2: Conventional treatment	5 times a week for 6 months	QOL (SF-36)	3 months 6 months
Yao (2010)[49]	China	150 participants (G1=80, G2=70). Mean age (SD): G1=52.4 years (6.32), G2=51.7 years (7.26)	Chronic heart failure	G1: Conventional treatment and tai chi G2: Conventional treatment	>5 times a week for 6 months	Physical function (6MWT), quality of life (SF-36)	6 months
Yeh (2004)[50]	USA	30 participants (G1=15, G2=15). Mean age (SD): G1=66 years (12), G2=61 years (14)	Chronic heart failure	G1: Usual care and tai chi exercise G2: Usual care	Twice weekly for 12 weeks	Physiological outcomes (peak oxygen uptake), biochemical outcomes (BNP), physical function (6MWT), QOL (MLHFQ)	12 weeks
Yeh (2008)[51]	USA	18 participants (G1=8, G2=10). Mean age (SD): G1=54.7 years (11.8), G2=64.2 years (16.2)	Chronic heart failure	G1: Tai chi exercise and usual care G2: Usual care	Twice weekly for 12 weeks	Biochemical outcomes (BNP), physical function (6MWT), quality of life (MLHFQ)	12 weeks

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DOI: 10.1161/JAHA.115.002562

Table 1. Continued

Article, Year	Country/Region	Participant Characteristics, Sample Size	Disease	Intervention	Duration of Trial Period	Outcomes	Time Point
Yeh (2011)[52]	USA	100 participants (G1=50, G2=50). Mean age (SD): G1=68.1 years (11.9), G2=66.6 years (12.1)	Chronic heart failure	G1: Usual care and tai chi exercise G2: Usual care and education sessions	Twice weekly for 12 weeks	Physiological outcomes (peak oxygen uptake), biochemical outcomes (BNP), physical function (timed up and go, 6MWT), QOL (MLHFQ), depression (POMS)	12 weeks
Yeh (2013)[53]	USA	16 participants (G1=8, G2=8). Mean age (SD): G1=68 years (11), G2=63 years (11)	Heart failure	G1: Tai chi exercise G2: Aerobic exercise	Twice weekly for 12 weeks	Physiological outcomes (blood pressure, Peak oxygen uptake, heart rate), biochemical outcomes (BNP), physical function (time up and go, 6MWT), quality of life (MLHF), depression (POMS)	12 weeks
Yu (2013)[54]	China	104 participants (G1=52, G2=52). Age range: 40–70 years	Hypertension	G1: Baduanjin exercise plus education G2: Education	3 or 4 times a week for 1 year	Blood pressure	1 year
Zhang (2013)[55]	China	120 participants (G1=60, G2=60). Mean age: G1=73.9 years, G2=76.5 years	Hypertension	G1: Baduanjin exercise plus drug G2: Drug	7 times a week for 2 months	QOL	2 months

6MWT indicates 6-minute walk test; BNP, B-type natriuretic peptide; G, group; GHQ, General Health Questionnaire; HAMD, Hamilton Depression Rating Scale; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; MLHFQ, Minnesota Living With Heart Failure Questionnaire; POMS, Profile of Mood States; QOL, quality of life; SCL-R, Symptom Checklist 90–Revised; SF-36, 36-Item Short Form; TC, total cholesterol; TCE, traditional Chinese exercise; TG, triglyceride; WHOQOL-BREF, World Health Organization Quality of Life project 26-item instrument.

Table 2. Risk of Bias Assessment of Included Studies

Article, Year	Random Sequence Generation	Allocation Concealment	Blinding of Participants and Personnel	Blinding of Outcome Assessment	Incomplete Outcome Data	Selective Reporting	Other Bias
Barrow (2007)[21]	Low	High	High	High	Low	Low	Unclear
Blake (2009)[22]	Low	Low	High	High	Low	Low	Unclear
Cai (2010)[23]	Low	High	High	High	Low	Low	Unclear
Caminiti (2011)[24]	Low	High	High	High	Low	Low	Unclear
Channer (1996)[25]	Low	High	High	High	Low	Low	Unclear
Chen (2006)[26]	Low	High	High	High	Low	Low	Unclear
Chen (2013)[27]	Low	High	High	High	Low	Low	Unclear
Chen (2013)[28]	Low	High	High	High	Low	Low	Unclear
Cheung (2005)[29]	Low	Low	High	Low	Low	Low	Unclear
Ding (2013)[30]	Low	High	High	High	Low	Low	Unclear
Gemmell (2006)[31]	Low	High	High	Low	Low	Low	Unclear
Hart (2004)[32]	Low	High	High	High	Low	Low	Unclear
Lee (2003)[33]	Low	High	High	High	Unclear	Unclear	Unclear
Lee (2003)[34]	Low	Low	High	High	Unclear	Unclear	Unclear
Lee (2004)[35]	Low	High	High	High	Low	Unclear	Unclear
Li (2012)[36]	Low	High	High	High	Low	Low	Unclear
Lin (2012)[37]	Low	High	High	High	Low	Low	Unclear
Luo (2006)[38]	Low	High	High	High	Low	Low	Unclear
Mao (2006)[39]	Low	High	High	High	Low	Low	Unclear
Ning (2010)[40]	Low	High	High	High	Low	Low	Unclear
Pan (2009)[41]	Low	Low	High	High	Low	Low	Unclear
Sato (2010)[42]	Low	High	High	High	Low	Low	Unclear
Taylor-Piliae (2012)[43]	Low	Low	High	Low	Low	Low	Unclear
Tsai (2003)[44]	Low	Low	High	Low	Low	Low	Unclear
Wang (1989)[45]	Low	High	High	High	Low	Low	Unclear
Wang (2010)[46]	Low	High	High	Low	Low	Low	Unclear
Wang (2012)[47]	Low	High	High	High	Unclear	Low	Unclear
Wang (2013)[48]	Low	High	High	High	Low	Low	Unclear
Yao (2010)[49]	Low	High	High	High	Low	Low	Unclear
Yeh (2004)[50]	Low	Low	High	Low	Low	Unclear	Unclear
Yeh (2008)[51]	Low	High	High	High	Unclear	Unclear	Unclear
Yeh (2011)[52]	Low	Low	High	Low	Low	Unclear	Unclear
Yeh (2013)[53]	Low	Low	High	Low	Low	Unclear	Unclear
Yu (2013)[54]	Low	High	High	High	Low	Low	Unclear
Zhang (2013)[55]	Low	High	High	High	Low	Low	Unclear

