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Combined Tai Chi and cognitive interventions for older adults with or without cognitive impairment: A meta-analysis and systematic review

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ABSTRACT

Background and purpose: Evidence from the field of cognitive interventions indicates that nonpharmaceutical interventions seem more promising in enhancing cognition. The number of clinical trials that examine the cognitive benefits of combined physical exercise with cognitive intervention on older adults has recently increased. Tai Chi (TC) has been recommended as an effective and safe exercise for older adults aged 60 and over. However, there is a lack of conclusion about whether combined TC with cognitive interventions can show more benefits than a single intervention for older adults. Thus, this review aimed to evaluate the effects of combined TC and cognitive interventions on older adults.

Methods: PubMed, Embase, PsycINFO, and Web of Science were searched for English peer-reviewed papers from inception until November 12, 2021. Data were extracted by two independent reviewers.

Results: A total of 1524 records were generated and nine studies were included. The pooled results showed that combined TC and cognitive interventions showed significantly large gains on memory [standardised mean difference (SMD) = 0.87, 95% confidence interval (CI): (0.01, 1.74), P 0.05], moderate gains on cognition [SMD = 0.74, 95% CI:(0.19, 1.29), P 0.05], and small size effects on balance. No statistically significant difference was found in executive function, depression, risk of falls, or well-being.

Conclusion: Combined TC and cognitive interventions have positive effects on improving cognition and balance in older adults, but their superiority over the single intervention, as well as their additional effects on the physical and psychological function, are required further investigation.

1. Introduction

Tai Chi, a popular traditional Chinese mind-body exercise, is a safe and cost-effective intervention for older adults.[1] A range of robust recent systematic reviews and meta-analyses have examined the effects of TC among older adults. The positive effects of cognition have been reported by a meta-analysis in which TC had a large effect on global cognitive ability and memory, and a moderate effect on executive function.[2] Similar beneficial effects were reported by recent systematic reviews and meta-analyses in global cognition, executive function, memory, visuospatial ability, and attention.[3–7] Additionally, TC was found to have a statistically moderate effect size in physical activities,[5] balance,[8,9] and depression[9] among adults over the age of 60. Taken together, TC is an ideal exercise for older adults to maintain their health.

There is a growing interest in combining physical exercises with cognitive interventions to maximise cognitive gains. A large number of systematic reviews and meta-analyses demonstrate that combined physical and cognitive interventions tend to be beneficial for older adults. Gheysen and colleagues[10] systematically examined 40 studies about the effects of the combined physical (aerobic or/with strength training) and cognitive interventions on cognition among older adults. The findings displayed that the combined intervention had the potential value to improve cognition (g = 0.316, 95% CI: 0.188–0.443). Gavelin et al.[11] conducted a review of 41 studies on the effects of combining various physical exercises with cognitive interventions for older adults with/without cognitive impairment and discovered small effects on overall cognition (g = 0.22, 95% CI: 0.14–0.30). Similar positive results were reported for the combination of physical-cognitive intervention, which could improve the cognition of older adults with/without cognitive impairment.[12–16]

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Although the value of the combined physical and cognitive interventions for older adults has been recognised, the question of whether combined physical and cognitive interventions are more effective than a single intervention remains debatable. Findings from laboratory animal studies indicate that combining physical and cognitive interventions demonstrated more cognitive benefits than physical intervention alone.[17,18] Nonetheless, inconsistent results were found in human studies. Guo et al.[19] compared combined physical and cognitive interventions with a control group and reported that the combined intervention had small effects on executive function among older adults (SMD= 0.26, 95% CI: 0.14–0.39). However, no effects on executive function were found when comparing the combined intervention with a cognitive intervention or a physical intervention. Similar findings were observed in the literature. A number of systematic reviews and meta-analyses stated that combined physical-cognitive interventions were not superior to single intervention in healthy older adults[20–22] and older adults with MCI,[23] whereas others reported that combining physical-cognitive interventions were more successful compared to a single intervention in healthy older adults[11,24] and older adults with cognitive impairment.[12,13,25] In conclusion, the knowledge that combined physical-cognitive interventions improve cognition is important but insufficient. Thus, there is a need to advance the knowledge about the benefits of combined intervention for older adults.

