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A Meta-Analysis of the Effects of Dance Programs on Physical Performance: Appropriate Health Promotion for Healthy Older Adults

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Background: Dancing is a type of physical activity that has been associated with physical benefits in older adults. Regular dancing can help maintain physical function and improve the quality of life in this population. This review evaluated randomized control trials (RCTs) of the effectiveness of dance programs on the physical function of healthy older adults. **Methods:** We systematically searched four databases (PubMed, Google Scholar, Embase, and ThaiLis) through December 2021 for primary studies evaluating dance programs in healthy older adults aged 60 years and over. The meta-analysis used a random-effects model to compute the effect sizes using a forest plot and Cochran's Q and I^2 statistics as heterogeneity measures. **Results:** Eight types of dance programs showed significantly improved physical function. Muscle strength was assessed using the five times sit-to-stand test (I^2=89%; p=0.003), chair-sit-to-stand-30S test (I^2=75%; p=0.006), and 30-s arm curl test (I^2=22%; p=0.260). Static balance was evaluated using the Berg-balance scales test (I^2=0%; p=0.620) and the one-leg-stand test (I^2=32%; p=0.220). Dynamic balance was tested based on the time up-and-go and eight-foot up-and-go tests (I^2=51%; p=0.110). Flexibility was assessed based on the back-scratch (I^2=56%; p=0.130) and sit-and-reach test (I^2=0%; p=0.930). **Conclusion:** Dance exercise programs improved muscle strength, balance, and flexibility. Such programs are effective and safe for healthy older adults for use as daily exercise to promote health. Therefore, researchers, healthcare providers, and policymakers should establish properly organized dance interventions to improve physical function in healthy older adults.

Key Words: Exercise, Physical fitness, Healthy aging, Health promotion

INTRODUCTION

The world's population has transitioned into an aging population. Developed countries, such as the member states of Europe and North America, have become aging societies.[1] Japan, an Asian country, has also progressed to a super-aged community. Thailand is ranked second in aging societies among ASEAN countries after Singapore. The Office of the National Economic and Social Development Board (NESDB) has predicted that Thailand would become an aging society in 2021. That is, people aged 60 years or above account for 20% of the population. In 2036, Thailand is predicted to become a super-aged community, with 30% of the population aged 60 years and over.[2]

Dancing is a participatory activity, a method for socialization, and reflects the national culture of each country. International literature describes Chinese dance exercises, such as Tai Chi Chuan as popular and characterized by the inclusion of breath and body movement. These exercises also induce concentration and calm.[3,4]

The modified tap dance in the United States is a native American art form focusing on ankle and foot movement.[5] Korean traditional dance in Korea is a slow-tempo exercise to accompany the music.[6,7] In Thailand, exercises are performed with various musical accompaniments, including Muay Thai aerobic dance, Khon dance, Seng Sanai (Isan traditional dance), Applied Ancient Muay Dance, and Thai Dance. Indeed, studies in Thailand were consistent with international investigations of body movement exercises accompanied by music. This increased the research evidence related to dance and promoted good health in older adults.[8-11]

However, evidence from randomized control trials (RCTs) examining the effectiveness of dance programs on physical function among healthy older adults is limited. Most studies were in patients with Parkinson's, dementia, and lumbar stenosis. The results of these different studies were inconclusive regarding which program was appropriate to slow body deterioration in healthy older adults. A recent meta-analysis by Liu et al.[12] examined the effectiveness of dance on physical function in healthy older adults. The physical function outcomes were balance function, mobility function, endurance performance, gait, and general health. Likewise, Blanco-Rambo et al.[13] examined the effectiveness of dancing in reducing the risk of falls in older adults. Fall risk is assessed by time up-and-go (TUG), Berg-balance scales test (BBS), and one-leg-stand test. Physical function can be evaluated by measuring muscle strength based on the five times sit-to-stand test (FTSS), 30-s arm curl test (30AC), or chair-sit-to-stand-30S test (30CST). The present systematic review and meta-analysis collected data from previous studies to determine the effectiveness of various dance programs on relevant issues to make informed decisions about choosing the most appropriate dance program for older adults. Therefore, this study reviewed the literature on the effects of dance programs on physical function in healthy older adults to prevent and slow the deterioration of the body.

MATERIALS AND METHODS

Search Strategy
This review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA)[14] checklist and flow diagram (Fig. 1) up until December 2021. We searched the PubMed, Google Scholar, Embase, and ThaiLis databases using keywords based on the PICO framework: P (healthy elderly), I (dance program), C (control group), and O (physical function) and the following keywords: "Dance program" ("Line dance" OR "Muay Thai aerobic dance" OR "Korean traditional dance" OR "Tai Chi Chuan exercise") AND "Physical function" AND "Healthy elderly" ("older adults" OR "elderly").

The criteria for inclusion in the meta-analysis were (1) published RCTs on the effects of dance programs (Line dance, Muay Thai aerobic dance, Korean traditional dance, and Tai Chi Chuan exercise) on the physical function of both female and male healthy older adults; (2) participant age 60 years and over without physical mobility limitations, and (3) sufficient data to perform the meta-analysis, including the mean, standard deviation (SD), and the sample size of both experimental and control groups. The exclusion criteria were qualitative research, review articles/editorial articles, proceedings, unavailable full text, and meta-analyses.

Search Outcomes
One researcher first searched the specified databases for data using the keywords above to identify studies meeting the inclusion criteria. Screening of the titles and abstracts revealed 18 relevant studies from PubMed, 49 from Google Scholar, 2 from Embase, and 42 from ThaiLis. Next, two researchers read the titles, abstracts, and research content carefully. A total of 52 publications were eliminated due to duplications (n=21), systematic review and meta-analysis (n=23), lack of focus on healthy older adults (n=5), and pilot studies (n=3). Differences of opinion between the two researchers were resolved through discussion with a third researcher. The systematic review and meta-analysis included a total of seven studies.

