


# Tai Chi Program to Improve Glucose Control and Quality of Life for the Elderly With Type 2 Diabetes: A Meta-analysis

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## Abstract

**Objective:** To systematically evaluate the effects of Tai chi for improving elderly patients with type 2 diabetes.

**Methods:** According to PRISMA checklist, we conducted this standard meta-analysis. The multiple databases like Pubmed, Embase, and Cochrane databases were used to search for the relevant studies, and full-text articles involved in the evaluation of Tai chi in improving elderly patients with type 2 diabetes. Review manager 5.2 was adopted to estimate the effects of the results among selected articles. Forest plots, sensitivity analysis and funnel plot for the articles included were also conducted.

**Results:** Finally, 7 relevant studies were eventually satisfied the included criteria. We found that Tai chi group had lower glucose than control group (mean difference (MD)=-12.47, 95%CI [-21.20, -3.73],  $P=.005$ ;  $I^2 = 32\%$ ), Tai chi group had higher activities-specific balance confidence (ABC) scale than control group (MD =9.26 with 95%CI [6.68, 11.83],  $P < .001$ ) and Tai chi group had higher single limb standing test score than control group (MD = 8.38, 95%CI [4.02, 12.74],  $P = .001$ ). The study was robust and limited publication bias was observed in this study.

**Conclusion:** Since we found Tai chi had better performance than usual care in improving old diabetes patients' glucose and life quality, the study supports that Tai chi can help old diabetes patients from several aspects including disease indicators, independence and life quality.

## Keywords

Tai chi, type 2 diabetes mellitus, the elderly, meta-analysis

### 1. What do we already know about this topic?

Tai Chi program can enhance the physical strength of patients, increase the body resistance, relax the spirit of patients, and eliminate the tension of cerebral cortex.

### 2. How does your research contribute to the field?

Our research systematically evaluates the effects of Tai chi for improving elderly patients with type 2 diabetes.

### 3. What are your research's implications towards theory, practice, or policy?

Since we find Tai chi had better performance than usual care in improving old diabetes patients' glucose and life quality, the study supports that Tai chi can help old diabetes patients from several aspects including disease indicators, independence, and life quality.

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## Introduction

Reducing the incidence rate and mortality rate of diabetic patients and improving their quality of life are important public health goals. Scientists studying the diabetes prevention program have found that people can reduce the incidence of diabetes and its complications by losing weight (5%–7% of body weight), eating a healthy diet (low fat, low calorie) and increasing physical activity<sup>1-3</sup>. Among the self-care behaviors that affect blood glucose control and diabetes complication prevention, regular exercise is one of the most problematic and underutilized therapies in diabetes management.<sup>4-6</sup> Tai chi is a form of traditional Chinese martial arts, which is being practiced as a physical and mental health exercise. Research shows that Tai chi is related to good changes of blood lipid, lowering blood pressure, and improving aerobic endurance.<sup>7-9</sup> Diabetes hurts nerve conduction in the central and peripheral nervous system, resulting in postural instability by altering peripheral nerve function.<sup>10</sup> Other consequences of diabetic peripheral neuropathy include reduced balance, strength, and gait parameters, which may be an intermediary factor leading to a high risk of falls in patients with diabetic peripheral neuropathy.<sup>11</sup> Due to the inability to produce appropriate neuromuscular responses, patients with diabetic peripheral neuropathy showed increased swinging amplitude and swing area. The reduction of balance may also lead to a decrease in physical, emotional, and social functions and ultimately harm the quality of life.<sup>12</sup>

Tai chi uses slow movements, breathing exercises, and meditation. This kind of training is low impact. In this kind of training, diaphragmatic breathing is coordinated with graceful movements to achieve spiritual tranquility.<sup>13-17</sup> Tai chi is practiced in a squatting position. Exercise intensity can be easily adjusted by controlling the angle of the knee joint (elderly subjects will use the high squat position, while healthy young subjects will use the low squat position). The classic Yang's Tai chi has 108 postures and some repetitive sequences.<sup>18-20</sup> Each training includes about 20 minutes of warm-up, 24 minutes of Tai chi and 10 minutes of calmness. The slow and gentle movements of Tai chi use all the main muscle groups and joints of the body, increase the strength of the muscles and joints, and improve balance, flexibility, endurance, range of motion, and coordination.<sup>21-23</sup>

