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Systematic Review

Physical and cognitive-based training in healthy older adults: Evidence from a systematic review and meta-analysis

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Abstract

Introduction: Several studies have shown that cognitive training interventions and regular physical activity are popular intervention in dementia prevention guidelines. The purpose of this study was to examine the effectiveness of physical and mental training on cognitive outcomes in, older adults.

Methods: For this systematic review and meta-analysis, randomized clinical trials (RCTs) published between 2000 and 6 February 2023 were extracted from several electronic databases, including, ProQuest, PubMed, Scopus, Embase, and Web of Science.

Results: The meta-analysis included 36 studies. The results indicated that the pooled MD for cognition was 0.49 (95% CI = 0.28 to 0.70, $I^2 = 79.3\%$, $P = 0.0001$) and both physical and mental training have a "large to larger" effect on Episode memory (pooled MD: 1.98; 95% CI = 1.20 to 2.77, $I^2 = 92\%$, $P = 0.001$). Also, as a result, the trainings had a "small to larger" impact on the executive function of older adults (pooled MD: 0.64; 95% CI = 0.26 to 1.02, I2 = 86.2%, $P = 0.0001$).

Conclusion: Our controversial results indicated that the non-pharmacological physical-mental training improves executive function which that can affect the ability of elders, while did not support the improvement of attention, processing speed, and verbal memory.

Keyword: Aged, Cognition, Exercise, Memory

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Introduction

Older adults may experience cognitive impairment negatively and directly may impact their self-care, autonomy, health condition, and successful aging.[1] Normal aging is related to daily functional memory complications, as demonstrated by challenges in learning unprecedented names, remembering events that happened the pasts day, and finding a particular word in discussion.[2] The most important age-related changes are related to cognitive tasks that require fast processing of data, including executive function and working memory.[3] A hallmark of cognitive aging is age-related changes in executive function which is associated with major declines in executive function, including reasoning, set-shifting, working memory, and inhibition.[4-6] Executive functions are an important part of our day-to-day life, which can affect some everyday functions, like allowing focused attention, engaging in resolving issues successfully, and planning for the future.[4] Memory is perhaps the first cognitive function to give several patterns of decrease in some aspects, such as episodic memory.[7]

The progressive trend of cognitive impairment among the older population increased the importance of prevention of cognitive impairment through providing efficient guidelines and strategies. Additionally, there is an increasing body of evidence pointing to preventing or reducing the rate of cognitive impairment by using variant strategies e.g., behavioral training,[8] mind-body exercise,[9] and neurofeedback training.[10,11]

Neuroimaging also indicated the beneficial effect of mental and physical training on cognitive health. brain-derived neurotropic factor (BDNF) may triggers metabolic, plasticity, learning, and memory processes, plays an important role in excitation of molecular machinery by physical activity. A variety of mechanisms such as regeneration after neuronal injury and prevention of neuronal degeneration are undertaken by BDNF in addition to maintaining and promoting the growth of neurons from neuronal degeneration.

Moreover, the brain plasticity of the mental training has been seen in various procedure, such as cerebral blood flow, grey matter structure and, with matter integrity and energy metabolism. For example Engvig[12] used an intensive memory training program in order to enhance memory skill. Results also revealed memory training may induce short-term structural changes in the structural grey matter and participants' memory. Scientists come to the conclusion that the different type of physical/mental activity, intensity and duration may be a specify factor in the change in serum concentration of BDNF and regional white matter integrity, and subsequently enhance memory and cognition. Therefore, identifying effective trainings in aging research is critical and necessary.

Additionally, up to the present time, there are some reviews that systematically described trainings in older adults but the number of articles that have examined the different components of cognition is rare, and so in most studies, the effect of mental and physical trainings had not been examined.

The research on physical and mental training over the last 23 years is summarized here to respond; to what types of trainings have been used to affect cognitive outcomes including total cognition, memory, episodic memory, verbal memory, attention, selective attention, sustained attention, executive function, inhibition, mental flexibility, working memory, reasoning, in healthy older adults? This is a fundamental query in the growing field of geriatric health, and the findings should be useful in establishing guidelines and recommendations for health-promoting programs for older adults.

