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REVIEW

Effects of dance intervention on global cognition, executive function and memory of older adults: a meta-analysis and systematic review

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Abstract

Objective To summarize and assess the effects of dance intervention on global cognition, executive function and memory in older adults.

Methods We searched the databases PubMed, Web of Science, Cochrane Library, EMBASE, Clinical Trials.Gov and four Chinese databases (CNKI, CBM, Wan Fang Data and VIP) to identify articles written in English or Chinese and published until April 2018. Randomized controlled trials and quasi-experiment were included if they evaluated the impact of dance on cognition, and individuals aged 60 and over.

Results Thirteen studies with a total of 1605 participants met the inclusions criteria. Our primary outcomes of interest are cognitive functions and are categorized into three cognitive domains: (1)Global cognition: meta-analyses for outcome related to global cognition indicated a large effect size. In the subgroup of using MMSE, results indicated a significant effect for dance on cognition [MD = 1.57, 95% CI (0.53, 2.61), $p = 0.003$; $I^2 = 62\%$], in the subgroup of using SCEF, effect sizes was statically significant and no heterogeneity between studies [MD = 33.25, 95% CI (30.94, 35.56), $p < 0.00001$; $I^2 = 0\%$]. (2) Executive functioning domain: meta-analyses revealed that there were no significant differences between the two groups in measures of executive function after the one study with a low-quality score was excluded [SMD = 0.13, 95% CI (−0.02, 0.27), $p = 0.09$; $I^2 = 0\%$]. (3)Memory domain: quantitative analysis showed that dance may benefit memory function in older adults. However, in our review, dance was more effective for elderly cognitions than exercise may be not support.

Conclusions Our meta-analysis and systematic review suggest that dance may be a safe and effective approach to improve cognitive function in older adults.

Keywords Dance interventions · Cognitive function · Older adults · Meta-analysis

Introduction

According to Alzheimer's disease International (ADI 2016) [1], as a result of the demographic aging, by 2030 there will be 65.7 million people suffering from dementia worldwide and by 2050 there will be 115.4 million. In this sense, cognitive decline has emerged as one of the most common age-related health problems for older adults [2] and is associated with increased risk for progression to dementia [3], increased physical disabilities [4], and also increased health care costs [5]. The high prevalence of cognitive impairment underlines the need for effective interventions to improve cognition in older adults. Fratiglioni et al. [6] propose three lifestyle factors play a significant role in slowing the rate of cognitive decline and preventing dementia: social network, cognitive leisure activity, and regular physical activity. Interestingly, dancing

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is analogous to such an intervention, which involves all of the factors mentioned above.

Dance, as a novel multicomponent interventional approach, has sparked increasing interest of gerontology researchers. A number of randomized controlled trials have shown that dance can support physical function [7], improve cognitive performance [8], reduce the amount of depressive symptoms [9], and promote life satisfaction [10] in older adults. Dance is not only an ideal physical activity but also an engaging social activity that improves fitness levels and promotes healthy activity, which are important for successful aging [11]. Dance can be performed in relaxed and pleasant environments and has a great natural appeal to older adults compared to other conventional exercises. Many studies identified dance as a motivator for the older adults to adhere to a physical activity program [12, 13].

Dance maybe a potentially superior activity for maintaining or improving cognitive ability [14]. Verghese et al. [15] examined the influence of in cognitive and physical leisure activities on the risk of developing dementia in a prospective study follow-up period of 5.1 years. The results of studies have indicated that dancing was the only physical activity associated with a markedly reduced risk of dementia. Dance is a complex sensorimotor rhythmic activity comprising balance, social interaction, emotions, acoustic stimulation and musical experience, all of which have the potential to ameliorate cognitive decline risk factors. In addition, dance is a physical activity requiring different cognitive functions including perception, attention, executive function, procedural memory, visuomotor integration, and motor skills [16]. For example, participants are required to pay attention and follow the music to perform complex motor sequences and smoothly switch between these patterns throughout the dance. Therefore, dance may stimulate and improve cognitive function.

Previous reviews have reported research evidence concerning the effects of dance for older adults on the risk of fall [17], cardiovascular risk [18], depressive symptoms [19], and physical benefits [20]. A review protocol [21] will determine the efficacy of dance on cognitive function among older adults. However, the primary outcome of interest for the protocol is executive function, such as task switching and response inhibition. To our knowledge, there has not been a comprehensive evaluation of dance interventions on global cognition, executive function and memory in older adults. Therefore, aim of this meta-analysis and systematic review is to assess the effects of dance interventions on global cognition, executive function and memory in older adults.

Methods

Search strategy

We searched the databases PubMed, Web of Science, Cochrane Library, EMBASE, Clinical Trails.Gov and four Chinese databases (CNKI, CBM, Wan Fang Data and VIP) to identify articles written in English or Chinese and published until April 2018. The search terms were "Dance", "Dancing", "Dance therapy", AND "Cognitions", "Cognitive function", "Brain function", "Memory", AND "Elderly", "Aging", "Older adults", "Senescence", "Biological Aging" (Appendix). In addition, the reference lists of identified studies were checked manually to include other potentially eligible trials.

Eligibility criteria

Eligible studies were included if they met all of the following criteria:

1. *Study design* The designs were randomized controlled trials (RCT) or/and quasi-experiment (Q).
2. *Study population* The participants were older adults (≥ 60 years).
3. *Intervention* Participated in dance sessions longer than 4 weeks were included. Studies assessed for eligibility could include dance intervention of any style, such as traditional folk dance or ballroom dance (salsa, tango, waltz). We assumed that all dance styles would be equally effective because they share similar principles; movements are synchronized to music and organized into spatial patterns, which tend to be modular in organization. We excluded studies in combined intervention (e.g., combined with pharmacological intervention or relaxation intervention).
4. *Control groups* The control group interventions were not restricted, with no intervention, health education, exercise, or other types of interventions were eligible.
5. *Outcome* The studies were required to report cognitive function as the primary or secondary outcome was eligible.