In patients with diabetes, ankle varus and valgus, anteroposterior, and medial lateral plane of the body movement also decreased. All of these physical indicators not only proved the increased instability of this group, but also found that diabetic patients had lower safety when standing and walking compared with healthy people.<sup>24-26</sup> Although a large number of studies have been done to determine how and when these complications manifest in patients, few interventions have been made to restore some or all of the functions that have been lost.<sup>27-29</sup> One study looked at how fingertip touch improves postural instability in patients with

diabetes and peripheral neuropathy, but this intervention does not improve sensation or function; it uses an alternative input (finger touch) to increase the information being processed to achieve balance.<sup>30-32</sup> Therefore, it may be necessary to improve the posture stability and sensory ability of patients with diabetes. Tai Chi Program can enhance the physical strength of patients, increase the body resistance, relax the spirit of patients, and eliminate the tension of cerebral cortex.

In recent years, the effects of Tai chi have been noted, but the detailed role of Tai chi in improving elderly patients with type 2 diabetes has not been fully understood. Here, we conduct a meta-analysis to confirm the effects of Tai chi in old diabetes patients' glucose and life quality.

## Methods

In the whole process, we used PRISMA checklist to conduct the research and the details of the PRISMA checklist were shown in supplement [Table 1](#).

## Search Strategy

We started systematic search from databases: PubMed, Embase, Cochrane library, and China National Knowledge Infrastructure (CNKI) from available papers in literature up to Jan 2021 for potentially eligible studies. For the search, we used the Mesh term of “tai chi” and “diabetes mellitus” and their relevant key words. The reference lists from retrieved studies were reviewed to identify any new eligible study. The searching details was shown in [Figure 1](#) following PRISMA checklist.

## Study Selection

The inclusion criteria were as follows:

- (1) Population: elder patients (more than 55 years old) with diabetes mellitus type 2.
- (2) Intervention: Tai chi.
- (3) Control: Usual care.
- (4) Outcome: glucose (mg/dL), activities-specific balance confidence scale and Single limb standing test.
- (5) Study: RCTs
- (6) No language limitations.

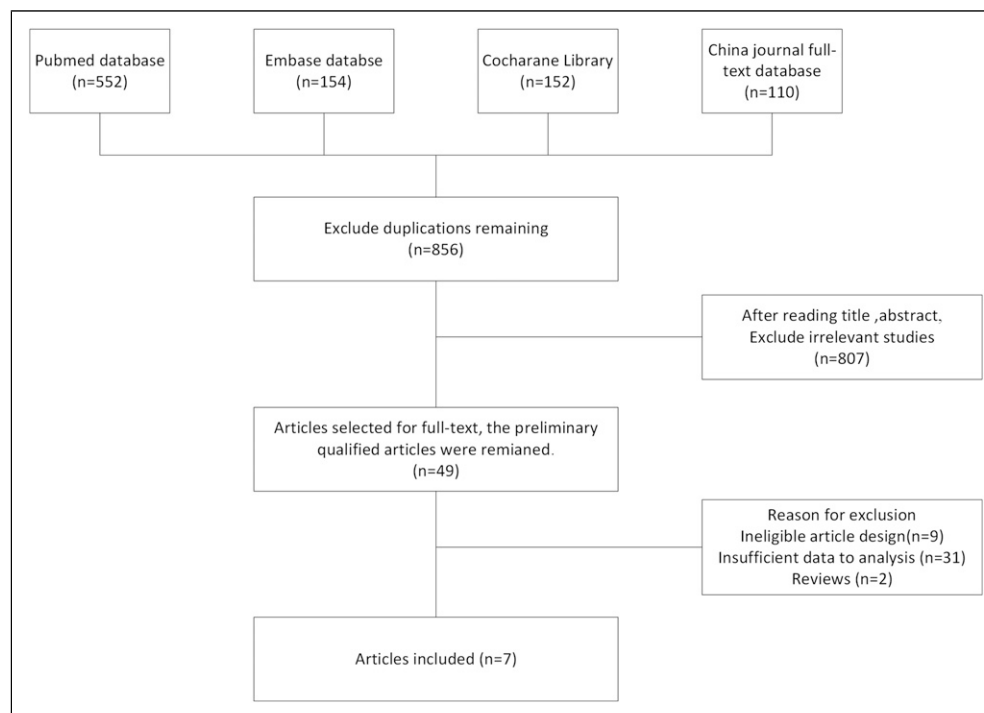
The exclusion was as follows:

- (1) Patients without diabetes mellitus type 2 or not elderly patients.
- (2) Data in research is limited or insufficient.
- (3) They were duplicates.

Combining the keywords searching and inclusion/exclusion criteria, we conduct the literature searching in 4

**Table 1.** Characteristics of studies included in the meta-analysis.

Study	Year	Language	Country	No.of Patients (Female/Male)	Age Range (Mean)	Groups	n	Years of Onset
Ahn <sup>1</sup>	2011	English	Korea	19/20	65±12.5	Tai chi Control	20 19	June 2003 to March 2008
Alsubiheen <sup>2</sup>	2020	English	Korea	16/8	63.8±8.1	Tai chi Control	12 12	September 2012 to May 2017
Alsubiheen <sup>3</sup>	2015	English	USA	16/8	63.8±8.1	Tai chi Control	12 12	April 2010 to June 2013
Chang <sup>10</sup>	2013	English	Taiwan	33/41	58.1±9.3	Tai chi Control	37 37	May 2003 to June 2008
Hung <sup>17</sup>	2009	English	Taiwan	20/36	58.1±13.4	Tai chi Control	28 28	August 2001 to February 2007
Richerson <sup>38</sup>	2007	English	USA	20/24	73.4±5.8	Tai chi Control	22 22	June 2001 to March 2006
Song <sup>43</sup>	2009	English	Korea	50/12	64±8.02	Tai chi Control	31 31	January 2002 to May 2008

**Figure 1.** Flow diagram of the study selection.

main databases: PubMed, Embase, Cochrane library, and China National Knowledge Infrastructure. The details of searching would be shown in search process section.

### Data Extraction and Quality Assessment

Two of the authors independently reviewed the formal published versions of all eligible studies for content and screened them according to the specified inclusion criteria using a data extraction

form based on the Cochrane Consumers and Communication Review Group's data extraction template. Disagreements were resolved by discussion between the 2 review authors; if no agreement could be reached, it was planned a third author which would decide. The following data were extracted:

- (1) Study characteristics: first author's name, country, sampling size, age and gender of the patients, intervention arms, and follow-up.

- (2) Outcomes: if the study reported mean value, we will extract mean value and standard deviation, if not, we will collect events and total in 2 arms.
- (3) Studies on same sample from different articles, the interested outcomes, longest follow-up and interested population was chosen.

The validity of eligible RCTs was assessed using the Cochrane risk of bias tool in Review Manager 5.2. Funnel plots were planned to evaluate the risk of bias across studies (Liu et al, 2013).

## Statistical Analysis

A  $\chi^2$ -based test of homogeneity was performed, and the inconsistency index ( $I^2$ ) statistic was determined. Mean difference and corresponding 95% confidence interval (CI) were used to summarize the results. The statistical heterogeneity of these studies was calculated by Cochran's Q test and  $I^2$  index (more than 50%,  $P < .1$ , high heterogeneity). Considering that a large number of people from different regions in each study are different, and different variables are adjusted in different studies, a random effect model is adopted to avoid possible heterogeneity. Meanwhile, if  $I^2$  index was less than 50%, a fixed effect model was adopted. We assess possible publication bias by funnel plot. All analyses were performed using review manager (version 5.2, Cochrane Collaboration, 2011). We also tried to conduct a sensitivity analysis based on the quality and weight of the test, and exclude each individual test in turn.