Quality Appraisal
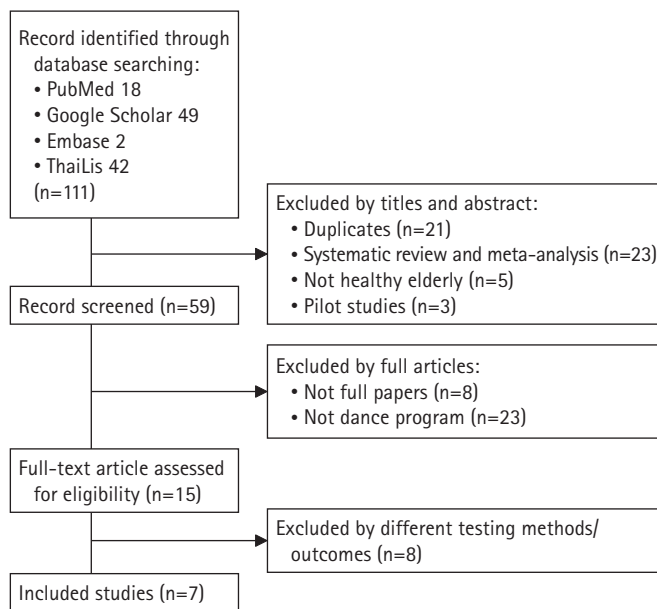We examined the heterogeneity of the seven studies based on fun-

Fig. 1. Flowchart of study selection for meta-analysis. Adapted from the PRISMA Guidelines.[14]

nel plots using Review Manager (RevMan) version 5.4. The studies on the effects of dance programs on physical function tended to have publication bias in all four areas: muscle strength, static balance, dynamic balance, and flexibility. The assessment results of the risk of bias for each issue were classified according to selected research reports. We assessed the quality of the seven selected RCTs according to the PRISMA guidelines. The seven types of bias were evaluated and categorized as low, high, or unclear risk. The assessment results were 71.43% for random sequence generation (selection bias), 71.43% for allocation concealment (selection bias), 14.29% for blinding of participants and personnel (performance bias), 28.57% for blinding of outcome assessment (detection bias), 100% for incomplete outcome data (attrition bias), 100% for selective reporting (reporting bias), and 100% for other bias (Fig. 2).

Data Extraction

We developed a form to extract data to perform the systematic literature review. The details in Table 1 included the author's name, the publication year, the country of publication, the research objectives, information on the experimental and control groups, the details of the dance programs and assessment of the physical function of healthy older adults, and the research results.

Data Analysis

We synthesized the general data by summarizing the points of interest; namely, the effects of dance programs on the physical function of healthy older adults. We then analyzed the descriptive statistics using the available information from the samples. The mean, SD, and sample sizes of the experimental and control groups were used in the meta-analysis performed using RevMan version 5.4. The heterogeneity between each selected research study was tested using Cochran's Q and I^2. The statistical significance was set at the 0.05 level. The acceptable criteria for I^2 were: not significant (0%–24%), low heterogeneity (25%–49%), medium heterogeneity (50%–74%), and high heterogeneity (75%–100%).[15] The
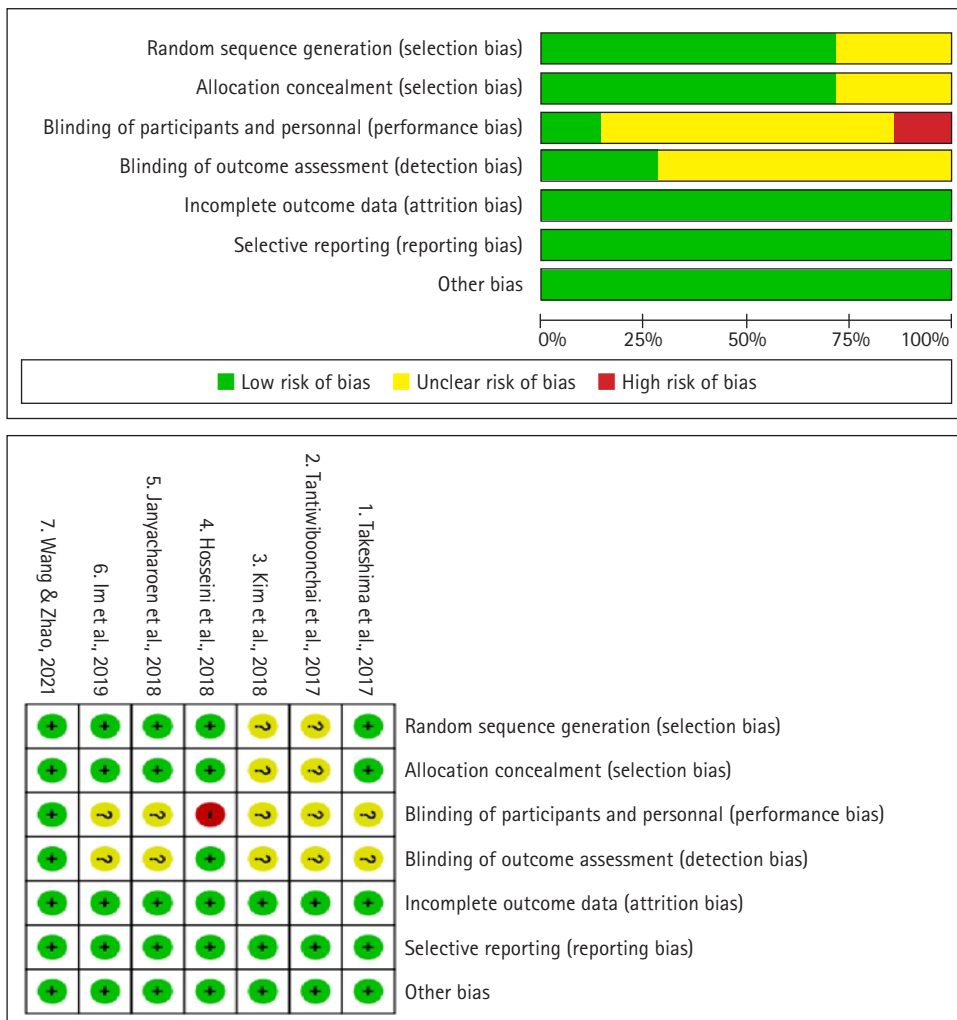

Fig. 2. Risk of bias graph and summary.