Methods

In this systematic review and meta-analysis, randomized clinical trials (RCTs) published between 2000 and February 6, 2023 were extracted from several electronic databases, including, ProQuest, PubMed, Scopus, Embase, and Web of Science. The study was limited to published papers in the English language that assessed the effects of trainings on cognition function. Those studies that were created to examine the impact of all trainings, excluding medicines, nutritional, advising, and driving training on improving cognition function, were included in this review. The study subjects were healthy older adults who had at least 55 years old.

The search strategy

To warrant the completeness of the included studies, we used Medical Subject Headings (MeSH) and free text words on the 5th online databases (ProQuest, Web of Science, PubMed, Scopus, and Embase) on papers published between 2000 and February 6, 2023. for relevant literature, the following keyword were used: Age, Older, Elder, Movement, Walking, Sports, Yoga, Activity, Exercise, Strengthening, Resistance, Pilates, Tai chi chuan, Brain training, Mental trainings, Executive Function, Attention, Cognition, Memory, Executive, Inhibit, Interference control, Cognition, Memory, Shifting, Mental flexibility, Updating, Planning, Switching, Fluency (see Supplementary file 1).in addition , manual searches were used to identify the additional studies that had not been identified in the initial search. This meta-analysis was done according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline[8] (see Supplementary file 2).

Study Selection Criteria

Two authors (F.A. and A.A.T) separately screened the selected studies; the selection was made based on the screening of titles/abstracts. Next, the full texts of the remaining papers were evaluated. Eligibility disagreements were reconciled by initial reviewers and, if necessary, by a third reviewer (Z.J).

Study quality assessment and risk of bias

The methodology quality of the included studies was independently assessed by two reviewers (F.A and A.A.T), and the third reviewer (Z.J) resolved any discrepancy through the Cochrane Collaboration tool[9] which consisted of six areas. Next, each area was labeled as either low, unclear, or high potential of bias. Additionally, two reviewers evaluated the methodological quality of the contained studies in a separate manner.

Publication bias

The funnel plot of the included papers displayed no document for publication bias. The Egger test results were not considerable for publication bias ($P > 0.05$) (see Supplementary file 3).

Statistical analysis

The mean differences (MDs) and standard deviation (SD) were computed using Stata software (Sv16). The standardized mean difference is to divide the mean difference by the SD and would compare the studies. All the studies report quantitative data and a weighted mean difference at a 95% confidence interval. Heterogeneity was estimated using statistics I-square:I^2 and the significance criterion was $I^2 > 50\%$. The Summary statistics reported were computed using random effects models based on unexplained heterogeneity between the studies. The chi-square test for heterogeneity was used to determine whether of distribution of results was consistent with the assumption that inter-experimental differences were attributable to chance variation alone. The statistical significance level was 0.05. The publication bias has been tested through funnel plots and the Egger regression test.

Results

We identified 680 publications and of the total 407 papers recorded, 35 papers have been included in the meta-analysis (Figure 1).

Characteristics of the studies

The studies were categorized into 12 groups including cognitive function, executive function, set-shifting, inhibition, reasoning, working memory, attention, selective attention, memory, delay memory, episodic memory, and verbal memory. All the participants ranged from 55 to more than 80 years of age. Research's sample sizes in the studies were between 14 to 487 participants (Table 1).

Methodological quality versus risk of bias assessment

A high risk of selection bias due to the absence of allocation concealment (n = 1), performance bias (n = 1), and other sources of bias (n = 2) was shown. Reporting bias (n = 26), attrition bias (n = 22), and a lack of randomization method (n = 21) was unclear for the majority of the included studies (Supplementary file 4).

Effects of trainings on cognition (meta-analysis finding)

The pooled MD for cognition was 0.49 (95% CI = 0.28 to 0.70, I^2 = 79.3%, P = 0.0001) (Figure 2A). As a result, trainings had a small to larger effect on the executive function (pooled MD: 0.64 (95% CI = 0.26 to 1.02, I^2 = 86.2%, P = 0.0001) (Figure 2B). In addition, trainings showed small to medium effect on set shifting (pooled MD: 0.37 (95% CI = 0.18 to 0.56, I^2 = 79.3%, P = 0.0001) (Figure 2C). But trainings had not to effect on inhibitions (Figure 2D). The heterogeneity among studies also was high.