the control group. The peak oxygen uptake of patients performing TCEs did not increase significantly compared with that of the patients in the control group, based on a random-effects model (SMD 0.04, 95% CI −0.46 to 0.55, P=0.87) (Table 3).

Sensitivity analysis revealed that the pooled results of SBP, DBP, and peak oxygen uptake did not change statistical significance of the overall analysis when studies were removed 1 by 1. When 1 study[24] was removed, however, the result of heart rate was significant in the sensitivity analysis; it offered

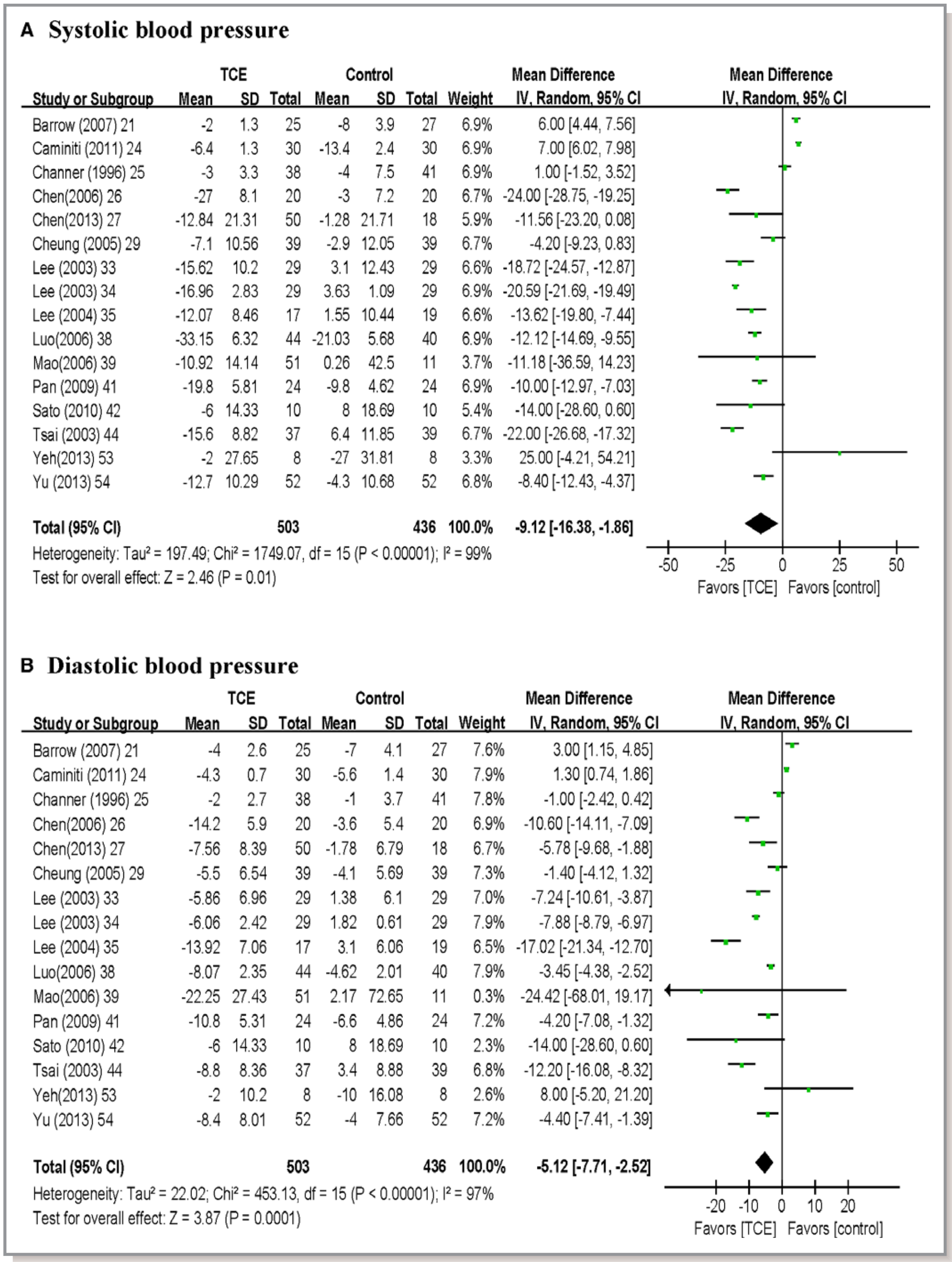


Figure 2. Meta-analysis of effects of traditional Chinese exercise on blood pressure: (A) systolic blood pressure, (B) diastolic blood pressure. IV, inverse variance; Std., standardized; TCE, traditional Chinese exercise.