Table 1. Literature reviews dance programs' physical function of healthy older adults

Variable	Study, year	Country	Type of dance	Age (y)	Intervention period (wk)	Experimental group			Control group		
						n	Mean±SD	Description	n	Mean±SD	Description
Muscle strength											
Five times sit-to-stand test (FTSS)	Wang and Zhao,[5] 2021	USA	Modified Tap Dance	63.9±4.21	12	22	6.4±1.3	Modified tap dance program (MTD)	22	7.1±1.2	Three health education lectures
	Janyacharoen et al.,[20] 2018	Thailand	Ancient boxing	65.9±4.9	12	28	9.3±2.0	Ancient boxing	28	12.2±2.9	Education about the exercise and home program to aid in daily practice
30-s arm curl test (30AC)	Takeshima et al.,[3] 2017	China	Tai Chi Chuan	72.2±5.0	12	25	32.5±3.6	Tai Chi Chuan exercise	24	27.3±3.9	Not change their physical activity habits
	Tantiwiboonchai et al.,[17] 2017	Thailand	Muay Thai Aerobic Dance	70.8±4.4	16	20	22.0±5.5	Muay Thai aerobic dance	20	14.5±5.4	Routine physical activity
Chair-sit-to-stand 30S (30CST)	Takeshima et al.,[3] 2017	China	Tai Chi Chuan	72.2±5.0	12	25	32.5±4.7	Tai Chi Chuan exercise	24	27.2±5.5	Not change their physical activity habits
	Tantiwiboonchai et al.,[17] 2017	Thailand	Muay Thai aerobic dance	70.8±4.4	16	20	19.7±6.8	Muay Thai aerobic dance	20	10.4±5.0	Routine physical activity
	Kim et al,[6] 2018	Korea	Korean traditional dance	78.0±1.5	12	7	26.14±5.27	Korean traditional dance	6	12.8±1.8	Routine physical activity
	Im et al,[7] 2019	Korea	Yoga and Korean dance	71.6±3.2	12	14	19.4±4.6	Yoga and Korean dance	11	13.7±3.3	Supervised in the fitness center at the same frequency and time and performed sedentary physical activities
Static balance											
Berg balance scales	Janyacharoen et al.,[20] 2018	Thailand	Ancient boxing	65.9±4.9	12	28	54.9±1.5	Ancient boxing	28	51.2±2.5	Education about the exercise and home program to aid in daily practice
	Bennett and Hackney,[24] 2018	USA	Line dance	65-93	8	12	50.4±4.6	Line dance	11	48.1±7.9	Normal daily activities
One-leg stance with eyes open	Tantiwiboonchai et al.,[17] 2017	Thailand	Muay Thai aerobic dance	70.8±4.4	16	20	30.8±30.0	Muay Thai aerobic dance	20	11.5±11.0	Routine physical activity
One-leg balance with eyes closed	Kim et al,[6] 2018	Korea	Korean traditional dance	78.0±1.5	12	7	5.0±3.5	Korean traditional dance	6	4.8±2.9	Routine physical activity
Dynamic balance											
Eight-foot-and-go test (UPGO)	Takeshima et al.,[3] 2017	China	Tai Chi Chuan	72.2±5.0	12	25	4.3±0.5	Tai Chi Chuan exercise	24	4.7±1.4	Not change their physical activity habits
Time up-and-go test (TUG)	Hosseini et al., 2018[4]	China	Tai Chi Chuan	60-80	8	30	12.63±4.13	Tai Chi Chuan exercise	30	18.7±4.9	Did not receive any intervention
	Tantiwiboonchai et al.,[17] 2017	Thailand	Muay Thai aerobic dance	70.8±4.4	16	20	8.4±2.7	Muay Thai aerobic dance	20	16.4±10.3	Routine physical activity
	Janyacharoen et al., 2018[20]	Thailand	Ancient boxing	65.9±4.9	12	28	9.0±1.7	Ancient boxing	28	7.5±1.1	Education about the exercise and home program to aid in daily practice
Flexibility											
Back scratch test (BS)	Takeshima et al.,[3] 2017	China	Tai Chi Chuan	72.2±5.0	12	25	-5.1±12.1	Tai Chi Chuan exercise	24	-7.3±12.8	Not change their physical activity habits
	Kim et al,[6] 2018	Korea	Korean traditional dance	78.0±1.5	12	7	10.0±4.4	Korean traditional dance	6	1.8±0.9	Routine physical activity
Sit-and-reach test (SRT)	Takeshima et al.,[3] 2017	China	Tai Chi Chuan	72.2±5.0	12	25	14.9±7.8	Tai Chi Chuan exercise	24	8.3±15.1	Not change their physical activity habits
	Tantiwiboonchai et al.,[17] 2017	Thailand	Muay Thai aerobic dance	70.8±4.4	16	20	10.8±8.2	Muay Thai aerobic dance	20	4.1±10.8	Routine physical activity
	Kim et al,[6] 2018	Korea	Korean traditional dance	78.0±1.5	12	7	33.2±8.7	Korean traditional dance	6	24.8±4.8	Routine physical activity

publication bias of the research was reported based on funnel plots. The statistical significance was set at the 0.05 level.

PHYSICAL FUNCTION OUTCOMES

Muscle Strength

FTSS
The FTSS is the most common method used to assess leg strength in older adults. Each participant is instructed to sit and stand from a chair repeatedly as quickly as possible with their arms folded across the chest to assess the risk of falling. The cut-off scores refer to the time used to categorize the participants as at risk or not at risk of falling. The cut-off scores are ≥ 11 seconds. Participants with FTSS times above this threshold are 4.40 times more likely to fall compared to those below the threshold. The FTSS test effectively predicts falls in older adults.[16]

30AC
Each participant is instructed to sit on a chair with the dominant upper arm extended to the side. The forearm is placed parallel to the floor with the palm facing the body while holding a 2-kg dumbbell. After hearing the "start" signal, each older adult curls the arm holding the dumbbell by bending the elbow completely and then lowers the arm until the elbow is straight. The total number of controlled arm curls performed in 30 seconds is counted. The participants use their other hand to support the elbow of the curling arm to prevent injury. The score is the total number of arm curls performed in 30 seconds.[17]

30CST (times)
30CST tests lower body strength. Each older adult is instructed to fold both arms across the chest and sit in the middle of a chair. After hearing the "start" signal, the participant must stand straight from the sitting position. The number of full stands and sits in 30 seconds is counted (the back of the participant must be straight against the wall or the assistant holds the back of the chair to prevent the chair from sliding backward during the test). The score is the total number of stands within 30 seconds.[18]

Static Balance

BBS
The BBS measures the balance ability by performing 14 sitting and standing activities. Each activity is rated from 0 to 4 based on the participant's capacity, need for assistance, and the time spent performing the test. The total test score is 56 points. BBS scores < 45 points indicate a high risk of falls. The BBS is a highly accurate and reliable tool for balance assessment.[16]

One-leg stance with eyes open and with eyes closed
One-leg stances with eyes open and closed are used to assess balance ability. The participant is instructed to stand with both heels on the edge of a drawn rectangle measuring 33 cm × 38 cm. The feet must be aligned and at shoulder width. The participant stands on the dominant leg and keeps the body upright and the hips straight. The non-dominant knee is then bent to 90º. The time elapsed from the start of the test to when the participant touches the ground with the non-dominant leg, felt the other leg, or could not bend the knee at 90º is recorded. The test is performed twice and the average time (in second) is used.[16]

Dynamic Balance

TUG and UPGO
The TUG is a 3-m balance test used to measure the time required to rise from the chair, walk to turn around a cone and return to sit on the chair. Times ≥ 20 seconds to complete this task indicate a significant problem with dynamic balance. Times of 10–19 seconds indicate mild to moderate balance problems. Finally, times of < 10 seconds indicate an average dynamic balance.[16] The UPGO is a test of balance over 2.44 m.