Data extraction

All data were reviewed and extracted by two independent investigators in a standardized manner. The following data were extracted from the studies and summarized in Table 1: first author, study design, study population (number, age), intervention characteristics (dance style, duration, frequency, and control group), all cognition-related outcomes measured

Table 1 Main characteristics of included studies

Study	Country	Study design	Participants	Measures/outcomes	Results
Alves [26]	Portugal	RCT	65 older adults (60–80 years) Dance group = 23 Walking group = 8 Control group = 24	Executive function: TMT-A&B, Flanker, Digit Span, SRT, SPWM, Go–No-Go, Task Switching, Dot Comparison, Manual Sequence, Raven's Matrices Memory: Memory Span test	Four-month ballroom dance intervention improves the cognition of healthy older adults
Coubard et al. [27]	France	Q	110 older adults (59–89 years) Dance group = 16 Fall prevention = 67 Tai Chi chuan = 27	Executive function: Arithmetic word problems, Stroop test, Rule shift cards test	Contemporary dance improved switching but not setting or suppressing attention. In contrast, neither fall prevention nor Tai Chi Chuan showed any effect
Doi et al. [8]	Japan	RCT	201 older adults with MCI (≥ 70 years) Dance group = 67 Music group = 67 Education group = 67	Global cognition: MMSE Executive function: TMT-A&B Memory: Story memory, Word list memory	Long-term cognitive leisure activity programs involving dance or playing musical instruments resulted in improvements in memory and general cognitive function compared with a health education program in older adults with MCI
Hackney et al. [34]	United States of America	Q	74 older adults (59–95 years) Dance group = 62 Education group = 12	Global cognition: MoCA Executive function: TMT-B Other: the Reverse Corsi Blocks, the Brooks Spatial Task	Cognitive function did not improve but maintained throughout the 6 months of adapted tango intervention
Kattenstroth et al. [24]	Germany	RCT	35 older adults (60–90 years) Dance group = 25 Control group = 10	Cognition: RBANS Attention: AKT, FAIR	Dance can in combination with many features have beneficial effects on cognition, attention, posture and balance, and sensorimotor performance, as well as subjective well-being
Kim et al. [31]	South Korea	Q	44 elderly syndrome patients (> 60 years) Dance group = 32 Control group = 12	Global cognition: MMSE-KC Executive function: TMT-A&B Memory: Modified Boston Naming Test, Word List Memory, Word List Delayed Recall, Word List Recognition, Construction Recall Other: Verbal Fluency Test, Construction Praxis	Dance exercise may reduce the risk for cognitive disorders in elderly people with metabolic syndrome
Kosmat and Vranic [25]	Croatia	RCT	24 older adults with no cognitive impairments (69–88 years) Dance group = 12 Education group = 12	Executive function: WSCT-64 Memory: AVLT	Training procedures, based on dance, could improve cognitive functioning in old-old
Lazarou et al. [28]	Greece	RCT	154 older adults with MCI (60–80 years) Dance group = 89 Control group = 65	Global cognition: MMSE, MoCA Executive function: TMT-B,ROCFT Memory: RBMT Attention: TEA	Dance may be an important non-pharmacological approach that can benefit cognitive functions
Merom et al. [32]	Australia	RCT	115 older adults (≥ 60 years) Dance group = 60 Control group = 55	Executive function: TMT-A&B, SCWT, DSB Learning and Memory: RAVLT, BVMT	The superior potential of dance over walking on executive functions of cognitively healthy and active older adults was not supported

Table 1 (continued)

Study	Country	Study design	Participants	Measures/outcomes	Results
Merom et al. [33]	Australia	RCT	530 older adults (39% age > 80 years) Dance group = 279 Control group = 251	Executive function: TMT-A&B	Dance intervention did not lead to significant improvements in cognitive risk factors as measured with the TMT-B
Muller et al. [23]	Germany	RCT	52 older adults (63–80 years) Dance group = 26 Sport group = 26	Memory: VLMT Attention: TAP	Dance significant improve cognitive function in both dance and exercise groups, but no groups differences emerged
Zhang et al. [30]	China	RCT	76 older adults (60–70 years) Dance group = 39 Control group = 37	Global cognition: SECF	Square dancing exercise can improve the cognitive function and the depression, anxiety status for the aged
Chen [29]	China	RCT	125 older adults (61–82 years) Dance group = 65 Control group = 60	Global cognition: SECF	Square dancing can significant improve cognitive function in older adults

MoCA Montreal Cognitive Assessment, *TMT-A&B* Trail Making Tests Parts A and B, *SCWT* Stroop Color-Word Test, *DSB* Digits Span Backwards, *RAVLT* Rey Auditory Verbal Learning Test, *BVMT* Brief Visuospatial Memory Test, *VLMT* an adapted German version of the "Rey Auditory Verbal Learning Test", *TAP* Test of Attentional Performance, *MMSE* Mini-Mental State Examination, *RBANS* Repeatable Battery of Neuropsychological Status, *AKT* paper-and-pencil non-verbal geriatric concentration test, *FAIR* Frankfurt Attention Inventory, *WSCT-64* Wisconsin Card Sorting Test, *AVLT* Modified Auditory Verbal Learning Test, *ROCFT* Rey–Osterrieth Complex Figure Test, *RBMT* Rivermead Behavioral Memory Test, *TEA* Test of Everyday Attention, *SRT* Simple Reaction Time, *SPWM* Spatial Working Memory, *SECF* Scale of Elderly Cognitive Function, *Q* quasi-experimented, *RCT* randomized controlled trial, *MCI* mid cognitive Impairment

and results. If the studies used different time points for measurement, we chose the time point closest to the end of the intervention. Extracted data were checked by a third reviewer and any disagreements were resolved by discussion and consensus. In case when various tests measured the same outcome in one study, we only selected the most common measures for synthesizing. In case where the outcome measures used were very different from one study to another, we used quantitative synthesis to report on additional studies.