inferior evidence for the effect of TCE on heart rate. The sensitivity analysis did not affect heterogeneity of blood pressure, heart rate, or peak oxygen uptake outcomes.

Effects of TCE on Biochemical Outcomes

Triglyceride

Six articles[28,29,35,41,44,45] involving 408 patients compared the TG levels of patients performing TCEs and those in the control group. Based on a random-effects model, the TG levels of patients performing TCEs significantly decreased (SMD -0.33, 95% CI -0.56 to -0.09, P=0.006; I^2=28%, P=0.23) compared with those of the patients in the control group (Figure 3A and Table 3).

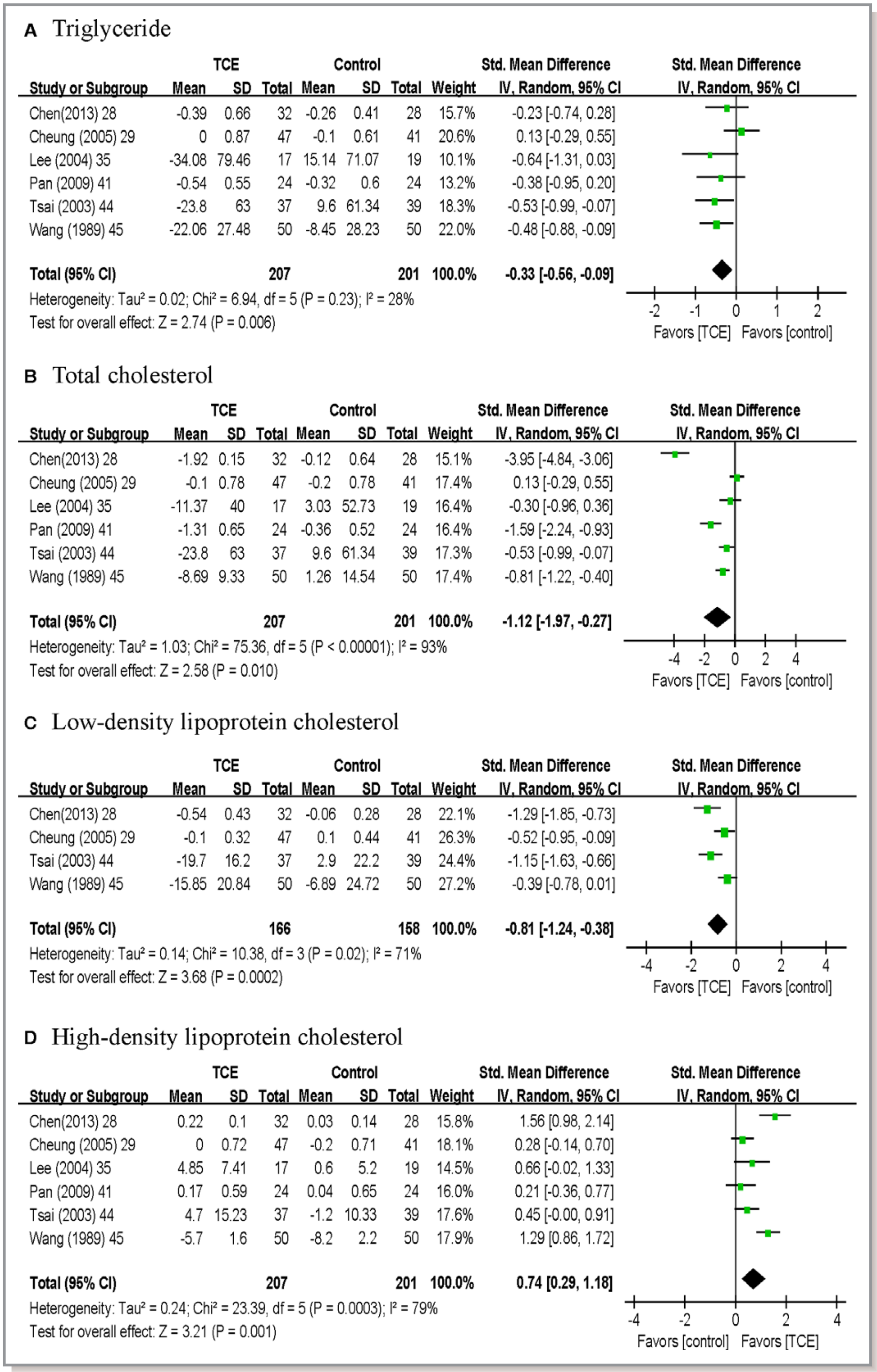
Total cholesterol

Six articles[28,29,35,41,44,45] involving 408 patients were included to estimate the effect of TCEs on the amount of