However, there is no consensus about what kinds of physical exercise should be combined with cognitive interventions to maximise the benefits for older adults. When compared to vigorous exercises, TC is an optimal exercise for older adults in terms of building flexibility and strength, as well as being less likely to cause injuries and muscle strain.[26] As the profits of TC have been recognised in the literature, it has been recommended as an effective exercise intervention to enhance both physical and psychological health.[27] Inspired by this evidence, the combined intervention in this review is defined as an intervention that comprises two different nonpharmacological interventions: TC and cognitive interventions. However, the effects of combined TC with cognitive interventions remain unknown. Moreover, there is no systematic review that has comprehensively analysed the effects of combined TC and cognitive interventions for older people. Therefore, the objective of this review and meta-analysis was to examine the effect sizes of combined TC and cognitive interventions at efficiently improving cognition, physical and psychological measures, as well as wellbeing.

2. Methods

The protocol of this review was not registered. This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines published in 2020[28] (Appendix A).

2.1. Search strategy

PubMed, Embase, Web of Science, and PsycINFO were first searched for all relevant citations published from the inception of a given database to December 2020. The search was rerun on November 12, 2021. We established search strategies that combined medical subject headings and text word searches. The search strategies included "tai-chi" OR "t'ai-chi" OR "tai-ji" OR "taiji" OR "taijiquan" OR "tai chi" OR "tai chi chuan" OR "tai ji quan" or "Tai ji" or "Tai ji quan*" OR "Tai chi chih" AND "cognitive train*" OR "cognitive interv*" OR "cognitive rehabil*" OR "cognitive therapy" OR "computer training" OR "cognitive exercise*". The search was limited to English articles. Review articles were also used as a source in a search for additional studies.

2.2. Inclusion and exclusion criteria

The trials selected in this review met the following inclusion criteria: (1) study design: published randomised controlled trials (RCTs) were included; (2) participants were older adults (age: 60 years and older); (3) intervention included both TC and cognitive interventions in the experimental group; (4) comparison: included a single intervention or no intervention but was not limited to drug treatment, regular treatment, and educational programmes; and (5) outcomes: the study contained at least one measurement that assessed cognition. The following studies were excluded: (1) conference abstracts, study protocols, and duplicate reports; (2) studies that did not have relevant data; (3) apart from TC, the intervention group included the other physical exercises; (4) the studies did not assess the effects of cognition; and (5) the studies did not report sufficient data to calculate the effect size.

2.3. Screening and selection strategy

The screening and selection process strictly followed the inclusion and exclusion criteria. The study selection process was performed by two independent reviewers. Any disagreements between the two reviewers were resolved through consensus with the help of a third reviewer.

2.4. Data extraction

Data and relevant information were extracted from the included studies by two independent reviewers. The extracted information from eligible studies included study reference, country, participants' characteristics, cognitive status, intervention group, control group, delivery format, mode of combination, duration, and frequency. Of note, if any vital information was unavailable from the publications, we contacted the study authors for additional information. If such information remained unavailable, all reviewers decided whether to include the study in this review. When studies employed two or more measures to assess cognition, the one most frequently used measure was included in the meta-analysis. For example, the Digit Span (DS) and Trail Making Test (TMT) are commonly used to assess executive function in this review. Given that the older age is associated with significant declines in working memory and inhibition,[29] the DS was selected over TMT.

2.5. Risk of bias and study quality assessment

The risk of bias in the included studies was evaluated by two reviewers based on the Cochrane Risk of Bias Tool.[30] This tool assessed six components: random sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting, and other bias. Each item was rated as a "high risk," "unclear risk," or "low risk" of bias. If any discrepancies existed, the third reviewer was consulted to reach an agreement.

2.6. Statistical analysis

Analyses were performed in the R programming language and environment version 4.1.2 using the 'meta-package'. The means, standard deviations (SDs), and the number of participants for each group pre-and post-intervention were extracted. When means and SDs were not available, the changes in the mean and SD, and the upper and lower limits of the 95% CI were used based on the Cochrane handbook for systematic reviews of interventions.[31] The SMD statistic was selected when the outcome was assessed by the different scales. I^2 statistics were calculated to assess the heterogeneity, which ranged from 0 to 100 (1–49% = small, 50–74% = medium, 75–100% = large).[32] A random-effects model was chosen because the included studies were not matched on the characteristics of the sample (e.g., cognitive status) that could influence the magnitude of the effect size. Sensitivity analysis was performed to search for the source of heterogeneity when the pooled result indicated high heterogeneity. Subgroup analyses were not performed due to a limited number of included studies (K<10). Given the limited sample sizes, publication bias was not assessed. The Cochrane

handbook shows that SMD is equivalent to the effect size (ES) in the social sciences. According to Cohen, $0.2 \leq ES < 0.5$ was considered a small effect, $0.5 \leq ES < 0.79$ was considered a moderate effect, and $ES \geq 0.8$ was considered a large effect.[33] The statistical significance was set as a P value < 0.05.