Study quality assessment

Study quality was assessed using the Downs and Black criteria [22] by two reviewers independently. The scales with the 27-item instrument are designed to assess the methodological quality of randomized and non-randomized studies. The instrument includes five quality domains: (1) reporting (10 items, 11 points), (2) external validity (3 items, 3 points), (3) bias (7 items, 7 points), (4) confounding (6 items, 6 points), and (5) power (1 item, 5 points). The maximum total score is 32 points. The quality was divided into four categories: poor (< 18), moderate (18–23), good (24–29) and, excellent (≥ 30). The Downs and Black criteria have a high internal consistency (Kuder–Richardson Formula 20:0.89), good inter-rater reliability (r = 0.75), and high test–retest reliability (r = 0.88).

Data analysis

The statistical analyses were performed using Review Manager, version5.0. All trials reported outcomes as continuous data, when studies used the same outcome scales, we calculated the mean difference (MD) with 95% CI. When studies used different scales to measure the same outcome, we used the standardized mean difference (SMD) with 95% CI in analyses. In all cases, we regard endpoint data as a superior method over change scores. This is preferred since data can be skewed in favor of the treatment or the control group where randomization is inadequate. If the endpoint data were not provided, they were calculated using baseline and change mean. Calculations were performed using a random effects model to accommodate for heterogeneity across studies. Under the random effects model, the individual study weights are more balanced, thus the summary effect is more conservative. Heterogeneity was assessed using the I^2 statistic, which is a quantitative measure of inconsistency across studies. Studies with an I^2 statistic of > 75% were regarded as high heterogeneity. When the heterogeneity identified across studies was high, we further performed subgroup analyses to explore possible explanations for heterogeneity, including study design (RCT/Q), study quality (low/high), and method used to evaluate cognitive function (MMSE/other). We also conducted sensitivity analyses to confirm consistency of the funding by omitting one study in each turn. A p value < 0.05 was considered statistically significant.

Results

Study research

573 studies were identified from electronic database search and two additional studies were identified by hand searching. 182 articles were excluded because of duplicate records. 328 studies were excluded based on the titles and abstracts. 65 full-text articles were then reviewed, from which 52 were excluded. Finally, 13 studies including 10 RCTs and 3 quasi-experiment that met our inclusion criteria were included in the systematic review and 9 studies underwent in the meta-analysis (Fig. 1).

Characteristic of studies

The characteristics of the eligible studies are summarized in Tables 1 and 2. The overall analysis of 13 studies investigating 1605 participants. Six studies [23–27] were conducted in the Europe (Germany [23, 24], Croatia [25], Portugal [26], France [27], Greece [28]), four in Asia (China [29, 30], Japan [8], South Korea [31]), two in Oceania (Australia [32, 33]), one in America (USA) [34]. The age of participants ranged from 59 [27] to 95 [34] years old. Ten studies assessed the elderly without any associated health condition, two studies [8, 28] examined the effect of dance on cognition in participants with MCI, and one study [31] evaluated the elderly patients with metabolic syndrome. The frequency of dance intervention varied from 45 [25] to 300 min [29, 30] per week, with the total training programs varied from 10 weeks [25] to 72 weeks [23]. Dance style varied across studies. Nine [8, 23, 25, 26, 28, 31–34] interventions were described as ballroom dance (eg., tango, waltz, Latin, jazz, salsa, cha-cha), two studies [29, 30] were used square dance, the other studies used

