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A Systematic Review of the Effectiveness of *Tai Chi* Exercises for Improving Balance and Lower Limb Muscle Strength of the Elderly in the Community

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Abstract

BACKGROUND: Balance disorders are the primary cause of falls, a significant health concern for the elderly. *Tai Chi* (TC) improves the balance and strength of the lower limb muscles that focus on centering the mind, bodywork, and breathing exercises.

AIM: A systematic review was conducted to search for evidence of the effects of *Thai Chi* in balancing and strengthening of lower extremities among the elderly in the community.

METHODS: According to the preferred reporting items for systematic reviews and meta-analyses guidelines, a systematic review was conducted. Databases included Science Direct, ProQuest, and PubMed, from 2015 to 2020, with research articles being original studies. The quality of research articles was assessed using the Physiotherapy Evidence Database scale. Systematically analyses were used for results syntheses.

RESULTS: Six articles were included in this review. TC exercises effectively improve the balance and muscle strength of the lower limbs among the elderly in the community. TC has a beneficial effect on evaluation in the short (8 weeks) and long (12 weeks) term to prevent falls among the elderly in the community.

CONCLUSION: TC exercises are beneficial for improving balance and muscle strength of the lower limb among the elderly in the community with Selected TC, Traditional TC, and Modified *Chen*-style TC.

Introduction

Balance disorders are the leading cause of falls, which are serious health problems for the elderly [1]. Data from the WHO identified 646,000 cases of fatal accidents per year [2]. *Tai Chi* (TC) is a martial arts style can improve balance and lower leg muscle strength, focusing on the mind, bodywork, and breathing exercises [3]. Several previous randomized trial studies have shown that TC exercises could improve lower limb muscle strength and balance among the elderly in the community [4], [5], [6], [7]. Many traditional long and complex TC exercises have been simplified. It is necessary to know the effectiveness of these movements [8].

TC movements are soft, rhythmic, suitable for the elderly, and considered a closed kinetic chain. It requires the synergy of the extremity and postural muscles [9]. TC movements are light to do because they focus on the mind, body exercise, and breathing exercises. This exercise is suitable for communities with various diseases caused by aging [10], [11]. TC is a type of low-affected exercise, which provides a minimal load on the joint muscles. Hence, this exercise is safe for the elderly [11], [12]. The gentle TC movements make the joints and muscles not burdened by excessive pressure [12].

The results of several recent studies have shown that TC was effective for fall prevention and balance control through strengthening lower extremity muscles [4], [5], [6], [7]. TC improved cardiopulmonary capacity, muscle strength, posture control, spinal flexibility, and balance with light to moderate intensity and reduced the risk of falls. The last two studies [3], [13] regarding the benefits of TC on lower extremity muscle strength showed a significant increase in knee flexors and knee extensors plantar flexors, and hip flexor dorsi.

When viewed from TC practice, it does not require ample space and costs [7]. TC movements are light to do with various backgrounds of the elderly disease will undoubtedly significantly affect overcoming balance disorders in the elderly [3]. Since the latest systematic review, no studies have systematically

reviewed the effectiveness review of TC exercises for improving the balance and strength of lower limb muscle among the elderly. The authors thus decided to undertake an updated systematic review through effectiveness review to evaluate the effectiveness of TC exercises for improving balance and strength of lower limb muscle among the elderly in the community.

Methods

This systematic review was reported following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement. The authors did not apply for ethical and patient consent because all analyses of this study were based on previously published literature.

Data sources and search strategy

The authors collected data during December 2020 through the Science Direct, PubMed, and Proquest databases. The library search was developed using the population, intervention, control, and outcomes (PICO) Logic Grid approach and the subject heading search using MeSH. The article search strategy used the Boolean operator's method with the PICO approach: Elderly OR Aged AND TC OR *Tai Ji* OR *T'ai Chi* OR TC *Chuan* OR *Tai Ji Quan* OR *Tai-ji* OR *Taiji* OR *Taijiquan* AND Exercise OR Exercise training OR Aerobic exercise OR Exercise isometric OR Exercise physical OR Exercise therapy OR Physical Fitness AND improve lower limb muscle balance OR improve lower extremity muscle strength AND randomized controlled trials (RCT). The inclusion criteria used in data collection were studies related to the effectiveness of TC exercises to improve balance and lower leg muscle strength among the elderly in the community from 2015 to 2020. The language used in the text was English. The exclusion criteria in the effectiveness of this review were published articles that were not original publications, such as letters to the editor, only abstracts and books. The journal of data collection results followed the inclusion criteria, and the analysis followed the research objectives.