Flexibility

Back-scratch test
The back-scratch (BS) test upper body flexibility with the hands crossed behind the back and attempting to touch the fingers. The distance between the middle fingers of both hands is measured in inches. The measurements are performed twice, with the best value recorded.[19]

Sit-and-reach test
The sit-and-reach test (SRT) test is used to evaluate lower body flexibility. First, the participant warms up by stretching the back and posterior leg muscles for 10–15 seconds 2–3 times on each other side. Next, the participant is instructed to remove their shoes and sit on the floor with their legs fully extended and the bottoms of their bare feet against the SRT testing box. The inner edges of both heels are aligned with the hip. The participants then slowly reach forward as far as possible with extended arms to place one hand on with the palms facing down. The stretch is held for approximately 2 seconds with the legs fully extended and knees straight. The furthest distance along the top of the SRT testing box

where the fingertip can touch the scales is measured. If the participant's knees are bent or if there is a jerky movement while testing, the attempt is not scored. The participant performs the test twice and the furthest distance is recorded.[17]

RESULTS

Muscle Strength

FTSS test

The analysis of FTSS test data applied a fixed mean difference. Among 100 healthy older adults from two full-text studies, 50 (50%) showed decreased FTSS test scores after receiving the dance intervention, with a mean difference of -1.16 (-1.79, -0.52) and an I^2 of 89%. The subgroup analysis included 100 subjects

from two full-text studies. The asymmetric graph distribution on the funnel plot (Fig. 3) indicated that these studies were prone to publication bias. In addition, the fixed model was employed. The heterogeneity was high (75%–100%) ($I^2 = 89\%$; p = 0.003) (Fig. 4A).

30AC test

The analysis of 30AC test data applied a fixed mean difference. Among 89 healthy older adults from two full-text studies, 45 (51%) showed increased 30AC test scores after receiving the dance intervention, with a mean difference of 5.84. (4.06, 7.63) and an I^2 of 22%. The subgroup analysis included 89 subjects from two full-text studies. The asymmetrical graph distribution on the funnel plot (Fig. 3) indicated that these studies were prone to publication bias. In addition, the fixed model was employed. The het-

The analysis of the five times sit–to–stand test

Study or subgroup	Dance program			Control			Weight	Mean difference IV, fixed, 95% CI	Mean difference IV, fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
1. Janyacharoen et al., 2018	9.3	2	28	12.2	2.9	28	23.9%	-2.90 [-4.20, -1.60]	
2. Wang et al., 2021	6.44	1.28	22	7.05	1.19	22	76.1%	-0.61 [-1.34, 0.12]	
Total (95% CI)			50			50	100.0%	-1.16 [-1.79, -0.52]	

Heterogeneity: Chi²=9.01, df=1 (p=0.003); I²=89%
Test for overall effect: Z=3.56 (p=0.0004)

Favours [dance program] Favours [control]
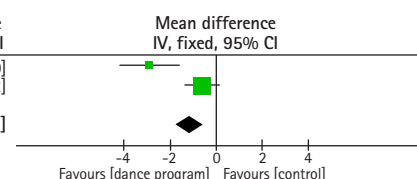
The analysis of the arm curl 30S test

Study or subgroup	Dance program			Control			Weight	Mean difference IV, fixed, 95% CI	Mean difference IV, fixed, 95% CI
	Mean [times]	SD [times]	Total	Mean [times]	SD [times]	Total			
1. Takeshima et al., 2017	32.5	3.6	25	27.3	3.9	24	72.1%	5.20 [3.10, 7.30]	
2. Tantiwiboonchai et al., 2017	22	5.5	20	14.5	5.4	20	27.9%	7.50 [4.12, 10.88]	
Total (95% CI)			45			44	100.0%	5.84 [4.06, 7.63]	

Heterogeneity: Chi²=1.28, df=1 (p=0.26); I²=22%
Test for overall effect: Z=6.41 (p<0.00001)

Favours [dance program] Favours [control]
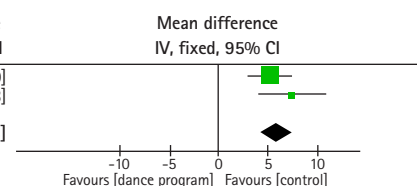
The analysis of the chair–sit–to–stand–30 (s) test

Study or subgroup	Dance program			Control			Weight	Mean difference IV, fixed, 95% CI	Mean difference IV, fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
1. Takeshima et al., 2017	32.5	4.7	25	27.2	5.5	24	34.0%	5.30 [2.43, 8.17]	
2. Tantiwiboonchai et al., 2018	19.7	6.8	20	10.4	5	20	20.5%	9.30 [5.60, 13.00]	
3. Kim et al., 2018	26.14	5.27	7	12.83	1.83	6	16.1%	13.31 [9.14, 17.48]	
4. Im et al., 2019	19.35	4.6	14	13.72	3.28	11	29.3%	5.63 [2.54, 8.72]	
Total (95% CI)			66			61	100.0%	7.51 [5.83, 9.18]	

Heterogeneity: Chi²=12.03, df=3 (p=0.007); I²=75%
Test for overall effect: Z=8.79 (p<0.00001)

Favours [dance program] Favours [control]
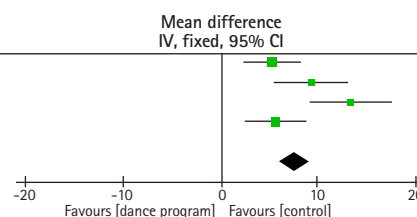
The analysis of the berg balance test