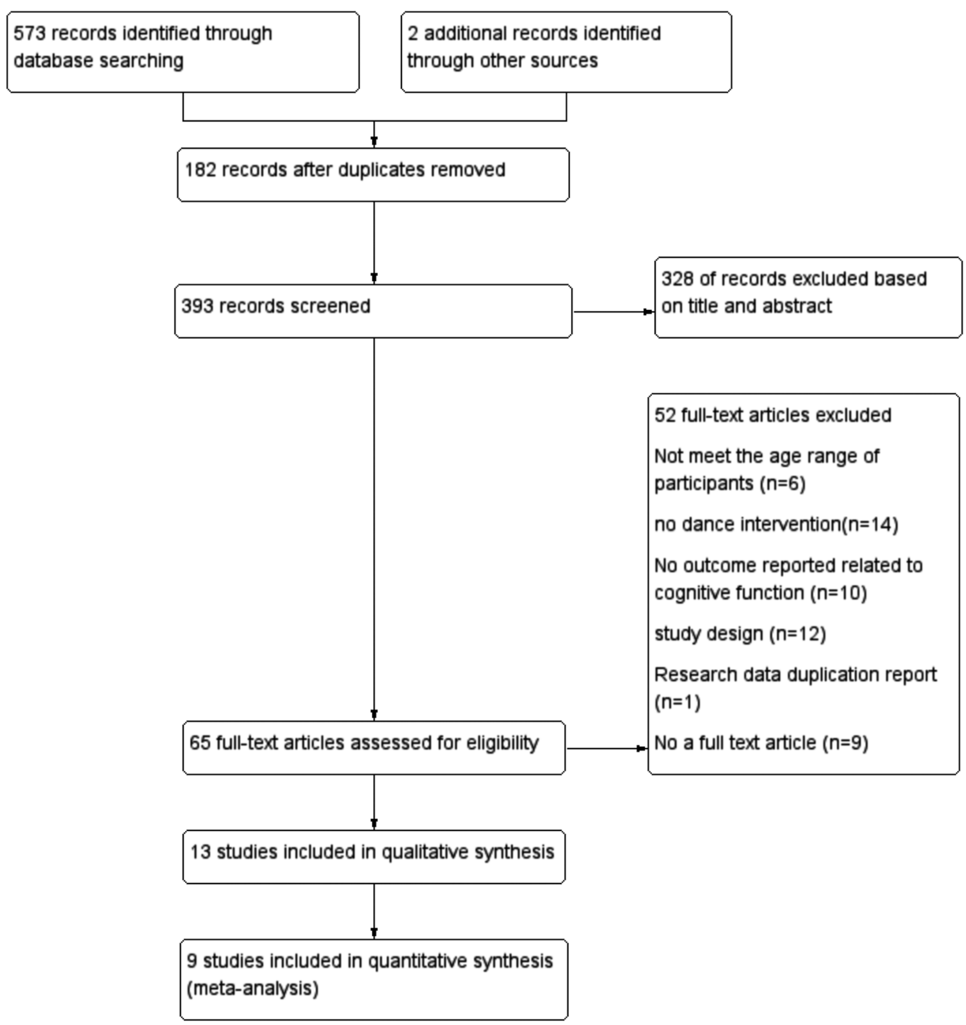

Fig. 1 Flow diagram for searching and selection of the included studies

Table 2 Characteristics of dance intervention and control groups

Study	Dance group characteristics	Dance length (weeks)	Frequency (times/week)	Dance session duration (min)	Control group characteristics
Alves [26]	Ballroom dance (with different rhythms, e.g., samba, bolero)	16	2	120	Walking group (participants walked together led by a professional exercise trainer) Control group (no intervention)
Coubard et al. [27]	Contemporary dance (based on specific theoretical, technical, and education principles with a focus on improvisation)	20–28	1	60	Fall prevention (emphasizes the development of balance and of lower limbs) Tai chi chuan (emphasizes the development of internal energy and of dynamic force)
Doi et al. [8]	Ballroom dance (including salsa, rumba, waltz, cha-cha, blues, jitterbug, and tango)	40	1	60	Music group (playing musical instruments) Education group (attend three health education classes)
Hackney et al. [34]	Tango (each session consist of practicing steps and partnering and rhythm enhancement exercises)	12	2	90	Education group (highly diverse health-related topics were discussed in a session)
Kattenstroth et al. [24]	Agilando™ (a special dance program developed for elderly people)	24	1	60	Control group (no intervention)
Kim et al. [31]	Latin (cha-cha consists of three fast steps and two slow steps with forward–backward and backward–forward weight transfer)	24	2	60	Control group (no intervention)
Kosmat and Vranic [25]	Waltz (each session consists of learning choreography and dancing slow waltz)	10	1	45	Education group (each session met with experimenter and discussed various topics about older adults)
Lazarou et al. [28]	Ballroom dances (such as tango, waltz, Viennese waltz, fox trot, rumba, cha-cha, swing, salsa, merengue, disco-hustle, as well as with Greek traditional ballroom dancing)	40	2	60	Control group (no intervention)
Merom et al. [32]	Ballroom dances (including rock and roll, foxtrot, waltz, and some Latin, e.g., salsa and rumba)	32	2	60	Walking group (a home-based self-help walking program)
Merom et al. [33]	Folk dances (including dances from the United Kingdom, United States, France, Italy, Israel, and Greece); ballroom dances (including rock and roll, foxtrot, waltz, salsa, and rumba)	48	2	60	Control group (no intervention)
Muller et al. [23]	Different genres dance (including line dance, jazz dance, rock ''n'' roll and square dance)	72	First period (24 weeks) 2 Second period (48 weeks) 1	90	Sport group (a conventional strength-endurance training program)
Zhang et al. [30]	Square dancing (a popular open-air fitness exercise throughout China)	48	4–5	30–60	Control group (no intervention)
Chen [29]	Square dancing (a popular open-air fitness exercise throughout China)	48	4–5	30–60	Control group (no intervention)

contemporary dance [27] and Agilando [24]. Agilando is a special dance program developed for elderly people and can be performed alone without a partner. Three [23, 27, 32] studies used exercise control groups included walking, strength-endurance and fall prevention, ten studies compared to no-exercising control groups included educational programs [8, 25, 34] and no intervention control groups [24, 26, 28–31, 33].

Our primary outcomes of interest are cognitive functions and are categorized into three cognitive domains: (1)Global cognition: there were eight [8, 23, 24, 28–31, 34] studies that evaluated global cognition using Mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA), Repeatable Battery of Neuropsychological Status (RBANS), Scale of Elderly Cognitive Function(SECF). (2)Executive functioning domain: nine [8, 25–28, 31–34] studies reported performance on the executive measures of Trail Making Tests Parts A and B (TMT-A&B), Digit Span, Wisconsin Card Sorting Test (WSCT-64), Digits Span Backwards (DSB), Rey–Osterrieth Complex Figure Test (ROCFT), Simple Reaction Time(SRT), Spatial Working Memory (SPWM), Stroop test, Flanker, Go–No-Go, Task Switching, Dot Comparison, Manual Sequence, Raven's Matrices, Arithmetic word problems, Rule shift cards test. (3)Memory domain: five [8, 25, 28, 31, 32] studies assessed performance on the memory measures of Rey Auditory Verbal Learning Test (RAVLT), Brief Visuospatial Memory Test (BVMT), Rivermead Behavioral Memory Test (RBMT), Rey Auditory Verbal Learning Test (VLMT), Story memory, Word list memory, Modified Boston Naming Test, Word List Memory, Word List Delayed Recall, Word List Recognition, Construction Recall, Memory Span test. The two most widely used assessment tools across studies were MMSE and TMT. Seven [8, 26, 28, 31–34] studies used the TMT, and three [8, 28, 31] studies used the MMSE.