According to Figure 3, trainings were effective in reasoning (pooled MD: 0.40; 95% CI = 0.23 to 0.562, I^2 = 21.1%, P = 0.224) (Figure 3A) and working memory of older adults (pooled MD: 0.25; 95% CI = 0.07 to 0.44, I^2 = 53.2%, P = 0.0002; Figure 3B). But trainings showed no effect on attention (Figure 3C) and Selective Attention (Concentration, Figure 3D).

Figure 4 indicates that trainings had a small to large effect on Memory (pooled MD: 0.64; 95% CI = 0.25 to 1.04, I^2 = 87%, P = 0.001) (Figure 4A); Delay memory (pooled MD: 1.18; 95% CI = 0.35 to 2.00, I^2 = 91.4%, P = 0.001) (Figure 4B); and larger effect on Episode

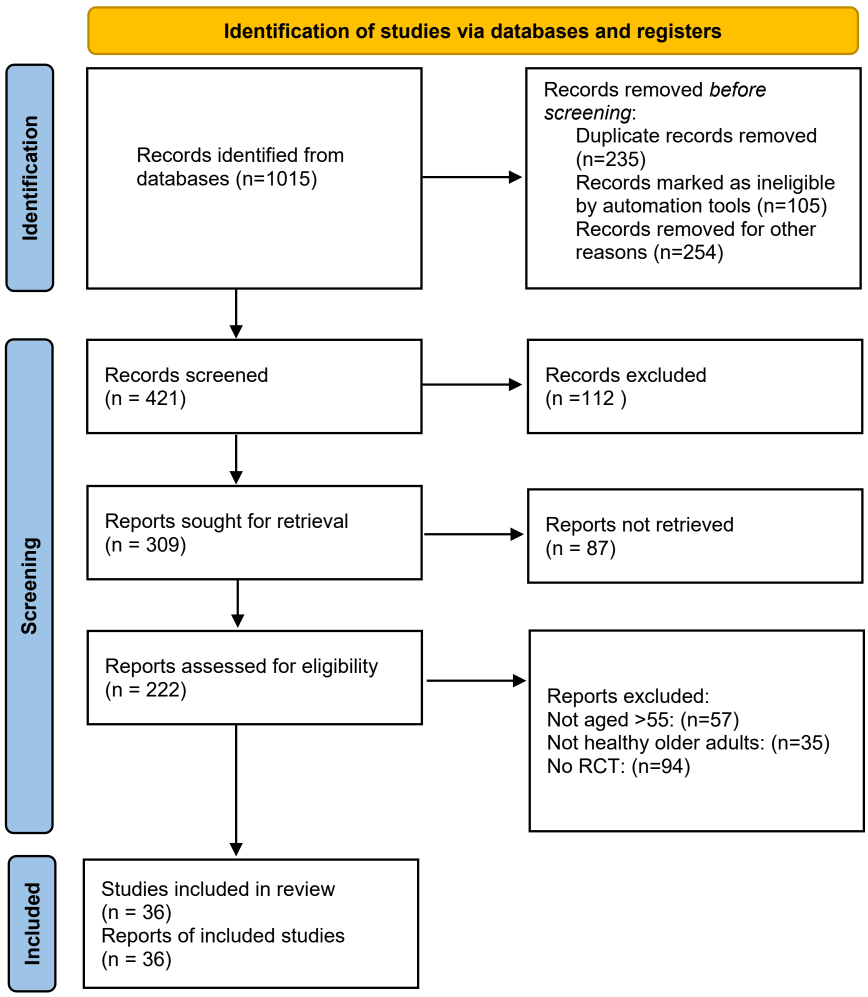

Figure 1. Prisma fallow diagram detailing the search strategy

Table 1. Main characteristics of the included studies in the meta-analysis

First author and country	Participants	Trainings	Period of time(min)	Scales	Outcomes (significant training effect)
Yusof; Malaysia[10]	- Training group: N: 23, Age: 67.6 ± 4.5 - Control group: N: 20, Age: 65.8 ± 3.6	Computerized software	1080	Montreal cognitive assessment	Delayed memory, cognition
Nouchi; Japan[11]	- Cognitive training: N: 27, Age: 71.67 ± 3.62 - Active control group: N: 28, Age: 73.11 ± 3.90	Cognitive training games	600-840	The MMSE, The JART, Cd and SS, D-CAT, ST and rST, DS-F and DS-B, LM	Inhibition
Roheger; Germany[13]	- Structured cognitive training program (NEUROvitalis) group: N: 35, Age: 66.61 ± 9.30 - Unstructured cognitive training program Mentally Fit (active control): N: 35, Age: 69.72 ± 8.31 - Passive control: N: 35, Age: 63.88 ± 10.89	NEUROvitalis program, the mentally fit program	1080	Dementia Detection immediate recall/delayed recall, brief test of attention, TMT A-B	Verbal short-term memory
Okamoto; Japan[14]	- Training group: N: 22, Age: 72 ± 1 - Control group: N: 24, Age: 73 ± 1	Interval walking training	1800	TMT A-B	-
Yeo; Singapore[15]	- Training group: N: 109, Age: 66.2 ± 4.74 - Control group: N: 118, Age: 65.8 ± 4.65	The brain-computer interface	1080	RBANS	-
Simon; USA and Sweden[16]	- Training group: N: 41, Age: 72.4 ± 5.6 - Control group: N: 41, Age: 73.7 ± 6.5	The cogmed training system	1000	TMT-A, DS, COWAT	Working memory, phonemic fluency
Chiu; Taiwan[17]	- Training group: N: 31, Age: 72.03 ± 4.85 - Control group: N: 31, Age: 72.32 ± 5.50	Executive function training	720	WCST, DS-F	WCST, DS-F