Study selection and data extraction

The first step in selecting study searches, the authors created a logic grid with the PICO approach to determine search keywords based on predetermined inclusion criteria. The population in the literature search was the elderly who were given TC interventions compared with other types of balance exercises with balance and strengthening of lower limb muscles.

The first author made the data selection by creating three Google Drive folders. These electronic folders were named "relevant," "same file in different database," and "not sure." Based on predetermined inclusion criteria, two authors (D.A. and T.H.) independently reviewed by reading the titles and abstracts of previously identified studies. Studies considered to meet the requirements were then made a folder with the name "relevant for review."

Data extraction was conducted independently by two authors (DA and TH) in Table 1. The extracted data were the characteristics of the study (first author, year of publication, study location, language of publication, study design), participant characteristics (sample size, age, TC training, intervention control), intervention program (training dose, total weeks, total hours), outcome (outcome and measurement tools).

Quality assessment

For studies considered worthy of being used as a review, the authors (DA and TH) assessed the quality of the selected papers. The authors evaluated the risk of bias of all selected RCT papers using the Physiotherapy Evidence Database scale (PEDro), modified to ten items [14], [15], [16]. The 10 PEDro assessment items included eligibility criteria, randomization, allocation concealment, similar baselines, blinding assessor, more than 85% retention, missing data management (intention-to-treat analysis), between-group comparison, point size, and variability measures, isolated TC-intervention. The assessment results were categorized into: <4 points as poor quality, 4–5 points as moderate quality, 6–8 points as good quality, 9–10 points as an outstanding quality. RCTs with a "moderate" to "excellent" quality rating are suitable for systematic reviews of physical therapy studies. Papers obtained with research designs other than RCTs, the authors would do critical appraisal using the appraisal tool from JBI.

Data synthesis

The author (D.A) analyzed the journals that met the criteria would be examined by the author (D.A), and the data obtained would then be checked by the author (T.H). The research journal was analyzed based on types of TC, follow-up time, and results focusing on balance and leg muscle strength.

Results

Study selection

The literature search obtained 724 journals from 3 database sources: Science Direct, PubMed,

Table 1: Summary of the characteristics of the TC studies for balance and lower limb muscle strength

Study		Participants characteristic			Intervention program			Study outcome	
Reference	Location, language, Study design	Participant	Tai Chi Exercise	Control Intervention	Training Dosage	Duration (wk)	Total (h)	Balance	Lower Limb Muscle Strength
Chen *et al.* 2020 [21]	Taiwan, (English), RCT	28 healthy adults>65 y/o	sTC (n 14)	tTC (n 14)	TC: 3 × 30 min/week CG: independently	8	12	After 8 weeks of training, the BBS, TUG, and FRT scores in the sTC group significantly improved overall. Although all three functional balance test scores improved in the tTC group, only the improvement in BBS was statistically significant (p = 0.001)	After 8 weeks, all muscle strength measurements increased by an average of 3.1 ± 1.0 kgw in the sTC group and 1.6 ± 0.8 kgw in the tTC group using a hand-held isometric dynamometer, MicroFET®3 (Hoggan Health Industries)
Penn *et al.* 2019 [17]	Taiwan, (English), Quasi-Experimental	70 healthy adults>65 y/o	iTC (n 25) and tTC (n 21)	Education Program (n 24)	TC: 3 × 30 min/ wk CG	8	12	BBS, TUG, FRT results on iTC group intervention showed a significant increase on balance (p = 0.001), and on tTC group intervention, only BBS increased (p = 0.005)	Hand-held isometric dynamometer measurement on the iTC intervention group showed a significant score to the 16 lower limb muscle groups (p = 0.007). The tTC group showed a substantial increase in the bilateral hip flexor, right hip extensor, left hip abductor, left hip abductor, and bilateral back left leg (p = 0.010-0.033). While the group control showed a considerable increase in right hip extensor muscle strength (p = 0.033)
Zou *et al.* 2019 [6]	China, (English), RCT	80 healthy adults 55-79 y/o	MTC (n 40)	TC 24 style (n 40)	TC: week 1-6: 3 × 60 min/week week 7–12: 5 × 90 min/week CG: week 1–6: 3 × 60 min/week week 7–12: 5 × 90 min/week	12	63	After MTC intervention for 12 weeks, there was a significant increase in TUG score of 0.213 (95% CI –0.382 to –0.044, P = 0.013)	After 12 weeks of intervention, the MTC score was better than TC-24 style in strengthening ankle muscle strengths with a CST score of 0.221 (95% CI –0.397 to –0.045, P = 0.014)
Kittichittipanich and Kusoom 2019 [19]	Thailand, (English), Quasi-Experimental	110 healthy adults>65 y/o	tTC (n 55)	Non-TC (n 55)	TC: 6 × 45 min/ week CG: -	12	54	LST measurement showed significantly different balance scores between the intervention group and control group (p = 0.001)	Lower limb muscle strength measurement using Dynamometer between intervention group and control group showed no significant difference
Kim *et al.* 2020 [20]	Korea, (English), RCT	50 older women 65-83 y/o	tTC (n 25)	Taekkyon (25)	TC: 2 × 60 min/ week CG: 2 × 60 min/wk	12	24	Both groups showed a significant increase in TUG, FRT, LST scores (p ≤ 0.05). The result revealed that *Tai Chi* exercise was better than *Taekkyon*	Lower limb muscle strength measurement using 5 × STS and 30 s STS tools showed no significant difference between both groups. Each had a considerable (p ≤ 0.05) score, but *Tai Chi* had a better post-test score than *Taekkyon*
Zhou *et al.* 2019 [18]	China, (English), RCT	60 Chinese adults 60–79 y/o	tTC (n 60)	–	TC: week 1–6: 3 × 60 min/week week 7–12: 5 × 90 min/week CG: week 1–6: 3 × 60 min/week week 7–12: 5 × 90 min/week	12	63	The balance test scores to three *Tai Chi* exercises using 6MWT. TUG showed a significant increase (p ≤ 0.05). The better score occurred on the second phase test. On the third phase test, the score was even better	Lower limb muscle strength measurement using LST showed a better result on the left ankle as the dominant one (p = 0.001) and no significant increase on the right ankle. The second phase test showed a significant result on both ankles (p = 0.001)