Study or subgroup	Dance program			Control			Weight	Mean difference IV, fixed, 95% CI	Mean difference IV, fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
1. Bennett et al., 2017	50.4	4.56	12	48.1	7.94	11	3.9%	2.30 [-3.05, 7.65]	
2. Janyacharoen et al., 2018	54.9	1.5	28	51.2	2.5	28	96.1%	3.70 [2.62, 4.78]	
Total (95% CI)			40			39	100.0%	3.65 [2.59, 4.70]	

Heterogeneity: Chi²=0.25, df=1 (p=0.62); I²=0%
Test for overall effect: Z=6.75 (p<0.00001)
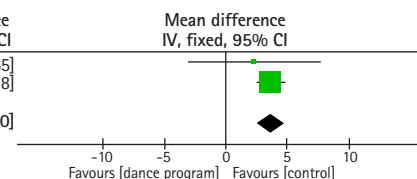
Favours [dance program] Favours [control]

Fig. 3. Analysis of five times sit-to-stand test (FTSS), 30-s arm curl test (30AC), chair-sit-to-stand-30S test (30CST), and Berg-balance scales test (BBS) of healthy older adults.
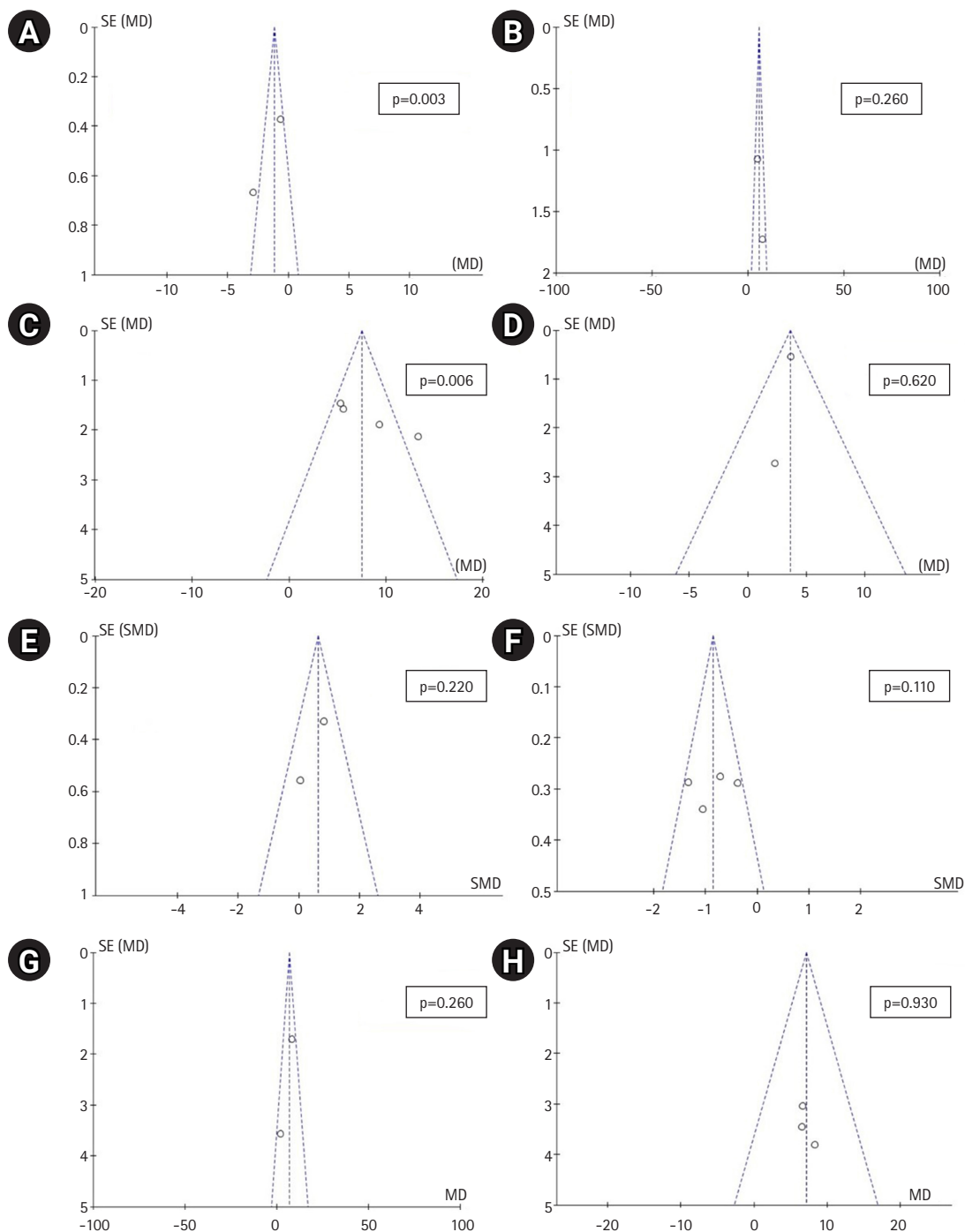
Fig. 4. Funnel plot analysis: (A) five times sit-to-stand test (FTSS), (B) 30-s arm curl test (30AC), (C) chair-sit-to-stand-30S test (30CST), (D) Berg-balance scales test (BBS), (E) one-leg stand test, (F) time up-and-go test (TUG) and eight-foot up-and-go test (UPGO), (G) back scratch test (BS), and (H) sit-and-reach test (SRT).

erogeneity was at the level of "not be important" (0%–24%) (I^2 = 22%, p = 0.260) (Fig. 4B).

30CST test

The analysis of 30CST test data applied a fixed mean difference. Among 127 healthy older adults from four full-text studies, 66

(52%) showed increased 30CST test scores following the dance intervention, with a mean difference of 7.51 (5.83, 9.18) and an I^2 of 75%. The subgroup analysis included 127 subjects from four full-text studies. The asymmetrical graph distribution (Fig. 3) indicated that these studies were prone to publication bias. In addition, the fixed model was used. The heterogeneity was high (75%–

100%) ($I^2 = 80\%$; p = 0.006) (Fig. 4C).

Static Balance

BBS test

The analysis of BBS test data applied a fixed mean difference. Among 79 healthy older adults from two full-text studies, 40 (51%) showed increased BBS scores after receiving the dance intervention, with a mean difference of 3.65 (2.59, 4.70) and an I^2 of 0%. The subgroup analysis included 79 subjects from two full-text studies who had received the dance intervention. The asymmetrical graph distribution on the funnel plot (Fig. 3) indicated that these studies were prone to publication bias.