3. Results

3.1. Identification of relevant studies

The database search yielded 1524 records. Of these, 835 records were removed as duplicates, and 658 records were excluded following the screening of study titles and abstracts. The remaining 31 articles were further screened, and three articles were removed due to no full-text availability; 19 articles were excluded because they did not meet the research criteria in this review. Three RCTs were excluded from the meta-analysis due to insufficient outcome data. Finally, nine RCTs were included in the meta-analysis. The study selection process is summarised in Fig. 1.

3.2. Characteristics of the included studies

Table 1 presents the characteristics of all nine studies included in this review. The sample size ranged from 12 to 389. The overall sample size was 979, including 467 in the experimental groups and 512 in the control groups. Among the nine studies included, three focused on older adults with mild cognitive impairment (MCI), two focused on older adults with probable dementia or mild stage dementia, one focused on healthy older adults, one focused on older adults with cognitive impairment, and one focused on older adults with memory impairment. The included studies were conducted in three countries: seven in China, one in Thailand, and one in the USA.

3.3. Quality assessment of included studies

The results of the risk of bias are presented in Fig. 2. For random sequence generation, six of the nine trials had adequate random sequence generation by a computer-generated schedule and random numbers. Two included studies did not mention the concrete method of random sequence generation.[34,35] One trial reported nonrandom sequence generation.[36] Regarding location concealment, only five trials mentioned the use of allocation concealment.[37–41] As researchers and participants are less likely to be blinded in behaviour intervention studies, five studies did not employ, and the other four did not report the blinding of participants and researchers. Seven studies[35–41]reported assessor blinding, while the remaining two studies did not.[34,42] Regarding the incomplete outcome data, five of the nine included studies stated the application of the intention-to-treat approach,[35,37–40] one study used the last observation carried forward technique,[42] and three studies did not use both approaches.[34,36,41] All the studies were considered to have a low risk for reporting bias because all included studies reported cognitive data. For other biases, all included studies had adequately matched participants in the two groups in the baseline data.

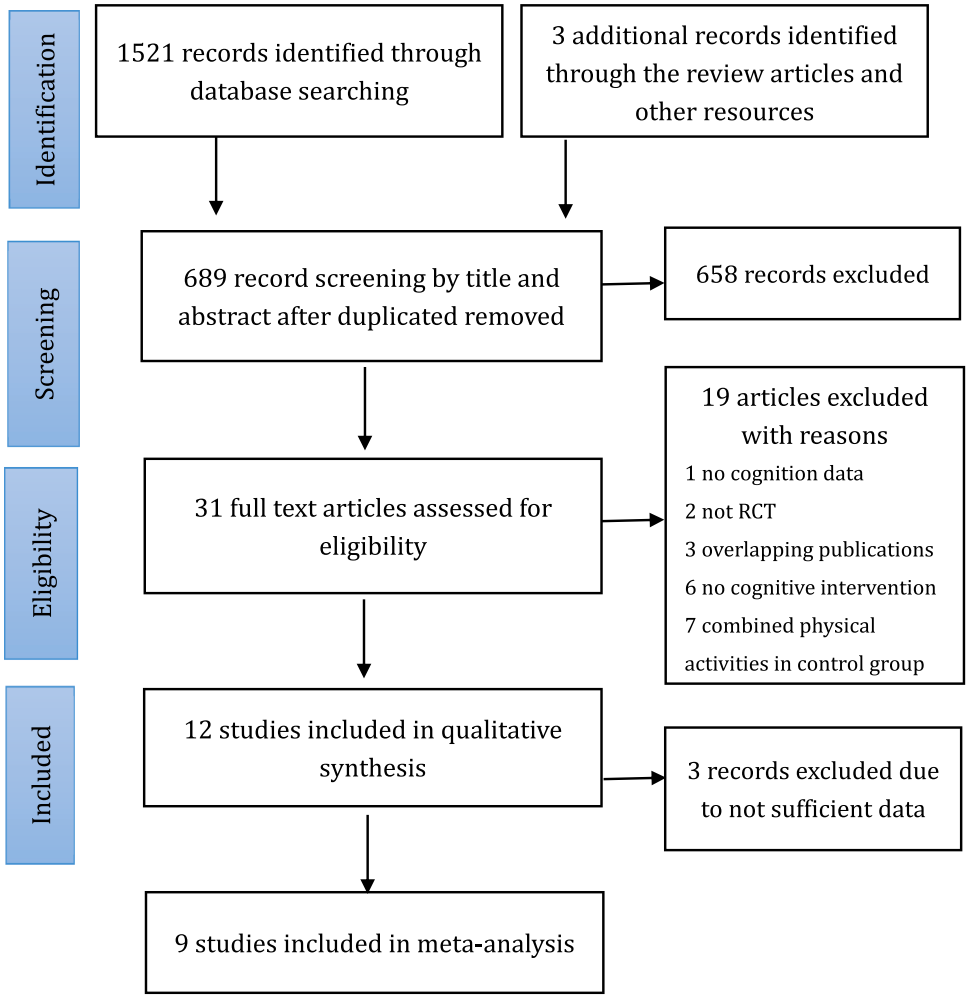

Fig. 1. PRISMA flow diagram: articles included and excluded in this review.