RCT: Randomized Controlled Trials, y/o: Years old, sTC: Selected *Tai Chi*, tTC: Traditional *Tai Chi*, iTC: Individualized *Tai Chi*, TC: *Tai Chi*, MTC: Modified Chen-style *Tai Chi*, CG: Control Group, min: Min, wk: Week, BBS: Berg Balance Scale, TUG: Time Up and Go Test, FRT: Function Reach Test, LST: One-Leg Standing Test, 6MWT: The 6 Meters Walk Test, CST: Chair Stand Test, 5 × STS: 5 Times Sit-to-Stand Test, 30 s STS: 30 S Sit-to-Stand Test.

and ProQuest. The results came through Mendeley to remove duplications. Seventy-six full-text journals were selected according to inclusion criteria set before, after data synthesis, six journals were obtained. The search process and literature review are shown in Figure 1.

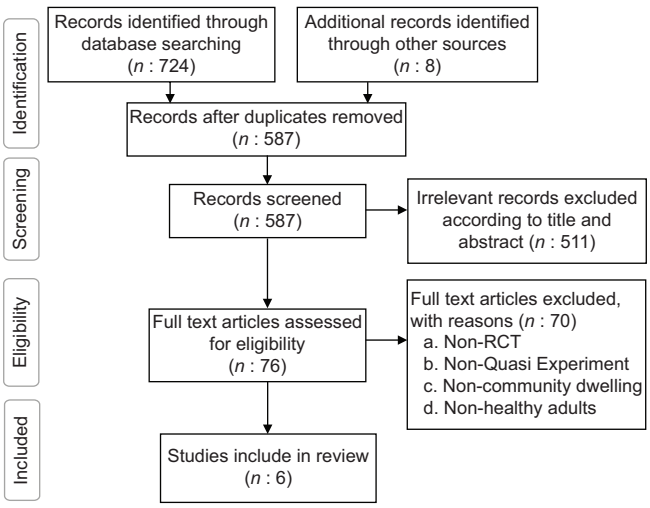

Figure 1: Flow diagram based on the preferred reporting items for systematic review and meta-analyses statement

Study characteristics

Participants

The participants from the six research journals in this review were six healthy elderly living in the community from 2019 to 2020 [6], [17], [18], [19], [20], [21]. These elderly lived in urban and rural areas, and the total participants were 398 elderly, comprising 240 intervention groups and 158

control groups. The average age of respondents was 55–85 years old.

Control intervention

Six research journals that met inclusion criteria had different intervention control using traditional TC (tTC) [6], [18], [21], nutrition education, exercises, balance, and falls [17], and other balance exercises [19], [20].