## Search Process

A preliminary search found 905 related publications, of which 63 were excluded from duplicate publications. After filtering by title and abstract, 49 articles remain. Forty two studies were excluded due to unsatisfactory article types and insufficient data. Finally, select 7 articles for meta-analysis. The research selection process is shown in Figure 1.

## Results

### Characteristics of Included Studies

The detailed characteristics of the included studies are shown in Table 1. All these studies were published from 2000 to 2021. The sample size is between 24 and 74. There were 162 cases in the Tai chi group and 161 cases in the control group.

### Quality Assessment

The methodological quality of the studies was evaluated by the quality assessment tool in Cochrane manual. Figures 2 and 3 show the quality assessment in this study. As we have seen, there is limited bias in the included articles. Only one study showed the problem of attrition bias (Richerson and Rosendale, 2007). From the perspective of deviation summary, there is no problem with selection deviation, performance deviation, detection deviation, and reporting deviation. Generally speaking, only 1 trial has a risk of bias and 6 trials have no risk.

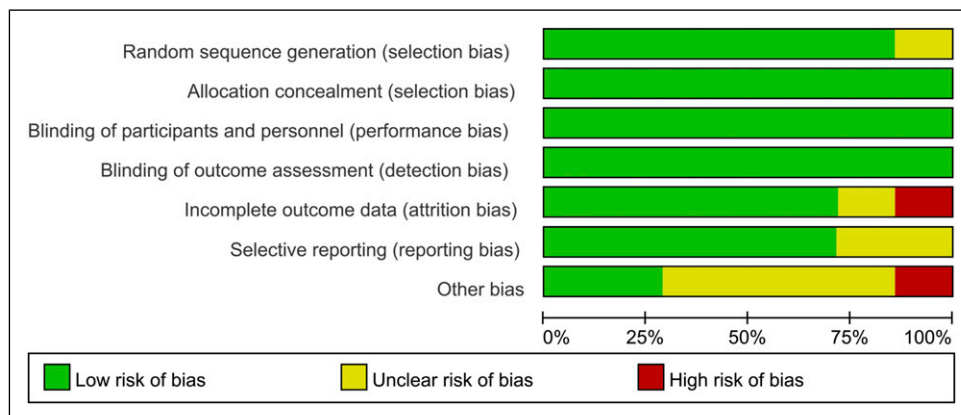
### Outcomes of Meta-analysis

1. Forest plot about glucose

Five studies involve in glucose between Tai chi and control groups using fixed effect model and it was shown in Figure 4. The result suggested that there was significant difference in glucose (MD=-12.47, 95%CI [-21.20, -3.73],  $P = .005$ ;  $I^2 = 32\%$ ). We could find that Tai chi group had lower glucose than control group and the mean difference is -12.47 which mean that the difference was small (about 10% of raw data).

2. Meta-analysis about ABC scale

In the analysis, 3 articles were included. The results of heterogeneity test showed that random effect model was



**Figure 2.** Assessment of the quality of the included studies: low risk of bias (green hexagons), unclear risk of bias (yellow hexagons), and high risk of bias (red hexagons).

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Ahn 2011	+	+	+	+	+	+	?
Alsubiheen 2015	+	+	+	+	+	?	?
Alsubiheen 2020	+	+	+	+	?	+	+
Chang 2013	+	+	+	+	+	+	?
Hung 2009	?	+	+	+	+	+	-
Richerson 2007	+	+	+	+	-	+	+
Song 2009	+	+	+	+	+	?	?

**Figure 3.** Risk of bias was assessed with use of the Cochrane risk-of-bias tool.

needed to analyze the data ( $I^2 = 91\%$ ). The overall effect of ABC (activities-specific balance confidence) scale was significant and mean difference was 9.26 with 95%CI [6.68 and 11.83] and overall P value was  $< .001$  (Figure 5). The result showed that Tai chi group had higher ABC scale than control group. Since the MD was 9.26 which is also about 10% of raw data in both groups, the difference between 2 groups is small.