In addition, the fixed model was used. The heterogeneity level was categorized as "not important" (0%–24%) ($I^2 = 0\%$; p = 0.620) (Fig. 4D).

One-leg stance with eyes open

The analysis of one-leg stand test data applied a fixed standard mean difference. Among 53 healthy older adults from two full-text studies, 27 (51%) showed increased one-leg stand test scores, with a mean difference of 0.63 (0.07, 1.19) and an I^2 of 32%. The subgroup analysis of one-leg stand test results after receiving the dance intervention included 53 individuals from two full-text studies. The graph distribution on the funnel plot was asymmetrical (Fig. 5). Therefore, these studies were prone to publication bias. In addition, the fixed model was employed. The heterogeneity was low (0%–24%) (25%–49%) ($I^2 = 32\%$; p = 0.220) (Fig. 4E).

Dynamic Balance

TUG and UPGO tests

The analysis of UPGO data used a fixed standard mean difference. Among 205 healthy older adults from four full-text studies, 103 individuals (50.25%) showed decreased UPGO scores following the dance intervention, with a mean difference of -0.85 (-1.14, -0.56) and an I^2 of 51%. The analysis of UPGO after the dance intervention in four full-text studies (subgroup analysis) included 205 individuals. The asymmetric graph distribution on the funnel plot (Fig. 5) indicated that these studies were prone to publication bias. In addition, a fixed model was employed. Medium heterogeneity (50%–74%) ($I^2 = 51\%$; p = 0.110) was observed (Fig. 4F).

Flexibility

BS test

The analysis of BS test data used a fixed mean difference. The anal-

ysis of 62 healthy older adult samples from two full-text studies showed increased BS test scores in 32 individuals (52%) receiving the dance intervention, with a mean difference of 7.05 (4.03, 10.07) and an I^2 of 56%. The subgroup analysis included 62 subjects from two full-text studies. The asymmetric graph distribution on the funnel plot (Fig. 5) indicated that these studies were prone to publication bias. In addition, a fixed model was employed. Medium heterogeneity (50%–74%) was observed ($I^2 = 56\%$; p = 0.260) (Fig. 4G).

SRT test

The analysis of SRT test data applied a fixed mean difference. Among 102 healthy older adults from three full-text studies, 52 (51%) showed an increased SRT test score following the dance intervention, with a mean difference of 7.09 (3.26, 10.93) and an I^2 of 0%. Subgroup analysis of SRT test results from three full-text studies included data from 53 older adults. The graph distribution of the funnel plot was asymmetrical (Fig. 5). Therefore, these studies were prone to publication bias. In addition, the fixed model was employed. The heterogeneity level was "not important" (0%–24%) ($I^2 = 0\%$; p = 0.930) (Fig. 4H).

DISCUSSION

The results of the meta-analysis in this study demonstrated that dancing can help healthy older adults to move better. Based on the values of the variables, namely muscle strength, balance, and flexibility, the groups receiving dance interventions had better performance compared to the control group.

Muscle Strength

The analysis of the fixed mean differences in the FTSS, 30AC, and 30CST test results revealed that high heterogeneity in the FTSS and 30CST tests ($I^2 = 89\%$; p = 0.003 and $I^2 = 75\%$; p = 0.006, respectively). For the 30AC test, the heterogeneity was at the level of "not important" ($I^2 = 22\%$; p = 0.260). Each dancing program had different dance moves, rhythm, exercise duration, and sample number.

The FTSS, 30AC, and 30CST tests are used to assess muscle strength. The FTSS and 30CST tests are used to evaluate the strength of the lower extremities while the 30AC test is used to measure the strength of the upper extremities. Previous studies reported significant increases in FTSS (p < 0.05) following the following dance interventions: ancient Thai boxing (from 10.06 ± 3.00 to 9.30 ± 2.00 seconds)[20] and modified tap dance (from 7.45 ± 1.51 to 6.44 ± 1.28 seconds).[5] Both dance programs required different upper and lower extremity movements. The

The analysis of the one-leg stand test

Study or subgroup	Dance program			Control			Weight	Mean difference IV, fixed, 95% CI	Mean difference IV, fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
1. Tantiwiboonchai et al., 2017	30.8	30	20	11.5	11	20	73.8%	0.84 [0.19, 1.49]	
2. Kim et al., 2018	5	3.46	7	4.83	2.86	6	26.2%	0.05 [-1.04, 1.14]	
Total (95% CI)			27			26	100.0%	0.63 [0.07, 1.19]	

Heterogeneity: Chi²=1.48, df=1 (p=0.22); I²=32%
Test for overall effect: Z=2.22 (p=0.003)

Favours [dance program] — Favours [control]
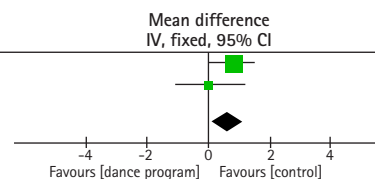
The analysis of the time up and go test and eight-foot up and go test (UPGO)

Study or subgroup	Dance program			Control			Weight	Mean difference IV, fixed, 95% CI	Mean difference IV, fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
1. Takeshima et al., 2017	4.3	0.5	25	4.7	1.4	24	26.1%	-0.38 [-0.94, 0.19]	
2. Tantiwiboonchai et al., 2017	8.4	2.7	20	16.4	10.3	20	18.9%	-1.04 [-1.71, -0.38]	
3. Hosseini et al., 2018	12.63	4.13	30	18.7	4.85	30	26.4%	-1.33 [-1.89, -0.77]	
2. Janyacharoen et al., 2018	7.5	1.1	28	8.7	2.1	28	28.6%	-0.71 [-1.25, -0.16]	
Total (95% CI)			103			102	100.0%	-0.85 [-1.14, -0.56]	

Heterogeneity: Chi²=6.07, df=3 (p=0.11); I²=51%
Test for overall effect: Z=5.75 (p=0.00001)

Favours [dance program] — Favours [control]
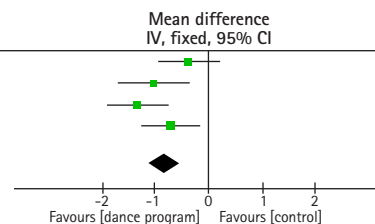
The analysis of the back scratch test