Study quality assessment

Thirteen studies evaluated the quality and each domain scores across studies are shown in Table 3. The poorest scores were 18 points, while the best ones were 29, out of 32 total points. Seven were moderate quality and six were good quality. The average score for all studies was 23.15 (Table 3).

Global cognition

Meta-analyses for outcome related to global cognition indicated a large effect size, but high heterogeneity compared to no-exercising [SMD = 1.65, 95% CI (0.55, 2.75), $p = 0.003$; $I^2 = 96\%$]. Therefore, we further conducted subgroup analyses to explore possible explanations for heterogeneity. Three [8, 28, 31] of the seven studies employed MMSE as a measure of global cognitive function, two [29, 30] studies used SCEF. In the subgroup of using MMSE, results indicated a significant effect for dance on cognition [MD = 1.57, 95% CI (0.53, 2.61), $p = 0.003$; $I^2 = 62\%$] (Fig. 2), in the subgroup of using SCEF, effect sizes were statically significant and no heterogeneity between studies [MD = 33.25, 95% CI (30.94, 35.56), $p < 0.00001$; $I^2 = 0\%$] (Fig. 3).

Only one German study [23] assessed the benefits of newly designed dance program as compared to conventional strength-endurance training, while in cognitive ability data, group differences emerged with regard to the use of Verbal Memory Test. The authors discussed that the intervention might be insufficient.

Table 3 Quality of included studies

Study	Reporting (11 points)	External validity (3 points)	Bias (7 points)	Confounding (6 points)	Power (5 points)	Total (32 points)	Quality as per cutoff described
Alves [26]	8	2	4	4	0	18	Moderate
Coubard et al. [27]	7	1	4	2	5	19	Moderate
Doi et al. [8]	10	3	6	5	5	29	Good
Hackney et al. [34]	10	2	6	5	0	23	Moderate
Kattenstroth et al. [24]	9	2	5	5	5	26	Good
Kim et al. [31]	7	2	6	3	5	23	Moderate
Kosmat and Vranic [25]	9	2	6	3	5	25	Good
Lazarou et al. [28]	7	3	5	4	5	24	Good
Merom et al. [32]	9	3	7	6	0	25	Good
Merom et al. [33]	10	3	6	6	0	25	Good
Muller et al. [23]	9	2	5	5	0	21	Moderate
Zhang et al. [30]	7	2	5	3	5	22	Moderate
Chen [29]	7	2	5	2	5	21	Moderate

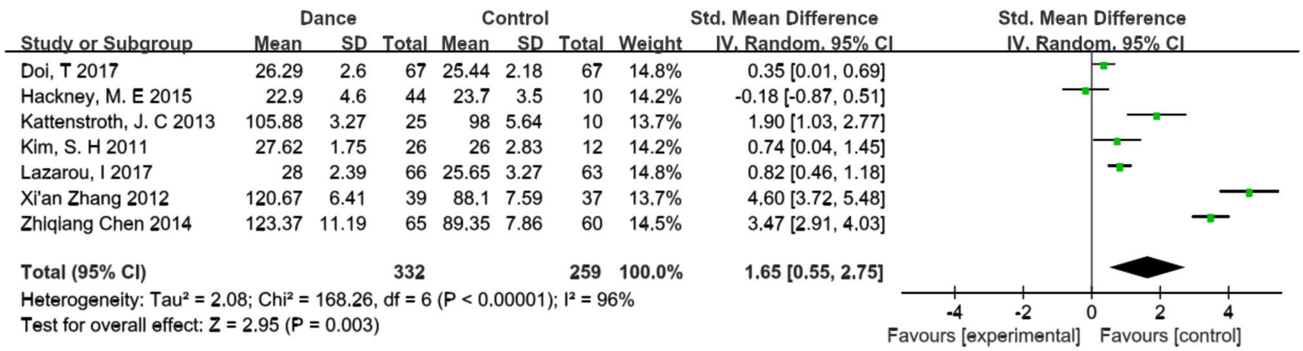

Fig. 2 Result of meta-analyses evaluating global cognition between dance and control