Table 3. Summary of Results

Outcome	Trials	Participants	Statistical Method	Effect Estimate	Heterogeneity	*P* Value
Physiological outcomes						
SBP, mm Hg	16[21,24,25,26,27,29,33,34,35,38,39,41,42,44,53,54]	939	MD (IV, random, 95% CI)	−9.12 [−16.38 to −1.86]	<0.001	0.01
DBP, mm Hg	16[21,24–27,29,33–35,38,39,41,42,44,53,54]	939	MD (IV, random, 95% CI)	−5.12 [−7.71 to −2.52]	<0.001	<0.001
Heart rate, beats per minute	9[24,25,29,33,34,42,44,51,53]	463	MD (IV, random, 95% CI)	−2.39 [−5.61 to 0.82]	<0.001	0.14
Peak oxygen uptake, L/min	4[42,50,52,53]	166	SMD (IV, random, 95% CI)	0.04 [−0.46 to 0.55]	0.11	0.87
Biochemical outcomes						
TG	6[28,29,35,41,44,45]	408	SMD (IV, random, 95% CI)	−0.33 [−0.56 to −0.09]	0.23	0.006
TC	6[28,29,35,41,44,45]	408	SMD (IV, random, 95% CI)	−1.12 [−1.97 to −0.27]	<0.001	0.01
LDL-C	4[28,29,44,45]	324	SMD (IV, random, 95% CI)	−0.81 [−1.24 to −0.38]	0.02	<0.001
HDL-C	6[28,29,35,41,44,45]	408	SMD (IV, random, 95% CI)	0.74 [0.29–1.18]	<0.001	0.001
BNP, ng/mL	3[50,52,53]	146	MD (IV, random, 95% CI)	−23.04 [−27.10 to −18.98]	0.73	<0.001
Physical function						
Timed up and go test, s	2[52,53]	116	MD (IV, random, 95% CI)	−0.20 [−0.64 to 0.24]	0.77	0.38
6-minute walk test, m	6[24,49–53]	374	MD (IV, random, 95% CI)	59.58 [4.95–114.20]	<0.001	0.03
Quality of life						
MLHFQ	5[21,50–53]	216	MD (IV, random, 95% CI)	−17.08 [−23.74 to −10.41]	0.02	<0.001
GHQ	2[22,46]	49	MD (IV, random, 95% CI)	−1.02 [−2.91 to 0.87]	0.19	0.29
SF-36, total	2[30,49]	148	MD (IV, random, 95% CI)	−5.95 [−16.16 to 4.27]	0.02	0.25
SF-36, general health	3[29,31,49]	126	MD (IV, random, 95% CI)	−1.56 [−2.52 to −0.61]	0.4	0.001
SF-36, physical function	3[29,31,43]	131	MD (IV, random, 95% CI)	0.82 [0.32–1.33]	0.45	0.001
SF-36, mental health	3[29,31,43]	131	MD (IV, random, 95% CI)	−2.67 [−10.08 to 4.75]	0.09	0.48
Depression						
HAMD	2[36,47]	129	MD (IV, random, 95% CI)	−3.97 [−5.05 to −2.89]	0.91	<0.001
POMS depression scale	2[52,53]	116	MD (IV, random, 95% CI)	−3.02 [−3.50 to −2.53]	0.76	<0.001

BNP indicates B-type natriuretic peptide; DBP, diastolic blood pressure; GHQ, General Health Questionnaire; HAMD, Hamilton Depression Rating Scale; HDL-C, high-density lipoprotein cholesterol; IV, inverse variance; LDL-C, low-density lipoprotein cholesterol; MD, mean difference; MLHFQ, Minnesota Living With Heart Failure Questionnaire; POMS, Profile of Mood States; SBP, systolic blood pressure; SF-36, 36-Item Short Form; SMD, standardized mean difference; TC, total cholesterol; TG, triglyceride.