Study or subgroup	Dance program			Control			Weight	Mean difference IV, fixed, 95% CI	Mean difference IV, fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
1. Takeshima et al., 2017	-5.1	12.1	25	-7.3	12.8	24	18.7%	2.20 [-4.78, 9.18]	
2. Kim et al., 2018	10	4.4	7	1.83	0.98	6	81.3%	8.17 [4.82, 11.52]	
Total (95% CI)			32			30	100.0%	7.05 [4.03, 10.07]	

Heterogeneity: Chi²=2.28, df=1 (p=0.13); I²=56%
Test for overall effect: Z=4.57 (p<0.00001)

Favours [dance program] — Favours [control]
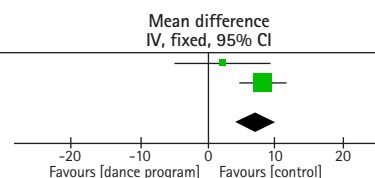
The analysis of the sit and reach test

Study or subgroup	Dance program			Control			Weight	Mean difference IV, fixed, 95% CI	Mean difference IV, fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
1. Takeshima et al., 2017	14.9	7.8	25	8.3	15.1	24	32.0%	6.60 [-0.17, 13.37]	
2. Tantiwiboonchai et al., 2017	10.8	8.2	20	4.1	10.8	20	41.6%	6.70 [0.76, 12.64]	
3. Kim et al., 2018	33.14	8.67	7	24.83	4.75	6	26.4%	8.31 [0.85, 15.77]	
Total (95% CI)			52			50	100.0%	7.09 [3.26, 10.93]	

Heterogeneity: Chi²=0.14, df=2 (p=0.93); I²=0%
Test for overall effect: Z=3.63 (p=0.003)

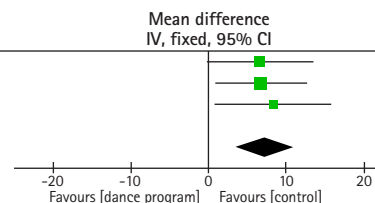Favours [dance program] — Favours [control]

Fig. 5. Analysis of the one-leg stand test, time up-and-go test (TUG) and eight-foot up-and-go test (UPGO), back scratch test (BS), and sit-and-reach test (SRT) of healthy older adults.

modified tap dance program lasted 60 minutes. Each set from all eight groups focused on movements of the torso, ankles, knees, and arms. Every exercise set concentrated on increasing the muscle strength of the center of mass, in addition to coordination and agility.[21] Ancient Thai boxing was applied to the traditional boxing of Sakon Nakhon province, Phu Tai Noi, from the northeastern region of Thailand. The sessions lasted 40 minutes, divided into 5, 30, and 5 minutes. The exercise consisted of 14 movements of both arms and legs. However, the ancient Thai boxing exercise applied by Janyacharoen et al.[20] consisted of 12 moves. The FTSS test of both dance programs increased the strength of the leg muscles responsible for hip flexion and hip extension and the muscles responsible for knee flexion-extension, such as the quadriceps, femoris, and hamstring muscles.

Two dancing programs showed significant improvements in 30AC test results (p < 0.05); namely, Tai Chi Chuan (from 32.2 ± 3.7 to 32.5 ± 3.6 times)[3] and Muay Thai aerobic dance (from 18.20 ± 3.60 to 22.00 ± 5.50 times).[17] These programs focused on movements of the upper and lower extremities. Tai Chi Chuan lasted for 60 minutes, divided into 10, 40, and 10 minutes. This long-form Yang style includes 108 slow, soft, and stable movements. In contrast, the Muay Thai aerobic dance lasted for 40 minutes, divided into 10, 20, and 10 minutes. This intervention consisted of 11 and seven movements to exercise the lower and upper extremities, respectively. The 30AC test results of both dance programs indicated that exercising the arm muscles increased the strength of the muscles responsible for elbow flexion, including the biceps brachii.

Four dancing programs showed significantly improved 30CST results: Tai Chi Chuan (from 32.40 ± 4.60 to 32.50 ± 4.7 times),[3] Muay Thai aerobic dance (from 14.8 ± 4.6 to 19.7 ± 6.8 times),[17] Korean traditional dance (from 12.86 ± 1.95 to 26.14 ± 5.27 times),[6] and yoga and Korean dance (from 14.35 ± 3.05 to 19.35 ± 4.60 times).[7] These four programs focused on movements of the upper and lower extremities. Korean traditional dance consisted of 11 moves that lasted 60 minutes, divided into 10, 40, and 10 minutes.[6] Yoga and Korean dance lasted 60 minutes, divided into 5, 50, and 5 minutes. The exercise consisted of 4 positions of static balance (30 minutes) and six classes of dynamic equilibrium (20 minutes).[7] The 30CST test showed that all four dance programs focusing on the exercise of the hip and legs could increase the strength of the leg muscles responsible for hip flexion and extension and the muscles responsible for knee flexion-extension.

Therefore, each dance program helped improve muscle strength among healthy older adults. In addition, dancing increased leg and arm muscle power due to aerobic exercises. Moreover, repetitive movements can increase the endurance and strength of leg and arm muscles, which are linked to motor control and learning based on the following aspects. (1) Cognitive: learning each form of the exercise. (2) Movement: some movements of the dancing exercises may be anti-gravity, such as holding the leg up, resulting in new learning by the motor system. The resulting muscle contractions will help increase muscle strength. (3) Emotion: Before exercising by dancing, warm-up exercises are needed to prepare the muscles and prevent injuries. Moreover, cooling down after a workout relaxes and restores the body to its normal condition by stretching the muscles and slowing breathing.[22] Therefore, dancing exercise in healthy older adults can increase muscle strength and ultimately promote health, maintain good mobility, and reduce the risk of falls.

Static Balance

The analysis of the BBS and the one-leg stand tests by the fixed mean difference showed that "not important" heterogeneity for the BBS ($I^2 = 0\%$; $p = 0.620$) and low heterogeneity for the one-leg stand test ($I^2 = 32\%$; $p = 0.220$).