### 3. Meta-analysis about single limb standing test

In the analysis, 4 articles were included. The results of heterogeneity test showed that fixed effect model was needed to analyze the data ( $I^2 = 45\%$ ). The overall effect of single limb standing test was also significant and the mean difference was 8.38 with 95%CI [4.02, 12.74] and overall P value was  $.001$  (Figure 6). Tai chi group had higher single limb standing test score than control group. In this part, the MD was 8.38 and it was more than 50% of raw data in both

groups, which indicated that the difference in single limb standing test was big.

### Sensitivity Analysis and Publication Bias

To examine the stability of the outcome, a sensitivity analysis was needed. When Ahn's article in 2011<sup>1</sup> removed, the result demonstrated that in heterogeneity part,  $I^2$  of sensitivity changed from 32% to 47%. It indicates that the heterogeneity is steady (Figure 7).

To assess publication bias in this study, a funnel plot was conducted. The result of funnel plot suggested that no significant evidence of potential publication bias existed (Figure 8).

### Discussion

From our results, we can find that glucose in Tai chi group was lower than control group. In analysis of ABC scale, Tai chi group was higher than control group. About single limb standing test, Tai chi was also higher than control group. Therefore, from these 3 different aspects, we can find Tai chi can help old diabetes patients in disease control, life independence and balance ability.

According to the U.S. Centers for disease control, 8.6 million or 18.3% of adults 65 and older have diabetes. Due to many physiological systems affected by the disease, diabetes research has been focused on identifying possible complications and their causes, and intervention measures to improve the quality-of-life of patients with diabetes are limited.<sup>33-35</sup> Fear of falling and loss of balance are 2 major complications of diabetes and aging. The elderly and diabetics are usually slow to respond. Over the years, the loss of balance of payments has been very serious. Falls increase medical costs for the elderly.<sup>36-39</sup> Yue and Xue reported that Taijiquan can effectively reduce blood glucose and HbA1c and improve most psychological aspects of quality of life during regular practice for more than 6 months. Tai Chi combines physical exercise and meditation based on balancing airflow. The influence of shadowboxing on diabetes control may be related to the aerobic exercise components of Taijiquan, but Qigong relaxation exercise may also affect blood glucose control.<sup>40</sup> This is consistent with our study.

Tai chi, as a traditional exercise method, has been used to improve balance and posture control in China. It is called a physical and mental skill, because people use their brains when they do exercises.<sup>41-44</sup> Tai chi is a kind of comprehensive movement, including the slow coordination of gravity shift, posture adjustment and synchronous deep breathing. This combination involves many different psychological and physiological factors, such as calmness and concentration in exercise, following the example of the coach, reaching the appropriate form to improve muscle elasticity, and combining exercise with deep breathing to improve cardiac output and provide sufficient blood flow for



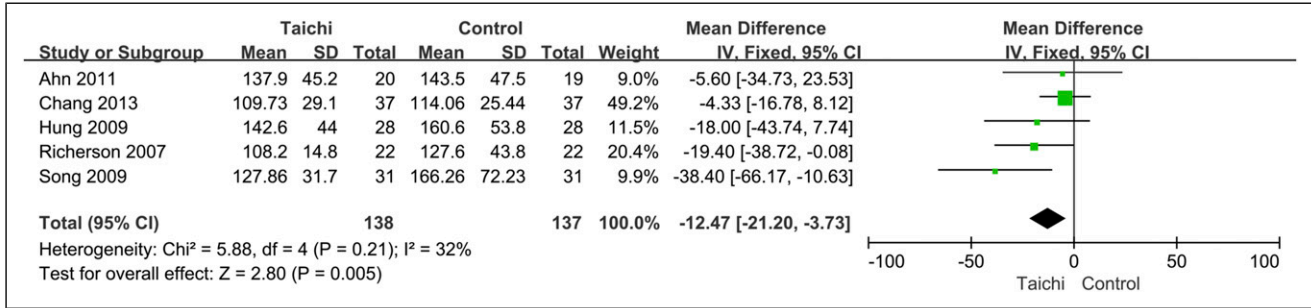


Figure 4. Forest plots of glucose between Tai chi and control groups.