Table 1
Study characteristics of included studies.

Reference	Country	Participants Pre/Post (Age: M ± SD)	Cognitive status	Intervention group		Control group	Delivery format	Mode of combination	Frequency	Duration
				TC	Cognitive intervention					
Lam et al.[37]	China	IG= 171/92 (77.2 ± 6.3) CG= 218/169 (78.3 ± 6.6)	Older adults at risk of cognitive decline	24-form TC	Memory enhancement strategies (a digital record+ verbal reminder)	Muscle stretching and toning exercise	Individual & group	Simultaneous	Three 30 min sessions	12 months
Tsai et al.[38]	USA	IG= 40/28 (78.89 ± 6.91) CG= 40/27 (78.93 ± 8.30)	Older adults with cognitive impairment (MMSE:18–28)	12-form TC	Memory enhancement strategies (visual and verbal memory training) + social support activities	Attention control	Individual & group	Simultaneous	Three 60 min sessions	20 weeks
Lu et al.[42]	China	IG= 15/13 (67.3 ± 6.6) CG= 16/14 (72.8 ± 6.7)	Healthy older	12-form TC	Memory enhancement strategies (procedure memory training)	Health education	Group	Sequential	Three 60 min sessions	16 weeks
Sungkarat et al.[39]	Thailand	IG= 33/29 (68.3 ± 6.7) CG= 33/30 (67.5 ± 7.3)	a-MCI (MMSE ≥ 24, MoCA < 26)	10-form TC	Memory enhancement strategies (a digital record and visual reminder)	Health education	Group	Simultaneous	Three 50 min sessions	12 weeks
Tian et al.[34]	China	IG= 30/30 (67.79 ± 6.96) CG= 30/30 (66.34 ± 5.87)	Memory impairment (RBMTII < 22)	24-form TC	Memory training (visual memory training, story repetition, etc)	TAU	Group	Sequential	Two to four 30 min sessions	6 months
Siu et al.[36]	China	IG= 80/74 (N/A) CG= 80/71 (N/A)	MCI (MMSE:19 – 28)	24-form TC	Memory enhancement strategies (a guided book+ digital record+ verbal reminder)	TAU	Group	Simultaneous	Two 60 min sessions	16 weeks
Young et al.[40]	China	IG = 51/46 (80.53 ± 6.26) CG= 50/46 (79.86 ± 6.59)	Mild stage dementia (MMSE: 20.67 ± 2.30)	8-style TC	Cognitive stimulation therapy	TAU	Group	Sequential	Two 60 min sessions	7 weeks
Xu et al.[41]	China	IG= 6/5 (70.67 ± 4.23) CG= 6/6 (74.50 ± 5.93)	MCI (MoCA: 19–21)	24-form TC	Risk factor modification (nutritional intervention + metabolic and vascular risk factors management) + cognitive training (Rummikub)	Heath advice	Individual & group	Sequential	Three 30 min sessions	12 weeks
Young[35]	China	IG= 41/37 (80.05 ± 6.17) CG= 39/36 (80.25 ± 6.33)	Older adults with probable dementia (MMSE:20.41 ± 2.14)	8-style TC	Cognitive stimulation therapy	TAU	Group	Sequential	Two 60 min sessions	7 weeks

Note: IG: intervention group; CG: control group; MCI: mild cognitive impairment; N/A: not applicable; TAU: Treatment as usual; M: mean; SD: standard deviation MMSE: Mini-Mental State Examination; MoCA: Montreal Cognitive Assessment; RBMT: Rivermead Behavioural Memory Test.

3.4. Characteristics of combined intervention

The characteristics of the nine included studies are presented in Table 1. The intervention duration varied in these included studies, with the duration of telehealth intervention ranging from 7 weeks to 12 months with a frequency of two to four 30–60 min weekly sessions. Five studies delivered the combined intervention by using a sequential design,[34,35,40–42] while four studies used a simultaneous design.[36–39] Regarding the delivery format, seven studies were conducted in the group format,[34–36,39–42] and two studies involved both individual and group components.[37,38] Except for one study (46.2%), the dropout rate in the other eight studies ranged from 0% to 30%.