The BBS, one-leg stance with eyes open and one-leg balance with eyes closed are used to test static equilibrium. The BBS assesses balance by performing 14 rounds of sitting and standing. The one-leg stance with eyes open is used to evaluate balance with eyes open, while the one-leg balance with eyes closed is used to assess balance with eyes closed. Previous studies reported higher scores on these tests after dancing interventions. The BBS resulted in a significant improvement after ancient Thai boxing (from 52.10 ± 5.10 to 54.90 ± 1.50 points)[20] and a trend toward signifi-

cance after line dancing (from 48.10 ± 7.94 to 50.40 ± 4.56 points).[23] Line dancing requires continuous leg and back movements in addition to weight transfer and posture control to move forward and backward, walk sideways, and turn the body. This dance style starts from easy to complicated movements. It requires 60 minutes, divided into 10, 40, and 10 minutes.[24] The BBS revealed that ancient Thai boxing and line dancing increased static balance. However, while line dancing showed improvement in the BBS, the difference was not statistically significant ($p > 0.05$), likely because the physical activity of line dance exercises did not alter the static balance in short-term studies.[24]

Muay Thai aerobic dance showed significantly improved one-leg stance with eyes open ($p < 0.05$, from 17.70 ± 21.70 to 30.80 ± 30.0 seconds).[17] The difference was higher, although without statistical significance ($p > 0.05$), for Korean traditional dance (from 3.71 ± 1.80 to 5.00 ± 3.46 seconds).[6]

The BBS, the one-leg stance with eyes open, and the one-leg balance with eyes closed improved because dance exercises increase leg and back muscle strength and may also enhance the coordination of the central nervous system, such as the cerebellum, which controls posture.[25]

Dynamic balance

The analysis of UPGO using a fixed standard mean difference showed a medium heterogeneity ($I^2 = 51\%$; $p = 0.110$). These two tests use a similar test method with slightly different measurement distances.

The UPGO is used to test dynamic balance. The TUG assesses emotional balance at a distance of 3 m, while the UPGO assesses dynamic balance at 2.44 m. (1) Tai Chi Chuan showed a significant improvement ($p < 0.05$) (from 19.23 ± 5.31 to 12.63 ± 4.13 seconds), lasting 55 minutes, divided into 5, 35, 5 minutes4); (2) Muay Thai aerobic dance (from 10.6 ± 2.0 to 8.4 ± 2.7 seconds)[17] and (3) ancient Thai boxing exercise (from 9.00 ± 1.70 to 7.50 ± 1.10 seconds) also showed improvements.[20] The UPGO test results were significantly improved ($p < 0.05$) after Tai Chi Chuan (from 4.40 ± 0.60 to 4.30 ± 0.50 seconds).[3]

Dance exercises can increase the strength of the muscles responsible for balance and motion and the nerve signals from the visual system, including postures, movements, and the vestibular system. Dancing could result in a better relationship between exercise and surroundings, allowing for better posture control during movement.[23]

Flexibility

The analysis of the BS and SRT tests using a fixed mean difference showed medium ($I^2 = 56\%$; $p = 0.130$), and not important ($I^2 = 0\%$;

p = 0.930) levels of heterogeneity, respectively.

The BS and SRT tests were used to assess upper and lower body flexibility, respectively.

Korean traditional dance significantly improved the BS test results (from 5.00 ± 1.38 to 10.00 ± 4.40 cm) (p < 0.01).[6] While Tai Chi Chuan improved the BS test results, the difference was not statistically significant (from -5.40 ± 12.20 to -5.10 ± 12.10 cm) (p > 0.05).[3] Both dance exercises increase upper body flexibility; namely, the muscles around the shoulder joints and arm muscles, as shoulder and arm movements are required to perform these exercises.

Muay Thai aerobic dance significantly improved the SRT test results (from 8.20 ± 6.90 to 10.80 ± 8.20 cm) (p < 0.05),[17] while Tai Chi Chuan and Korean traditional dance showed non-statistically significant improvements in SRT test results (Tai Chi Chuan: from 14.70 ± 7.70 to 14.90 ± 7.80 cm,[3] Korean traditional dance: from 28.93 ± 7.25 to 33.14 ± 8.67 cm, p > 0.05).[6] These three dance programs increased lower body flexibility; namely, lower back and posterior leg muscles, as these dances require body and leg movements.

Therefore, repetitive movements in each posture cause the muscles to relax. For example, static stretching before and after exercise causes the muscle fibers and tendons to stimulate the Golgi tendon and send signals to the alpha motor neuron, inhibiting muscle activity and inducing muscle relaxation.[24] However, Tai Chi Chuan showed no statistically significant improvement in BS and SRT test values.[3] Additionally, the Korean traditional dance exercises showed no statistically significant improvements in SRT test values.[6] These findings may be the result of complex and unfamiliar exercise postures, which resulted in no statistical differences even after 12 weeks of exercise.

LIMITATIONS

This meta-analysis has several limitations. First, we searched only four electronic databases, which might limit our findings and their generalizability. Future studies should include multiple databases (e.g., Scopus, Web of Science, and Cochrane) to increase the number of primary studies. Second, we focused only on peer-reviewed papers of RCTs assessing the effects of dance programs on physical function. Future studies should consider other study designs (e.g., quasi-experimental study), which might increase the uniqueness of the meta-analysis. Future studies should also include "gray" literature (e.g., unpublished studies, abstracts, or conference proceedings) to provide a balanced review and reduce publication bias. Third, we included only Thai and English languages. Future stud-

ies should include other languages in the evaluation of the effects of dance programs on physical function performance in healthy older adults. which may have been omitted. Finally, this study presented the results for various dance programs such as Tai Chi Chuan, Muay Thai aerobic dance, Line dance, Korean traditional dance, and ancient Thai boxing exercises. However, the differences in movements and rhythm, as well as duration may affect the results of the meta-analysis according to the variables, namely muscle strength, static balance, and flexibility. Therefore, research evidence is insufficient based on the analysis of these variables. In addition, the term "physical function" used in the search may be too broad, leading to the inclusion of a limited number of studies in the meta-analysis.

CONCLUSION

The results of the current meta-analysis confirmed that dance programs improve physical performance in healthy older adults. Moreover, these programs are valuable and safe for this population. The evidence in this study tends to support the American College of Sports Medicine. Furthermore, the dance programs resulted in significantly improved physical performance, e.g., muscle strength, static balance, dynamic balance, and flexibility. The programs were effective and safe; hence, they should be used as daily exercise to promote health in healthy older adults. However, this study did not consider older adults with health problems that require local rehabilitation, such as patients with osteoarthritis who cannot lose weight due to knee joints. Water walking is the recommended form of exercise in these patients, as the water helps support the body weight and reduces joint pressure. Therefore, researchers, healthcare providers, and policymakers should establish properly organized dance interventions to improve physical functions in healthy older adults or others according to context and appropriateness.

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