Outcome measures

The research journals included the inclusion criteria aimed at assessing balance and lower limb muscle strength. In this review, the balance result involved static balance (for example, sitting position, legs), dynamic balance (for example, endurance and walking style to keep balanced), and the measurement results of lower limb muscle strength (for example, extensor strength assessment and abductor on lower limb muscle).

TC exercise

The results showed three TC interventions used: Selected TC (sTC) [17], [21], tTC [18], [19], [20], and Modified Chen-style TC (MTC) [6]. The TC exercises given to participants were simplified to easy the elderly from accepting interventions and determining whether the simplified TC practice could provide more effective balance and lower limb muscle strength. Short-term benefits received evaluation after eight weeks of intervention [17], [21] and long-term benefits of TC practice after 12 weeks of intervention [6], [18], [19], [20].

TC exercises were given in 8 weeks with an intensity of 3 times/week, with a duration of 30 min per session [17], [21]. Exercises were given for 12 weeks to determine the long-term effectiveness of TC [6], [18], [19], [20]. The 1st week to 6 weeks of participants was given 60 min of exercise with a division of 10 min of warming up to 40 min of TC exercises and 10 min for cooling. After six weeks of training, a mid-term assessment was carried out to evaluate the training's effectiveness [6]. At week 6–12, the intensity of TC exercise was increased to 5 times/week with a time of 90 min per session, with a 10-min warm-up to 70 min of TC exercise and 10 min of cooling down [6], [18], [19], [20]. Summary of characteristics study of the six journals can be seen in Table 1.

Quality assessment

Of the six studies included in the literature review, four studies implement RCT design based on Table 2. The quality of those four studies was excellent for the systematic review, getting a score of 8 on the PEDro scale. They [6], [18], [20], [21] had bias on the results (intention-to-treat analysis); three studies had selection bias [6], [18], [21] (concealed allocation); four studies [6] had performance bias (assessor blinding failure). All included journals blinded the respondents and therapists. They [6], [18], [20], [21] also reported the differences between groups with point estimation and validity tests. Only one journal did not have isolated TC exercise [20].

Table 2: Summary of methodological quality for all randomized controlled trials according to the modified PEDro scale

Author, Year	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Sum Score
[21]	1	1	0	1	0	1	0	1	1	1	7
[6]	1	1	0	1	0	1	0	1	1	1	7
[20]	1	1	1	1	0	1	0	1	1	0	7
[18]	1	1	0	1	0	1	0	1	1	1	7

Item 1: Eligibility criteria, item 2: Randomization, point 3: Concealed allocations, Item 4: Similar baselines, point 5: Blind of the assessor, item 6: Over 85% retention, item 7: Missing data management (intention to treat analysis), item 8: Between-group comparison, item 9: Point size and variability measures, item 10: Isolated TC intervention, 1: Explained explicitly and presented, 0: No, inadequately described, or unclear.

Two journals were studied using a quasi-experimental design with critical appraisal and tool JBI with 9 criteria [17]. Obtained 8 "Yes" and 1 "Unclear" [19] received 7 "Yes," 1 "No," and 1 "Unclear." The two research journals with a quasi-experimental design can include in this systematic review.

Effectiveness of TC exercise

Balance

TC exercise toward balance in the six studies showed a significant result on the intervention group [6], [17], [18], [19], [20], [21]. The significantly increased balance was the effectiveness of TC exercise in the short-term (8 weeks) [17], [21] and long-term (12 weeks) [6], [18], [19], [20]. Time up and go test (TUG), FRT, and 6 MWT measurements on the studies revealed a considerable significance in dynamic increased balance on the elderly in the intervention group [6], [17], [18], [20], [21]. Some studies, including static balance using berg balance scale (BBS) and leg standing test (LST), also showed similar results, especially sitting on standing [17], [19], [20], [21].

Overall, the measurements to balance static or dynamic from the six studies discovered a significant result with a range of ($p = 0.001$–<0.05). It implies that the effectiveness of individualized TC or modified with other exercises would increase the balance on the elderly compared to the control group. Thus, TC exercise on static or dynamic balance significantly increased short- and long-term intervention for the elderly in the community.

Lower limb muscle strength

Measurement of lower limb muscle strength using Hand-held Isometric Dynamometer, chair stand test, LST, 5× second sit-to-stand test (STS), and 30 s STS showed significant results in the intervention group

with a range (p = 0.001 – <0.05). Lower limb muscle strength measurement was carried out separately on the right and left legs to determine the strength between the legs. Measurements were made to determine the short-term (8 weeks) [17], [21] and long-term (12 weeks) effects [6], [18], [19], [20] on lower leg muscle strength in the elderly. Individualized TC exercises, assisted by tools or other exercises, could significantly increase lower leg muscle strength among the elderly in the community.