A Triglyceride

Study or Subgroup	TCE Mean	TCE SD	TCE Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Chen(2013) 28	-0.39	0.66	32	-0.26	0.41	28	15.7%	-0.23 [-0.74, 0.28]
Cheung (2005) 29	0	0.87	47	-0.1	0.61	41	20.6%	0.13 [-0.29, 0.55]
Lee (2004) 35	-34.08	79.46	17	15.14	71.07	19	10.1%	-0.64 [-1.31, 0.03]
Pan (2009) 41	-0.54	0.55	24	-0.32	0.6	24	13.2%	-0.38 [-0.95, 0.20]
Tsai (2003) 44	-23.8	63	37	9.6	61.34	39	18.3%	-0.53 [-0.99, -0.07]
Wang (1989) 45	-22.06	27.48	50	-8.45	28.23	50	22.0%	-0.48 [-0.88, -0.09]
Total (95% CI)			**207**			**201**	**100.0%**	**-0.33 [-0.56, -0.09]**

Heterogeneity: Tau² = 0.02; Chi² = 6.94, df = 5 (P = 0.23); I² = 28%
Test for overall effect: Z = 2.74 (P = 0.006)

B Total cholesterol

Study or Subgroup	TCE Mean	TCE SD	TCE Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Chen(2013) 28	-1.92	0.15	32	-0.12	0.64	28	15.1%	-3.95 [-4.84, -3.06]
Cheung (2005) 29	-0.1	0.78	47	-0.2	0.78	41	17.4%	0.13 [-0.29, 0.55]
Lee (2004) 35	-11.37	40	17	3.03	52.73	19	16.4%	-0.30 [-0.96, 0.36]
Pan (2009) 41	-1.31	0.65	24	-0.36	0.52	24	16.4%	-1.59 [-2.24, -0.93]
Tsai (2003) 44	-23.8	63	37	9.6	61.34	39	17.3%	-0.53 [-0.99, -0.07]
Wang (1989) 45	-8.69	9.33	50	1.26	14.54	50	17.4%	-0.81 [-1.22, -0.40]
Total (95% CI)			**207**			**201**	**100.0%**	**-1.12 [-1.97, -0.27]**

Heterogeneity: Tau² = 1.03; Chi² = 75.36, df = 5 (P < 0.00001); I² = 93%
Test for overall effect: Z = 2.58 (P = 0.010)

C Low-density lipoprotein cholesterol

Study or Subgroup	TCE Mean	TCE SD	TCE Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Chen(2013) 28	-0.54	0.43	32	-0.06	0.28	28	22.1%	-1.29 [-1.85, -0.73]
Cheung (2005) 29	-0.1	0.32	47	0.1	0.44	41	26.3%	-0.52 [-0.95, -0.09]
Tsai (2003) 44	-19.7	16.2	37	2.9	22.2	39	24.4%	-1.15 [-1.63, -0.66]
Wang (1989) 45	-15.85	20.84	50	-6.89	24.72	50	27.2%	-0.39 [-0.78, 0.01]
Total (95% CI)			**166**			**158**	**100.0%**	**-0.81 [-1.24, -0.38]**

Heterogeneity: Tau² = 0.14; Chi² = 10.38, df = 3 (P = 0.02); I² = 71%
Test for overall effect: Z = 3.68 (P = 0.0002)

D High-density lipoprotein cholesterol

Study or Subgroup	TCE Mean	TCE SD	TCE Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Chen(2013) 28	0.22	0.1	32	0.03	0.14	28	15.8%	1.56 [0.98, 2.14]
Cheung (2005) 29	0	0.72	47	-0.2	0.71	41	18.1%	0.28 [-0.14, 0.70]
Lee (2004) 35	4.85	7.41	17	0.6	5.2	19	14.5%	0.66 [-0.02, 1.33]
Pan (2009) 41	0.17	0.59	24	0.04	0.65	24	16.0%	0.21 [-0.36, 0.77]
Tsai (2003) 44	4.7	15.23	37	-1.2	10.33	39	17.6%	0.45 [-0.00, 0.91]
Wang (1989) 45	-5.7	1.6	50	-8.2	2.2	50	17.9%	1.29 [0.86, 1.72]
Total (95% CI)			**207**			**201**	**100.0%**	**0.74 [0.29, 1.18]**

Heterogeneity: Tau² = 0.24; Chi² = 23.39, df = 5 (P = 0.0003); I² = 79%
Test for overall effect: Z = 3.21 (P = 0.001)

Figure 3. Meta-analysis of effects of traditional Chinese exercise on biochemical outcomes: (A) triglyceride, (B) total cholesterol, (C) low-density lipoprotein cholesterol, (D) high-density lipoprotein cholesterol. IV, inverse variance; TCE, traditional Chinese exercise.

total cholesterol (TC). TC of the patients performing TCEs significantly improved (SMD −1.12, 95% CI −1.97 to −0.27, P=0.01; I^2=93%, P<0.00001) compared with that of the patients in the control group based on a random-effects model (Figure 3B and Table 3).

Low-density lipoprotein cholesterol

Four articles[28,29,44,45] involving 324 patients compared the low-density lipoprotein cholesterol (LDL-C) levels between patients performing TCEs and those in the control group. In a random-effects model, the LDL-C of patients performing TCEs significantly decreased (SMD −0.81, 95% CI −1.24 to −0.38, P<0.001; I^2=71%, P=0.02) compared with that of the patients in the control group (Figure 3C and Table 3).

High-density lipoprotein cholesterol

Six articles[28,29,35,41,44,45] involving 408 patients were included in the meta-analysis to assess the effect of TCE on HDL-C. The HDL-C of patients performing TCEs significantly improved (SMD 0.74, 95% CI 0.29–1.18, P=0.001; I^2=79%, P=0.0003) compared with that of the patients in the control group based on a random-effects model (Figure 3D and Table 3).