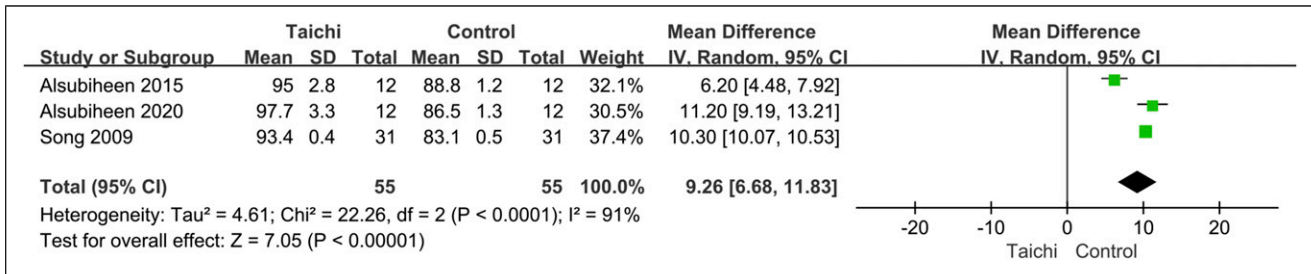


Figure 5. Forest plots of ABC scale between Tai chi and control groups.

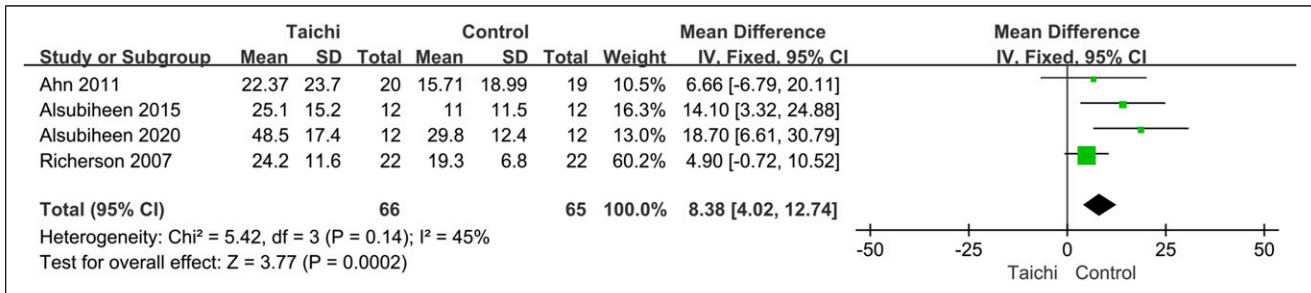


Figure 6. Forest plots of single limb standing test between Tai chi and control groups.