In the intervention group, various forms of TC were observed, including 24-form, 12-form, 10-form, and 8-form. Regarding the cognitive intervention, five studies involved memory enhancement strategies,[36–39,42] including verbal or visual reminders and procedure memory training. Seven studies applied two-component intervention: four RCTs used a combination of TC and memory enhancement strategies,[36,37,39,42] two RCTs combined TC with cognitive stimulation therapy,[35,40] and one RCT combined TC with memory training.[34] Two RCTs involved three-component interventions: one RCT combined TC with cognitive training and a risk factor modification group,[41] and the other combined TC with memory enhancement strategies and social support activities.[38]

In the control groups, all studies applied a single intervention. Of those, four studies provided usual/standard care or standard education for participants,[34–36,40] three studies provided health education/lecturer/health advice for the participants,[39,41,42] one study provided muscle stretching and toning exercise during clinical encounters that were developed by physiotherapists,[37] and one study provided an attention

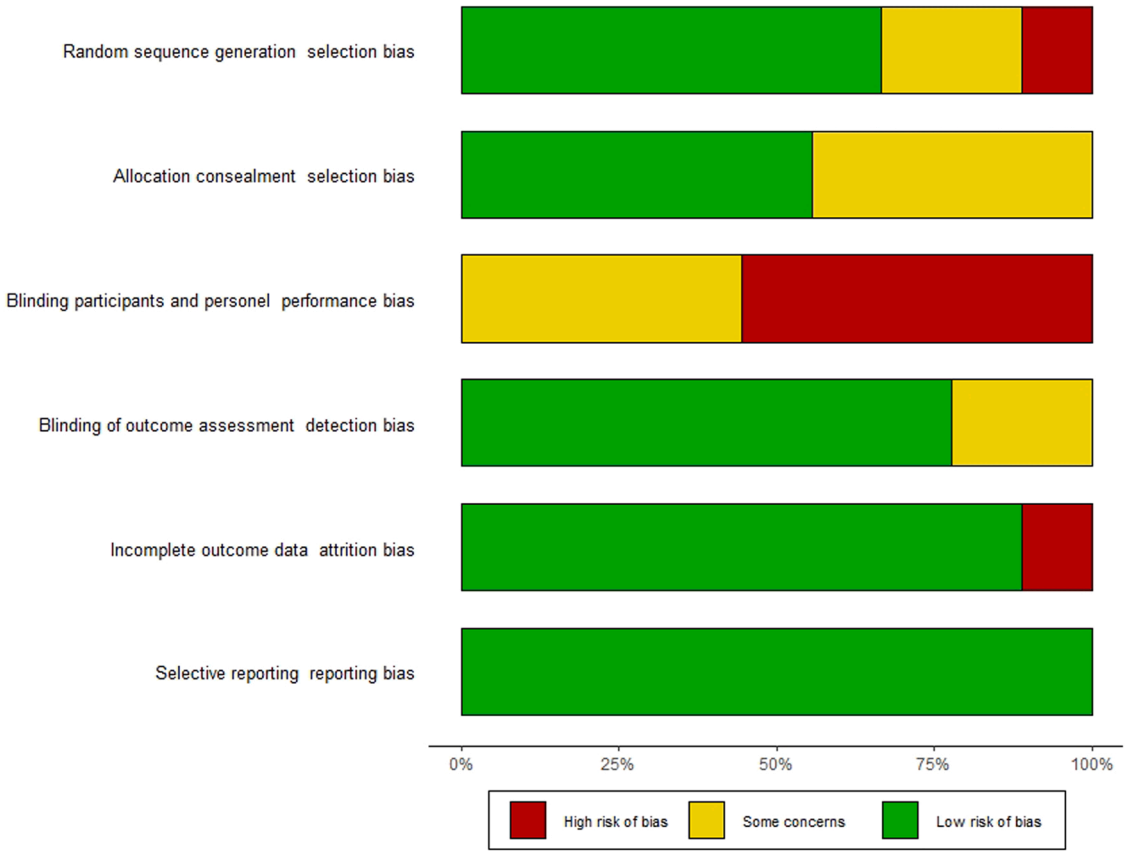

Fig. 2. Risk of bias for each included study.

control programme.[38]

3.5. Effects of combined intervention

3.5.1. Cognition

3.5.1.1. Global cognition. Various measures were used to assess global cognition in this review. Five studies assessed global cognition by the MMSE,[35–38,40,41] two studies used the ADAS-Cog,[37,41] two studies used the Dementia Rating Scale,[35,40] two studies used the Clinical Dementia Rating, and one study used the Montreal Cognitive Assessment (MoCA).[29] Four studies used two questionnaires to assess global cognition.