B-type natriuretic peptide

Three articles[50,52,53] involving 146 patients compared the B-type natriuretic peptide (BNP) of patients performing TCEs and those in the control group. Based on a random-effects model, the BNP of the patients performing TCEs significantly improved (MD −23.04 ng/mL, 95% CI −27.10 to −18.98, P<0.001) compared with that of the patients in the control group (Table 3).

Sensitivity analysis revealed that TG, TC, LDL-C, and HDL-C outcomes were stable when studies were removed 1 by 1. The significance of the BNP outcome was changed in the sensitivity analysis when 1 study[52] was removed; this result offered inferior evidence for the effect of TCE on BNP. The sensitivity analysis did not affect heterogeneity of TG, TC, LDL-C, HDL-C and BNP outcomes.

Effects of TCE on Physical Function

Timed up and go test

Two articles[52,53] involving 116 patients compared the timed up and go tests of patients performing TCEs and those in the control group. No significant difference was found between the 2 groups (MD −0.2 second, 95% CI −0.64 to 0.24, P=0.38) (Table 3).

Six-minute walk test

Six articles[24,49–53] involving 374 patients were used to estimate the effect of TCE on 6-minute walk test. The 6-minute walk tests of patients performing TCEs improved by 59.58 m (95% CI 4.95–114.20, P=0.03; I^2=93%, P<0.00001) compared with that of the control group, based on a random-effects model (Figure 4A and Table 3). Sensitivity analysis revealed that the 6-minute walk test outcome was not stable when studies were removed 1 by 1. The sensitivity analysis did not affect heterogeneity of the timed up and go or 6-minute walk test outcomes.

Effects of TCE on Quality of Life

Minnesota Living With Heart Failure Questionnaire

Five articles[21,50–53] involving 216 patients were included to assess the effect of TCE on MLHFQ. The MLHFQ scores of patients performing TCEs significantly improved (MD −17.08, 95% CI −23.74 to −10.41, P<0.001; I^2=67%, P=0.02) compared with that of the patients in the control group, based on a random effects model (Figure 4B and Table 3).

General Health Questionnaire

Two articles[22,46] involving 49 patients compared the GHQ scores of patients performing TCEs and those in the control group. No significant differences were found between these groups based on a random-effects model (MD −1.02, 95% CI −2.91 to 0.87, P=0.29; I^2=43%, P=0.29) (Table 3).

36-Item Short Form

Five articles[29–31,43,46,49] involving 374 patients were used to estimate the effect of TCE on SF-36. Compared with the patients in the control group, those performing TCEs showed improved SF-36 general health results (MD −1.56, 95% CI −2.52 to −0.61, P=0.001; I^2=0%, P=0.4) and SF-36 physical function (MD 0.82, 95% CI 0.32–1.33, P=0.001; I^2=0%, P=0.45). No significant differences were found between the 2 groups in terms of SF-36 total score (MD −5.95, 95% CI −16.16 to 4.27, P=0.25; I^2=82%, P=0.02) and SF-36 mental health results (MD −2.67, 95% CI −10.08 to 4.75, P=0.29; I^2=43%, P=0.09) (Table 3).

Sensitivity analysis revealed that MLHFQ outcome was stable when studies were removed 1 by 1. The significance of SF-36 outcome was changed in the sensitivity analysis when 1 study was removed;[31] this result offered inferior evidence for the effect of TCE on SF-36. The sensitivity analysis did not affect heterogeneity of SF-36 outcome, but sensitivity analysis affected heterogeneity of MLHFQ outcome.

Effects of TCE on Depression

Hamilton Depression Rating Scale

Two articles[36,47] involving129 patients compared HAMD scores for patients performing TCEs and those in the control