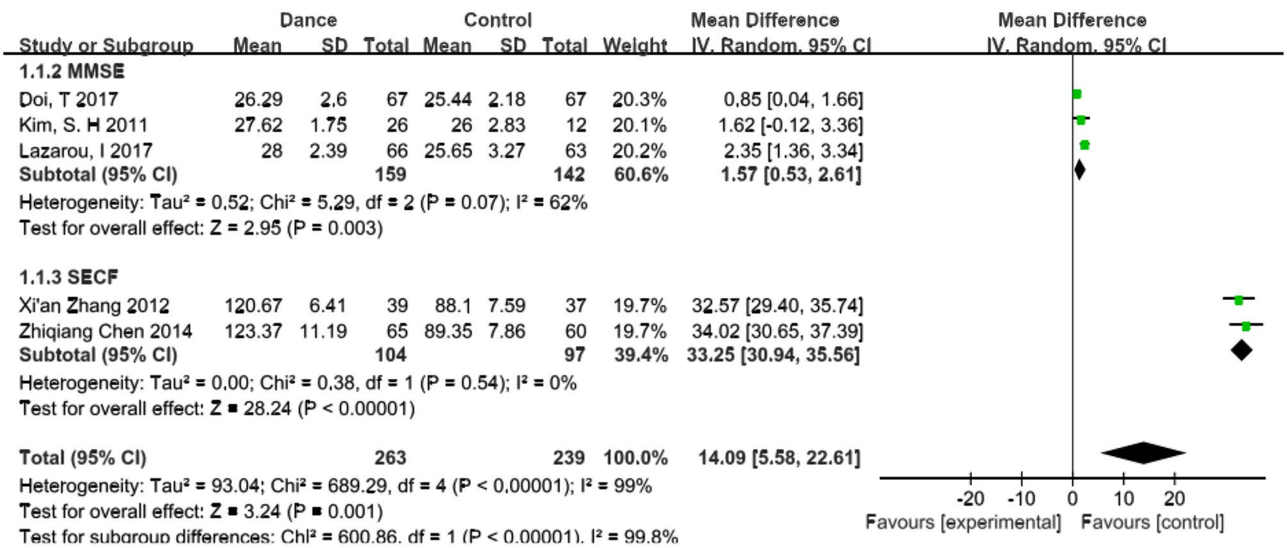

Fig. 3 The effects of dance on global cognitive function was measured by MMSE and SCEF

Executive function

The effects of dance on executive function were evaluated in seven [8, 25, 26, 28, 31, 33, 34] studies that compared to no-exercising controls using the TMT-B. Meta-analyses revealed no significant differences between the two groups in measures of executive function [SMD = 0.17, 95% CI (− 0.07, 0.42), $p = 0.17$; $I^2 = 42\%$] (Fig. 4a). Sensitivity analysis of executive function showed no heterogeneity but remained with no statistically significant differences when one study [26] with a low-quality score indicating bias was excluded [SMD = 0.13, 95% CI (− 0.02, 0.27), $p = 0.09$; $I^2 = 0\%$] (Fig. 4b).

Dafna [32] 2016 determined whether dance benefits executive function more than walking. The finding from 115 participants did not support the superior potential of dance over walking on executive functions of cognitively health and active older adults. The authors argued that significant differences between the dance and the walking group were not found because the participants, particularly the walking group, appeared to be highly active at baseline. Another explanation could be the nature of intervention, which lacked sufficient physical and mental challenges. Future research requires high intensity and higher dosage of intervention. Olivier [27] examined the impact of contemporary dance improvisation on attention control (a dimension of executive function) of older adults, as compared to two other motor training programs, fall prevention, and Tai Chi Chuan. After 5.7-month training, the results indicated that CD improved switching but not setting or suppressing attention, while neither fall prevention nor Tai Chi Chuan showed any effect.

Memory function

We found four studies [8, 25, 28, 31] that compared with non-exercising controls were conducted to evaluate the effectiveness of dance intervention on memory with a total 423 older adults. Assessment tools for memory function