The effect of the combined intervention on MMSE and MoCA scores was examined by pooling data from 1110 participants across six trials. The pooled results revealed that the overall effect of the intervention group on global cognition was significant when compared with the control group [SMD = 0.74, 95% CI (0.19, 1.29), P < 0.05, I^2 = 89%, n = 668] (Fig. 3). Considering that the pooled results exhibited high heterogeneity, a leave-one-out sensitivity analysis was performed by iteratively removing one study at a time to ensure that our findings were not influenced by any particular study. Sensitivity analysis revealed similar results that our results were not driven by any single study. All P values remained < 0.05 (Appendix B).

3.5.1.2. Memory. Four studies measured the effects of the combined intervention on memory. Three studies assessed memory by the Logical Memory delayed recall score,[37,39,41] while one study used the Rivermead Behavioural Memory Test second edition.[34] The results revealed a large effect size on memory [SMD = 0.87, 95% CI (0.01, 1.74), P < 0.05, I^2 = 91%, n = 398] (Fig. 4). Sensitivity analysis revealed that the findings were influenced by three studies.[34,39,41] The P value from one study[37] remained < 0.05 (Appendix C).

3.5.1.3. Executive function. Three studies assessed executive function. Two studies used DSB[39,41] and one study used the auditory Stroop test to

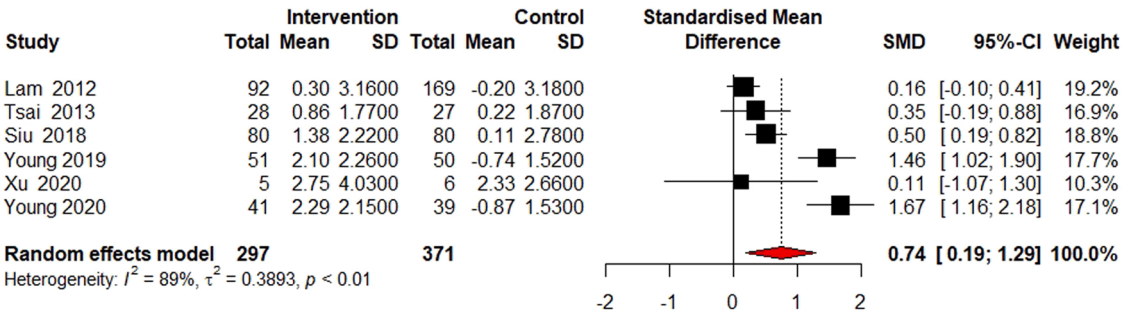

Fig. 3. Forest plot for combined intervention on global cognition.

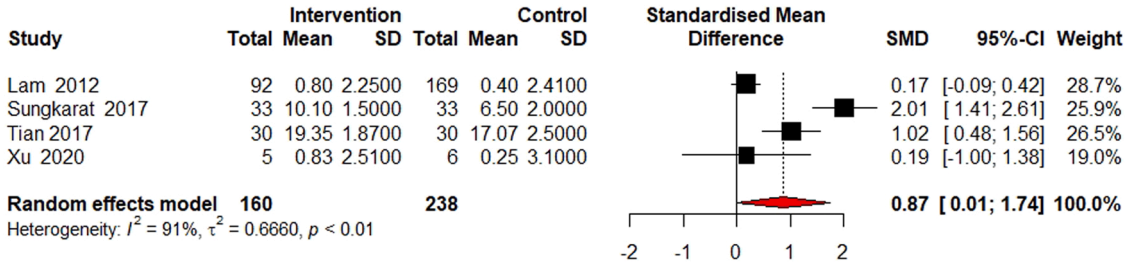

Fig. 4. Forest plot for combined intervention on memory.

assess executive function.[42] The study results found no statistically significant mean effect size on executive function [SMD = 0.24, 95% CI (−0.35, 0.82), P = 0.43, I^2 = 80%, n = 358] (Fig. 5).

3.5.2. Balance

Balance was measured by the Stepping-down Task and Berg Balance Scale in two included studies.[37,42] Compared with the control group, the combined intervention had small-sized effects on measures of balance [SMD = 0.28, 95% CI (0.04, 0.52), P < 0.05, I^2 = 0%, n = 291].