Discussion

Summary of the main results

This systematic review was conducted to assess the effectiveness of TC exercises for improving balance and leg muscle strength. The results showed TC exercise effectively improved balance and leg muscle strength in the elderly. As per the author's knowledge, this study is the first systematic review to assess the effectiveness of TC exercises in improving balance and leg muscle strength among the elderly in the community. The results are critical for therapists and the elderly in doing TC movements to improve balance and lower limb muscle strength to reduce the risk of falling.

Relevance to previous reviews

The study focuses on effectiveness in determining TC exercises for the elderly in the community. The results showed that three TC exercises improved balance and lower limb muscle strength. TC is a martial arts style in China whose movements focus on the mind and breathing exercises [22]. Many recent studies have reported the effectiveness of TC given to the elderly. In this systematic review, the authors discuss the effectiveness of several TC exercises on improving balance and lower leg muscle strength among the elderly in the community. The six journals that included three types of TC movements are selected TC (consisting of individualized TC and simplified TC), tTC, and MTC [6], [17], [18], [19], [20], [21]. The three types of TC movements each showed significant effects on balance and lower extremity muscle strength.

Several recent studies [4], [8], [9], [23], [24], [25], [26] reported that selected TC could give a better effect than tTC movements due to complex movements resulting in the elderly not moving actively. The selected TC movements were easily set by TC practitioners and determined through a center of pressure (COP) assessment classified into four levels of difficulty [9], [23], [27]. This classification allows the elderly or respondents to get TC movements according to their abilities [23].

A previous research [23] reported that the selected TC exercise obtained significant BBS, TUG, and Functional reach tests. The balance analysis got a p = 0.001–0.004, and the analysis of knee extensor strength received p = 0.002. These results indicate that selected TC exercises effectively improve balance and lower limb muscle strength [9]. This research also examined the different effects of simplified Tai Chi movements on functional movements in the elderly. The simplified TC movements effectively improved practical activities in the elderly, especially on balance, compared to tTC movements.

tTC movements also significantly improved balance and lower limb muscle strength in the elderly [22]. Several studies have shown that tTC movements (TC-24, TC-42, and TC-56) could have a significant effect on balance and leg muscle strength in the elderly seen from exercise implementation for 12–24 weeks [3], [5], [28]. The MTC movement [6] improved cognitive function, balance, and leg muscle strength in the elderly. It emphasized several activities, providing additional stimulation to the lumbar muscles, such as improving balance, lower back muscle strength, and lower extremity muscles [29].

Implication for future research

Compared to other types of exercise, TC may be more effective in improving balance and lower limb muscle strength in the elderly, observed in this review. Several aspects regarding TC in the elderly include fall rates, quality of life, and cognitive abilities. Future studies should clearly describe the level of compliance of the respondents. Finally, the study design had various methodological weaknesses, such as lack of allocation concealment, assessor blindness, and intention-to-treat analysis. Assessors were not blinded in four of the selected research journals, potentially leading to subjectivity and bias. Thus, the results of this systematic review should be interpreted with caution.

Implication for future clinical practice

This systematic review selected TC exercises based on the COP using a computerized system. Thus, clinical practitioners with a simple technique provided selected TC using a particular method to determine the difficulty level. In this systematic review, the authors reported the results of earlier studies, showing that selected TC was more effective than the other two types of movement. Thus, expert practitioners must interpret more carefully because each TC movement must have its advantages.

Review limitation

This systematic review noted several research limitations. First: Four selected research journals were conducted in China and Taiwan. All samples from six journals were Chinese. It is unknown whether the results of this systematic review can be generalized to non-Chinese populations with different cultural backgrounds, which may influence the effectiveness and outcomes of TC. Second: Six research journals reported research samples in good health, and most participants were early adults. Therefore, the TC exercises to a sample of older adults over 85 years old and with limited chronic disease need further research to determine the beneficial effects. Third: since this study was limited to the effectiveness of TC for improving balance and muscle strength of the lower limbs, this review does not discuss other beneficial effects of TC practice.

Conclusion

In this systematic review, TC exercises could significantly improve balance and lower limb muscle strength among the elderly of the community. More robust multicenter studies including different ethnic groups, elderly participants, blindness to assessors, and validated outcome measures were needed before conclusions.

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