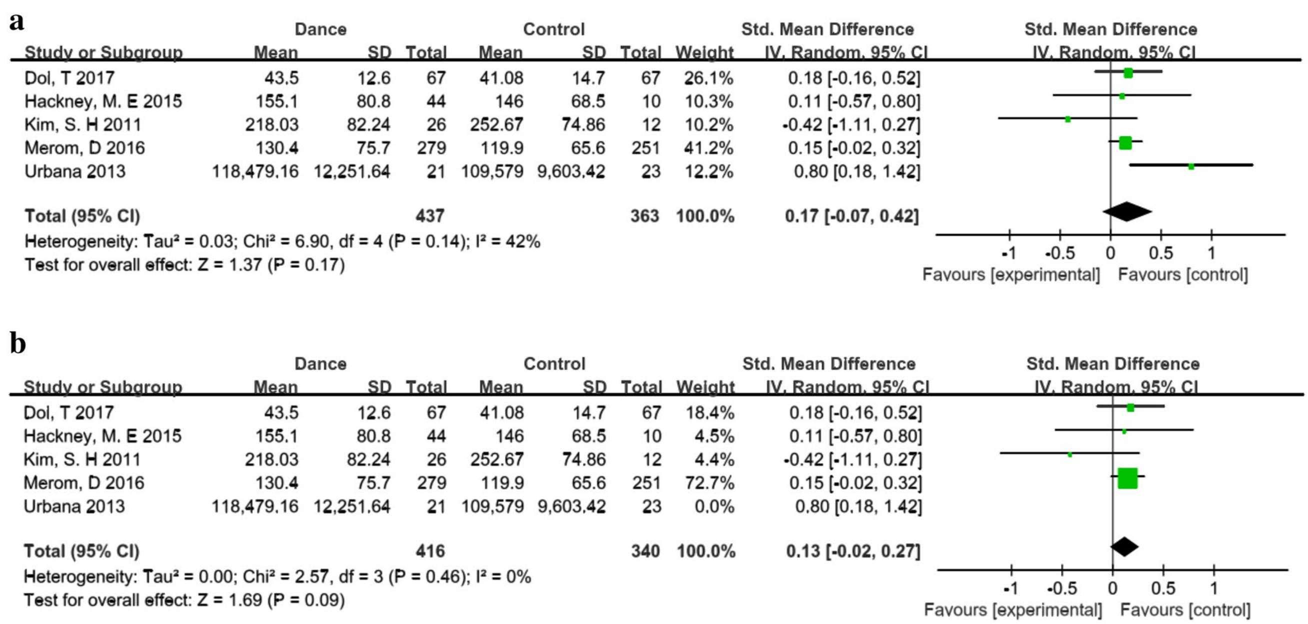

Fig. 4 The effects of dance on executive function in older adults

varied substantially, these outcomes on memory were not employed consistently across studies precluding quantitative synthesis. Therefore, our study only qualitatively describes the memory domain. All four studies reported significant improvements in memory for the dance intervention. Two studies [8, 28] evaluated the effect of dance intervention for older adults with mild cognitive impairment (MCI). One study [8] of 201 Japanese adults with MCI was determined to compare a 40-weeks dance to health education. Memory function measured using the story memory and world list memory tests from the National Center for Geriatrics and Gerontology Functional Assessment Tool study cognitive assessment battery. The results indicated that dance interventions resulted in improvements in memory function compared with control group. However, dance was beneficial for story recall but not for world list recall in this trial. The authors discussed that story recall might be more sensitive than word recall to the early memory changes of Alzheimer disease. The other [28] study explored the effects of International Ballroom Dancing on cognitive function in elders with amnestic mild cognitive impairment (aMCI). Short-term and long-term memories were measured by Rivermead Behavioral Memory Test story direct and delayed recall (RBMT). Significant differences between groups were found in benefit of the dance group, while the control group showed worse performance in the memory function. Se-Hong2011 [31] reported on finding from 44 elderly metabolic syndrome patients with normal cognitive function. Statistically significant improvement on memory domain was found in dance group with regard to word list delayed recall ($p = 0.038$) and word list recognition ($p = 0.007$). Kosmat [25] investigated the efficacy of dance intervention of moderate length (10-weeks, 45 min/week) on cognitions in 24 older adults with no cognitive impairments. In this study, a modified AVLT procedure was used to tap short-term memory. The authors found an improvement in short-term auditory-verbal memory in dance group.

Only one study [32] investigated the memory performance of social dance among community-dwelling older adults as compared to walking. Dance participants performed better on visuospatial immediate and delayed recall were measured by RAVLT and BVMT.The authors discussed the most likely explanation is that spatial learning and memory are useful for learning dance, and that participants doing the dance intervention may have practiced this skill to help remember dance steps leading to improvement.

Discussion

This is the first meta-analysis and systematic review to evaluate the efficacy of dance intervention on global cognition, executive function and memory in older adults. The present meta-analysis showed a positive effect of dance on global cognition, while there were no significant differences of dance on executive function in elderly. The present quantitative analysis showed that dance may benefit memory function in older adults. However, in our review, dance was more effective for elderly cognitions than exercise may be not support.

Seven studies evaluated the effect of dance intervention on global cognition in older adults when compared with no-exercising controls [8, 24, 28–31, 34]. In these individual studies, five out of seven reported significant improvement for dance groups. Meta-analysis results revealed that dance significantly improve global cognition in elderly. Four studies [8, 25, 28, 31] that compared with non-exercising controls were conducted to evaluate the effectiveness of dance intervention on memory. Quantitative analysis showed that dance may benefit memory function in older adults. Several explanations for the impact of dance cognitive function have been suggested. First, dance is classified as a moderately aerobic exercise. This intensity dancing and exercise have been shown to have positive effects on cognition [35] and brain structure [36, 37]. Cognitive decline may be partially caused through cerebrovascular insufficiency, which tends to increase with age. However, exercises maintain cerebrovascular integrity by sustaining blood flow and the supply of oxygen and nutrients to the brain [38]. Exercise affects cognition by increasing brain-derived neurotrophic factor (BDNF) and synapses, and promoting neuronal growth and survival [39, 40]. Second, dance is a combination of music and exercise that may add further benefits on cognition. More generally, music employs numerous emotional and cognitive activities and provides acoustic stimulation. "Neurologic music therapy" (NMT) has been developed as a systematic treatment method to improve sensorimotor, and cognitive domains of functioning via music [41]. From animal research, music exposure can enhance brain-derived neurotrophic factor (BDNF) expression level in dorsal hippocampus (DH) and thus enhance spatial cognition ability [42]. Third, another possible benefit of dance on cognition is the effective education and learning associated with dancing. Participants are required to follow the instructor's lead to learn dance steps and directions, and complex motor sequences during dance class. Verghese et al. [15] argued that participation in leisure activities, similar to education, may increase cognitive reserve, reducing the incidence and delaying the onset of dementia. Similarly, the learning therapy was reported as an effective cognitive rehabilitation for the dementia patients by improving prefrontal function [43]. Learning of new and complex dance-related movement induces changes in multiple brain regions in unfamiliar dance situations [14]. Cross [44] found that learning to dance by effective observation appeals to be closely related to learning by physical practice, both in the level of achievement and also the neural substrates that support the organization of complex actions. Finally, dance is a multicomponent training with physical, cognitive, and social dimensions, all of which may be synergetic benefits when delivered in combination. Animal research showed that combining physical activity with sensory enrichment has stronger and longer-lasting effects on the brain than either treatment alone [23].

There were two studies [31, 34] with no significant improvements of global cognition in older adults. Madeleine evaluated Tango for older adults in independent living on the cognition measure of the Montreal Cognitive Assessment (MoCA). The results indicated that cognitive function did not improve but was maintained in dance group compared to control groups. The authors discussed that several participants in this study performed difficulty with ADLs at baseline, and the speed of cognitive decline greatly increase for many older adults after ADL performance difficulty begins [34]. Se-Hong Kim concluded that a 6 month of dance exercise did not significant improve cognitive function measured by the MMSE-KC. The authors explained this finding by the lack of sensitivity of MMSE. Additionally, both studies [31, 34] are small sample size and quasi-experimental design that subjects were neither randomized nor blinded. It is possible that experiments' potential bias might have affected finding.