3.5.3. Fall

Only two RCTs assessed the risks of falls. Fall was measured by a modified Get Up and Go test[38] and the Physiological Profile Assessment.[39] A random-effects model indicated that TC did not significantly reduce the risk of falls compared to the control group [SMD = 1.34, 95% CI (−2.18, 4.86), P = 0.46, I^2 = 98%, n = 121].

3.5.4. Depression

Depression was measured by the Cornell Scale for Depression in Dementia and the 15-item Geriatric Depression Scale in two studies.[37,41] The results revealed no statistically significant mean effect size on the depression scales [SMD= 0.01, 95% CI (−0.24 0.26), P = 0.96, I^2 = 0%, n = 272].

3.5.5. Well-being

Wellbeing was assessed in two trials, but none of them found that the IG had significant effects on wellbeing. One study[41] used the validated Chinese version of the EuroQOL 5-D (EQ-5D) questionnaire, the five-level version (EQ-5D), and its visual analogue scale (EQ-VAS). The results revealed no statistically significant effects on favoured TC on EQ-5D (median=0.01, quartiles: (−0.03, 0.12), P = 0.325) and EQ-VAS (median=10.0, quartiles: (−2.5, 27.0), P = 0.658). Another study[35] that used Dementia Quality of Life (DQOL) demonstrated that combined intervention did not show more beneficial QOL than CG after treatment (change score of DQOL score: IC: 1.24 ± 11.28; CG: 2.95 ± 10.60; P = 0.565).

4. Discussion

4.1. Main findings

The purpose of this meta-analysis was to examine the effects of combined TC and cognitive interventions among older adults. Nine eligible studies were included, which were predominantly conducted in China and the community setting. The overall effects of this meta-analysis showed that the combined TC and cognitive interventions had positive effects on global cognition, memory, and balance in older adults. The findings also found no effects on executive function, depression, risk of falls, or well-being.

The combined TC and cognitive interventions demonstrated medium effects on global cognition. To some extent, these findings did not support the assumption that the combined intervention generates more effects than a single TC intervention on global cognition. In particular, Gu and colleagues[7] analysed six studies of older adults with cognitive impairment and reported that TC has a large effect on the MMSE scale (MD=1.81). Another two recent meta-analyses reported moderate effects of TC on people with cognitive impairment[43] and older people with MCI.[25] When considering participants' cognitive status, these unexpected results may be influenced by cognitive status because two studies included patients with probable dementia[35] and patients with mild dementia.[40] This difference indicates the importance of considering dementia may limit the benefit of the combined intervention for older adults. Furthermore, this difference also calls for more RCTs with vigorous designs to examine the effects of the combined intervention in older adults with various cognitive statuses.

Compared with the control group, our findings showed large effects on memory. However, these findings should be interpreted with caution. The sensitivity analysis showed that high heterogeneity was driven by three included studies.[34,39,41] The heterogeneity may be caused by differences in intervention design, sample sizes, and cognitive statuses across the three trials. It is recognised that the relationship between issues that cause heterogeneity and memory is complex. Thus, future studies should consider these issues together to fully understand the true effects of the combined intervention on memory.

This review also adds evidence about the effects of the combined intervention on memory among older adults. TC has been proven to have positive effects on memory performance by remodelling the structure and function of the hippocampus in healthy older adults.[44] Conversely, two recent meta-analyses reported a small effect of TC on memory (SMD =0.31, 0.37).[25,43] It is worth mentioning that five studies applied memory enhancement strategies as a component of cognitive intervention. For example, the participants were asked to remember the procedures of TC or receive verbal reminders from family members and researchers. Unlike other physical activities (e.g., walking or jogging),

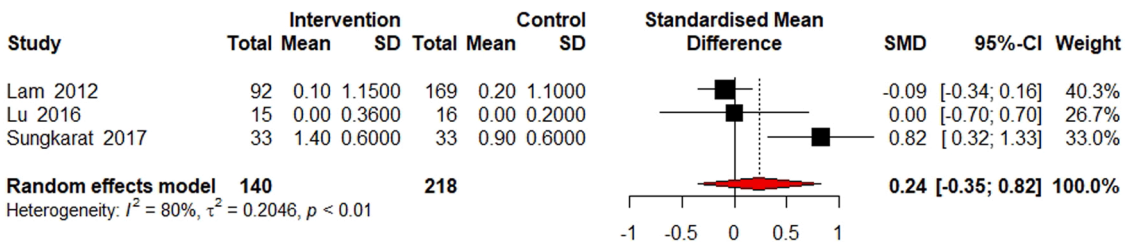

Fig. 5. Forest plot for combined intervention on executive function.

the practice of TC exercise is dependent on memory ability. Thus, these memory strategies in TC exercise played an important role in maintaining memory by strengthening short-term and procedural memory. Thus, TC with memory enhancement strategies may contribute to maximising the benefits of memory. Overall, the findings reveal the value of using a combination of TC and memory-enhancing strategies to produce more cognitive benefits for older adults.