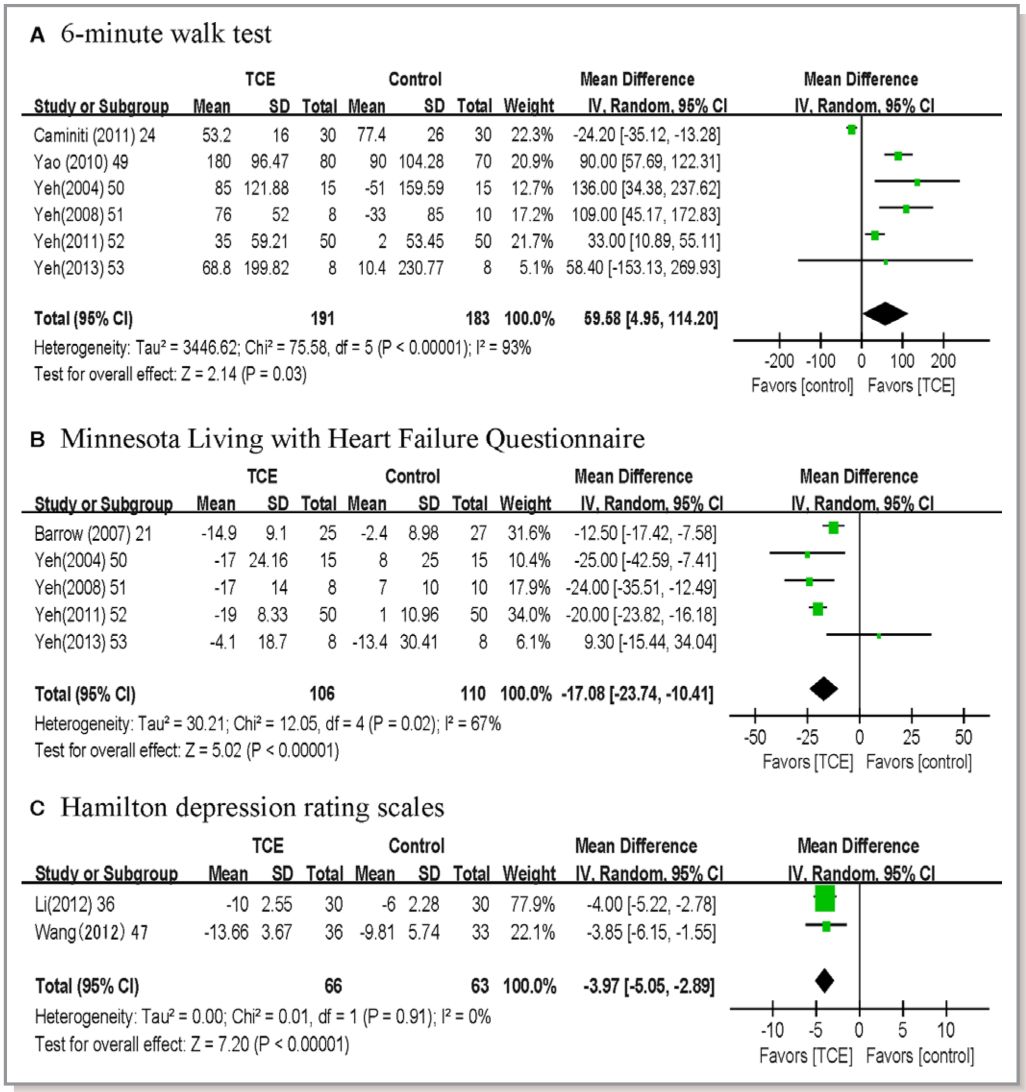


Figure 4. Meta-analysis of effects of traditional Chinese exercise on (A) 6-minute walk test, (B) Minnesota Living with Heart Failure Questionnaire, and (C) Hamilton depression rating scales. IV, inverse variance; TCE, traditional Chinese exercise.

group. The HAMD scores of patients performing TCEs improved (MD −3.97, 95% CI −5.05 to −2.89, P<0.001; I^2=0, P=0.91) compared with those of patients in the control group, based on a random-effects model (Figure 4C and Table 3).

POMS Depression Scale

Two articles[52,53] involving 116 patients were included to assess the effect of TCE on the POMS depression scale. The POMS depression scale scores of the patients performing TCEs significantly improved (MD −3.02, 95% CI −3.50 to −2.53, P<0.001; I^2=0%, P=0.76) compared with those of patients in the control group, based on a random-effects model (Table 3).

Publication Bias

The Egger's regression test results did not show any publication bias for SBP (asymmetry test P=0.46), DBP (asymmetry test P=0.192), heart rate (asymmetry test P=0.406), TG (asymmetry test P=0.503), TC (asymmetry test P=0.08), HDL-C (asymmetry test P=0.814), 6-minute walk test (asymmetry test P=0.871), and MLHFQ (asymmetry test P=0.304).

Discussion

TCEs are mind–body exercises that focus on posture, coordination of breathing patterns, and meditation. Several

TCEs are used to treat patients with CVDs. Previous systematic reviews focused on specific TCEs, such as tai chi and qigong.[18,56–58] This systematic review compiled evidence from a large number of trials assessing the effectiveness of TCEs to evaluate the overall effect of TCEs on patients with CVD compared with other exercises or of the absence of any intervention.

This systematic review and meta-analysis included 35 RCTs involving 2249 patients with CVD to provide further evidence of the effect of TCEs on physiological outcomes, biochemical outcomes, quality of life, and depression in CVD patients. The SBP, DBP, TG, TC, LDL-C, HDL-C, BNP, 6-minute walk test, MLHFQ, SF-36 (general health and physical function), HAMD, and POMS depression scale of patients performing TCEs significantly improved compared with those of the patients in the control group. The benefits of TCEs for SBP, DBP, TG, TC, LDL-C, HDL-C, MLHFQ, and depression of CVD patients reached certain levels that could signify clinical importance. In particular, the effects TCE on blood pressure and blood lipids are clinically significant because blood pressure and LDL-C are the primary targets for cardiovascular risk reduction.