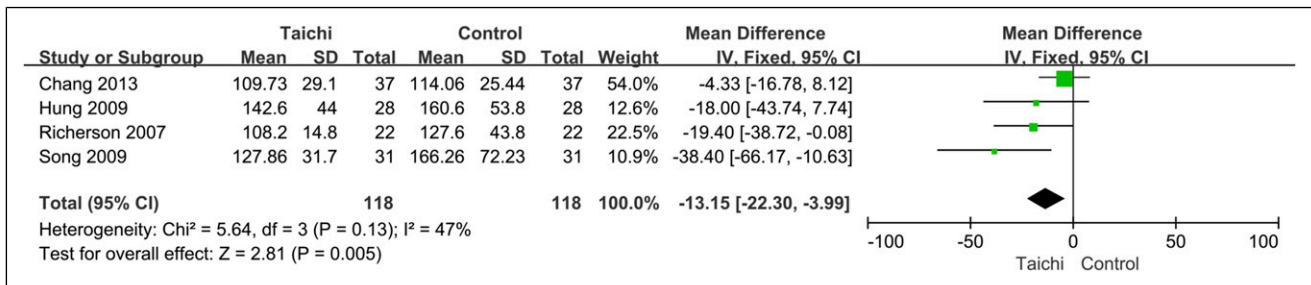
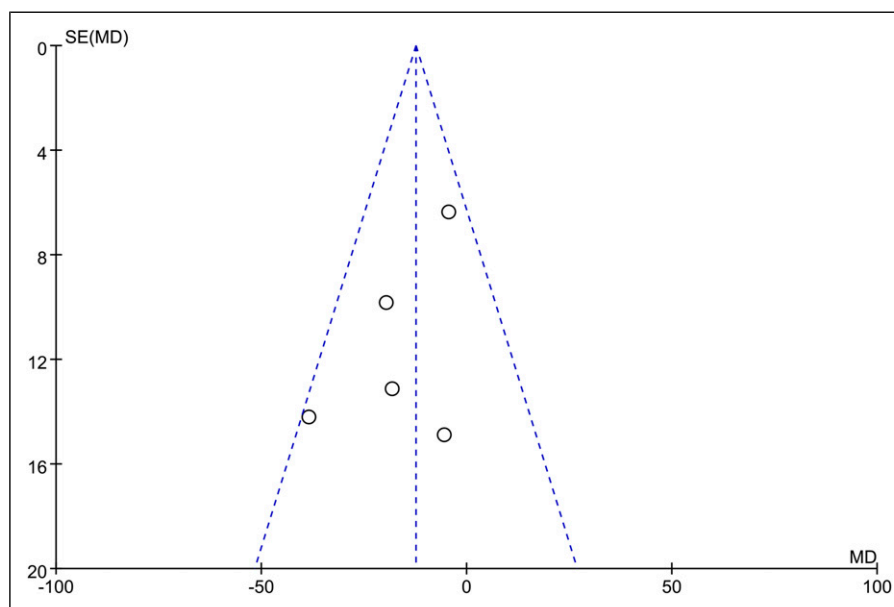


Figure 7. Sensitivity analysis forest plots of glucose between Tai chi and control groups.

muscles.<sup>45-48</sup> Xiao and Zhuang show that Taijiquan is a potential method to promote and accelerate the “relearning” process. It can improve balance and gait, and more importantly, prevent falls<sup>49</sup> and this is also consistent with our results.

In a cross-sectional study of the elderly, Tai chi practitioners reported significantly higher quality of life in most subscales of SF-36.<sup>50</sup> Even after controlling for demographic variables, the improvement in quality of life was significantly



**Figure 8.** Funnel plot of publication bias.

related to the number of years and frequency of practicing Tai chi.<sup>51-53</sup>

In previous studies, diabetic patients who exercised Tai chi for more than 12 weeks reported higher cutaneous vascular conductivity and better peripheral nerve conduction velocity of bilateral median and tibial nerves.<sup>54-56</sup> These findings suggest that Tai chi exercise can improve sensory function and neuropathy related symptoms. Previous studies<sup>57,58</sup> have also shown that elderly people with peripheral neuropathy have improved plantar sensation after 24 weeks of Tai chi exercise. With the improvement of plantar sensation, Tai chi training can help the subjects to control their posture better and get better balance. The effect of Tai chi exercise on the balance of the elderly or diabetic patients has also been fully supported by the literature.<sup>59-64</sup>

Above all, the results showed that Tai chi had better performance than control group in evaluation of glucose and life quality including balance and independence. This is consistent with several reported articles. However, some limitations existed in this article. First, more indicators evaluating other aspects should be included, and this could be conducted in the future. Second, more researches from various countries and subgroup by different race could be analyzed in the next research. Third, we included only a small number of studies, and the small patient population may increase bias in the analysis.

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### Author Contributions

[(This will be published with your article. Please provide authors' initials as appropriate)]

Criteria

Author Initials

Made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data.

Yanmei Wang, Pei Yang, Wenhui Zhang

Involved in drafting the manuscript or revising it critically for important intellectual content.

Yanmei Wang, Jianjun Yan, Peng Zhang, Min Lu

Given final approval of the version to be published. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content.

Yanmei Wang, Jianjun Yan, Peng Zhang, Pei Yang, Wenhui Zhang, and Min Lu

Agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Yanmei Wang.

### Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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