Wang and colleagues[8] conducted a meta-analysis and found small to moderate effects on dynamic steady-state balance, static steady-state balance and proactive balance among older adults. This meta-analysis supports the results and shows small benefits on balance ability. Given that there is no cognitive intervention targeting the balance in this review, TC is a probable explanation for positive training effects. However, a previous meta-analysis[8] suggested that high-frequency TC exercise for at least eight weeks provided more benefits on balance. One study in this review was intended to explore the effects on balance with three 60-minute weekly sessions for 16 weeks.[42] Another study conducted three 30-minute weekly sessions for 12 months and found effects on balance.[37] Although the frequency and duration of the two included studies were consistent with the previous findings, attention must be taken in future trials in which duration and frequency should be taken into account in the combined intervention when targeting the balance.

However, the present review did not support the argument that simultaneously combined intervention is superior to sequentially combined intervention in improving cognition.[3,12,45] The findings from this review stated that both simultaneous and sequential combined interventions showed positive cognitive and physical effects for older adults. Furthermore, these findings indicate that combined TC and cognitive interventions can be delivered in both simultaneous and sequential formats. Overall, there remains a substantial gap in how combined interventions should be delivered to maximise the cognitive and physical impacts on older adults.

In addition, we found no convincing evidence that the combined intervention is superior to either physical or cognitive intervention alone. Two studies compared the differences between the combined intervention strategy and a single physical or cognitive intervention in the current review. One study[37] compared the combined intervention to a muscle stretching and toning exercise and found statistically significant effects in delay recall and depression, while another study[38] compared the combined intervention to an attention control intervention and found the effects on reducing pain and stiffness. These limited findings indicate a strong possibility that the combined TC and cognitive interventions can provide additional benefits to older people, but more studies are required to support this claim.

Finally, this meta-analysis revealed that the combined TC and cognitive interventions were not effective in executive function, depression, risk of falls, or wellbeing. These results may be influenced by the limited number of studies, the wide range of sample sizes, various cognitive statuses, and different forms of TC. Thus, the potential of combined TC and cognitive interventions to better elucidate older adults' physical and psychological function remains underexplored. These issues call for a need for more studies to explore the specific effects of combined TC and cognitive interventions in this field.

4.2. Strengths and limitations

The strengths of this review were using the systematic approach in searching, identifying, and including the literature. First, we focused on combined TC and cognitive interventions rather than various types of nonpharmacologic interventions or all interventions. Second, to understand the isolated effects of combined TC and cognitive interventions, we included the study that only contained TC without another physical exercise in the intervention group. Finally, only RCTs were included in this meta-analysis.

Several limitations were found in the present review. First, the findings of this review should be interpreted cautiously due to the small number of studies included in this meta-analysis. Considering that additional data were not available, three eligible articles were excluded from this review. It is recognised that publication bias may be raised since favourable findings are more likely to be published. Second, the heterogeneity of the different cognitive statuses of participants from the included studies may impact the interpretation of the results. Older adults with normal cognition, cognitive impairment, memory impairment, MCI, probable dementia, and mild stage dementia were identified in this review. Thus, the benefits of the combined intervention for older adults with varying cognitive statuses were inequitably distributed. Given the inability to conduct the subgroup analysis, the potential effects of combined TC and cognitive interventions on older adults with various cognitive conditions warrant further investigation. Finally, the primary focus of this review was on the cognitive effects of combined TC and cognitive interventions. As a result, the studies that contained merely extra outcomes without cognitive outcomes were excluded. To some extent, it is likely to miss out on studies that may provide more additional effects from combined TC and cognitive interventions. However, the diversity of outcomes presented in the included studies means that the current search method employed in the field has been covered.

5. Conclusions

The findings from this review strongly suggest that combined TC and cognitive interventions have considerable advantages for improving cognition and balance in older adults. In particular, combining TC with memory enhancement strategies appears to be a potentially effective intervention for older people. Based on the limited existing literature, there is no conclusion that the combined intervention has more benefits than the single intervention. More research is needed to investigate the additional effects of the combined intervention on the physical and psychological function of older adults, as well as its superiority over the single intervention.

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Ethical Approval /Patient consent

Not applicable.

Authors' contributions

All authors have provided amendments and approved the final manuscript. FL, YQ, and LW all contributed equally as first authors.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgements

Not applicable.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ctim.2022.102833.

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