A meta-analysis[59] showed that by reducing the SBP and DBP by 10 and 5 mm Hg, respectively, TCE could reduce the occurrences of stroke and coronary heart disease by 41% and 22%, respectively. Another systematic review revealed that the morbidity and mortality of CVDs could be reduced by up to 50% if blood cholesterol was reduced by ≈20%, SBP by 10 to 15 mm Hg, and DBP by 5 to 8 mm Hg.[60] Based on current evidence from systematic reviews, TCE could improve the quality of life and reduce the depression of CVD patients; however, no significant differences were found between patients performing TCEs and those in the control group in terms of heart rate, peak oxygen uptake, timed up and go test, and 12-item GHQ.

Although the intensity of TCE ranged from low to moderate, we found that TCE could improve physiological outcomes (eg, blood pressure), biochemical outcomes (eg, cholesterol and TG), quality of life (eg, MLHFQ), and depression of patients with CVDs. TCE has a complex mechanism for treating CVD. TCE is based on the theoretical principles of traditional Chinese medicine. The integrated exercise of mind and body, which includes stillness of mind, flow of breath, movement of body, and self-correction of posture, activates the natural self-regulatory (self-healing) ability and evokes a balanced release of endogenous neurohormones and a wide array of natural health recoverymechanisms.[61] Nevertheless, the contribution of TCEs in improving the health of patients with CVD requires further investigation.

The pooled estimate of effect for the outcome (Figure 2) has significant heterogeneity. There may be important clinical and methodological differences among studies that influence the differences between intervention and controls. Some differences existed in inclusion criteria and among the participants, who came from different countries and may have different understandings of TCE. Different types of TCE include not only include tai chi but also baduanjin, yijinjing, and other forms. Even tai chi has a lot of branches.

Strengths and Limitations

This paper is the first systematic review and meta-analysis to assess and compare the effects of TCE with other exercises or with no intervention regarding physiological outcomes (eg, blood pressure), biochemical outcomes (eg, cholesterol and TG), quality of life, and depression among patients with CVD. Unlike prior systematic reviews, more than a quarter of the included studies were published within the past 2 years.

This systematic review searched a wide variety of electronic databases for relevant articles. We searched primarily for articles in the Chinese electronic database because TCEs originated in China. Two reviewers independently selected the studies, extracted the data, and evaluated the quality of the studies to decrease bias and transcription errors. Consequently, the results of our systematic review are considered robust.

Our meta-analysis had several limitations. First, although all included studies were RCTs, only a few (9 of 35) clearly indicated allocation concealment in their experimental procedures; therefore, selection bias or confounding may be present. Moreover, only 8 of the included studies blinded their assessors. Second, only 2 or 3 of the included studies assessed the effect of TCE on BNP, timed up and go test, GHQ-12, SF-36, HAMD, and POMS. More quality RCTs are needed to have confidence in the results in the future. Third, although 6 electronic databases were searched systematically for relevant articles by using a prespecified search strategy and because publication bias was assessed by Egger's regression test, we did not search for any unpublished trials. Consequently, the probability of publication bias may also exist in our study. Fourth, the follow-up durations of most studies were no longer than 1 year; therefore, we did not perform the meta-analysis to assess the long-term effect of TCE for CVD patients. Although each included study was an RCT, most of these studies did not adhere to the generally accepted standards in reporting clinical trials (eg, the Consolidated Standards of Reporting Trials statement).[62] The methodological standards of future studies must be improved in terms of allocation concealment, blinding of outcome assessment, adequate follow-up, and intention-to-treat analysis. Fifth, TCE includes different types of exercise, and it is necessary to have detailed subgroups for different types of TCE and different types of controls in the future.

Conclusions

This study showed that TCE could provide more benefits than other exercises or no intervention for decreasing SBP and DBP and improving biochemical outcomes, physical function, quality of life, and depression in patients with CVD. The results may improve some CVD risk factors; therefore, the clinical implications of our systematic review results showed that TCE should be useful for patients with CVD, medical staff, and health care decision makers. Nevertheless, extreme heterogeneity in the analyses remained unexplained, and the number of high-quality studies was not large in the systematic review. More multicenter RCTs with large sample sizes must be conducted to assess the effects of TCEs in CVD patients. The long-term effectiveness of TCEs for patients with CVD must also be evaluated. Theories about how TCE could treat patients with CVDs and prevent such diseases should be further clarified.

Author Contributions

All authors read and approved the final manuscript. Conceived and designed the experiments: P.-J. Chen, X.Q. Wang and Y.L. Pi. Extracted the information from the eligible studies: Y. Liu, R. Wang, X. Li. Analyzed the data: B.L. Chen, Y. Zhu, X.Q. Wang. Contributed reagents/materials/analysis tools: Y.J. Yang, Z.B. Niu. Wrote the paper: X.Q. Wang, P.J. Chen.

Sources of Funding

This study was supported by the Shanghai Key Lab of Human Performance (Shanghai University of Sport) (No. 11DZ2261100); National Natural Science Foundation of China (81501956); Innovation Program of Shanghai Municipal Education Commission (15ZZ084); Shanghai Committee of Science and Technology (14490503800); Shanghai Youth Science and Technology Sail Project (15YF1411400), the Key Disciplines Group Construction Project of Pudong Health Bureau of Shanghai (grant no. PWZxkq2011-02).

Disclosures

None.

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