Executive function, the management of cognitive process, has been conceptualized as four components; the abilities to formulate goals, plan how to achieve them, carry out goal-oriented plans, and perform effectively [45]. Previous studies imply that an activity that engages attention and memory progress would improve executive cognitive function [46]. Dancing is analogous to such activity, which requires executive function including focus of attention, remember instructions, and juggle multiple tasks successfully. However, the present meta-analysis showed that no significant improvements of dance on executive cognition. Some possible reasons are discussed below. First of all, previous research has shown that the effect of exercise on executive function is inconsistent and depends on the characteristics of the subjects [47] and exercise duration [48]. Therefore, the heterogeneity of participants in term of cognition at baseline may influence the finding. In several participants with ADL impairment at baseline, the speed of cognitive decline increased significantly [34]. So, it's hard to maintain or improve their executive function. Other subjects were cognitively active at the start of the dance group. Engaging older adults who are generally fit and active may leave little room for improvement if, as a consequence, the brain already exhibits efficient processing [31, 33]. No improvement in executive function may be due to inadequate training does, such as short intervention period and low dance intensity. On the other hand, no significant differences in executive function between groups may have been the result of active controls. Social interaction that experienced in the education group can affect cognition [49].

Compared with traditional exercise, dance is a complex sensorimotor rhythmic activity integrating multiple physical, cognitive, and social elements [50] and provides multisensory stimulation in an enriched environment [51]. Consistent evidence demonstrates that a multimodal exercise intervention can achieve superior effects on cognitive function as opposed to single modality interventions [52, 53]. In our review, two RCTs [23, 32] did not find that dance intervention was more effective for elderly cognitive functions than exercise. The third study by Coubard OA suggests that dance improve cognition as compared to other motor training programs. However, the quality of this study was too poor to draw any useful conclusions. The present quantitative synthesis shows that improvements in cognition were observable in both dance and exercise groups, but no group differences emerged. One explanation could be the nature of dance intervention, which is a moderate-intensity physical activity. Prolonged intervention time and increased intervention dosage might have greater cognitive benefits.

There are several limitations to this meta-analysis and systematic review. First, there is too few studies that focus on the effects of dance on cognitive function in older adults, so a limited number of studies are included in this study. Moreover, the analysis of global cognition showed high heterogeneity across the included studies, and we explored that heterogeneity comes from the variation in cognitive measures by subgroup. Because of the heterogeneity of the measures, we have to limit our meta-analyses to only the most commonly measured outcomes. In addition, our review was limited to published studies in the English and Chinese language, which may increase the risk of publication bias.

Further research in this area should pay attention to the following points. To date, most of the studies focus on the effects of dance on cognition in older adults with normal cognition. Further studies should pay more attention to the elderly with cognitive impairment such as MCI and dementia; to improve and maintain the effect of intervention, the duration of dance intervention should be extended appropriately and conduct a long-term follow-up. There is a need for further standardized cognitive outcome measures allowing for more pooling of homogenous data; larger and well-designed RCTs are required to evaluate the effects of dance on cognition with aging.

Conclusion

Our meta-analysis and systematic review suggest that dance may be a safe and effective approach to improve cognitive function in older adults. However, studies with larger, high quality, and homogeneous are required to determine the effects of dance on executive function and memory function.

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Compliance with ethical standards

Conflict of interest The authors declared no conflicts of interest relevant to this article.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study, formal consent is not required.

Appendix

PubMed search strategy

((((((“dance therapy”[MeSH Terms] OR (“dance”[All Fields] AND “therapy”[All Fields]) OR “dance therapy”[All Fields] OR (“dance”[All Fields] AND “therapies”[All Fields]) OR “dance therapies”[All Fields]) OR (“dance therapy”[MeSH Terms] OR (“dance”[All Fields] AND “therapy”[All Fields]) OR “dance therapy”[All Fields] OR (“therapy”[All Fields] AND “dance”[All Fields]))) OR (“dance therapy”[MeSH Terms] OR (“dance”[All Fields] AND “therapy”[All Fields]) OR “dance therapy”[All Fields] OR (“therapies”[All Fields] AND “dance”[All Fields]))) OR (“dancing”[MeSH Terms] OR “dancing”[All Fields] OR “dance”[All Fields])) OR (“dancing”[MeSH Terms] OR “dancing”[All Fields])) AND (((((((“cognition”[MeSH Terms] OR “cognition”[All Fields] OR “cognitions”[All Fields]) OR (“cognition”[MeSH Terms] OR “cognition”[All Fields] OR (“cognitive”[All Fields] AND “function”[All Fields]) OR “cognitive function”[All Fields])) OR (“cognition”[MeSH Terms] OR “cognition”[All Fields] OR (“cognitive”[All Fields] AND “functions”[All Fields]) OR “cognitive functions”[All Fields])) OR (“cognition”[MeSH Terms] OR “cognition”[All Fields] OR (“function”[All Fields] AND “cognitive”[All Fields]) OR “function, cognitive”[All Fields])) OR (“cognition”[MeSH Terms] OR “cognition”[All Fields] OR (“functions”[All Fields] AND “cognitive”[All Fields]) OR “functions, cognitive”[All Fields])) OR ((“brain”[MeSH Terms] OR “brain”[All Fields]) AND (“physiology”[Subheading] OR “physiology”[All Fields] OR “function”[All Fields] OR “physiology”[MeSH Terms] OR “function”[All Fields]))) OR (“memory”[MeSH Terms] OR “memory”[All Fields]))) AND ((((((((“aged”[MeSH Terms] OR “aged”[All Fields] OR “elderly”[All Fields]) OR (“aging”[MeSH Terms] OR “aging”[All Fields])) OR (“aging”[MeSH Terms] OR “aging”[All Fields] OR “ageing”[All Fields])) OR (“aged”[MeSH Terms] OR “aged”[All Fields])) OR (“aging”[MeSH Terms] OR “aging”[All Fields] OR “senescence”[All Fields])) OR (“aging”[MeSH Terms] OR “aging”[All Fields] OR (“biological”[All Fields] AND “aging”[All Fields]) OR “biological aging”[All

Fields])) OR older[All Fields]) OR (older[All Fields] AND ("adult"[MeSH Terms] OR "adult"[All Fields] OR "adults"[All Fields]))).

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