Vaportzis; UK[18]	- Training group: N: 22, Age: 68.4 ± 3.5 - Control group: N: 21, Age: 69.8 ± 3.0	Cognitive activities by tablet	1200	The cognitive battery	-
Gill; UK[19]	- exercise + dual- task: N: 23, Age: 72.6 ± 7.4 - exercise only: N: 21, Age: 74.5 ± 7.0	A group- based exercise program with a dual-task training program A group- based exercise program alone	3120- 5850	TMT A-B, animal naming test, DSST, COWAT, AVLT	Cognitive function
Desjardins-Crépeau; Canada[20]	- Mixed aerobic/resistance training DT training group: N: 22, Age: 72.7 ± 7.4 Computer lessons: N: 16, Age: 70.9 ± 7.4 - Stretching and toning exercises DT training program training: N: 20, Age: 73.2 ± 6.3 Computer lessons: N: 18, Age: 72.5 ± 7.0	Combination aerobic and resistance training program, stretching and toning exercises, DT training program, computer lessons	2160	RAVLT, CWIT, TMT- A-B	Speed of processing, Inhibition abilities, Task switching abilities
Nouchi; Japan[21]	- Training group: N: 32, Age: 72.81 ± 6.18 - Control group: N: 32, Age: 71.38 ± 4.92	Learning therapy group	1380- 2070	Stroop test, Verbal fluency task LM, FSN, DS	Executive functions, episodic memory, attention
Millán-Calenti; Spain[22]	- Training group: N: 80, Age: 73.45 ± 5.95 - Control group: N: 80, Age: 75.48 ± 6.85	The computerized cognitive training		MMSE	Cognition
Lee; Singapore[23]	- For all participants: N: 39, Age: 65.2 ± 2.8	Card-matching memory training	n	RBANS domain index	Delayed memory, cognition

Table 1. Continued.

First author and country	Participants	Trainings	Period of time(min)	Scales	Outcomes (significant training effect)
Kim; Korea[24]	- Traditional group: N: 24, Age: 67.7 ± 5.4 - Robot group: N: 24, Age: 68.0 ± 6.1 - Control group: N: 37, Age: 66.9 ± 4.0	Traditional cognitive training, the robot-assisted cognitive training		CANTAB	Executive function, cognitive, visual memory
Diamond; Australia[25]	- Training group: N: 36, Age: 67.33 ± 8.7 - Control group: N: 28, Age: 65.64 ± 8.4	Computer-based training		RAVLT, LM, RCFT, Phonemic and semantic verbal fluency, DS, TMT A-B	Verbal memory
Cavallini; Italy[26]	- Trained group: N: 16, Age 83.19 ± 7.34 - Control group: N: 18, Age: 87.06 ± 5.30	Self-help memory training	75	Associative learning, Grocery list learning, Figure–word pairing, Text learning, Face–name learning, Object list learning, Word list learning, Everyday problems test	Memory
Nishiguchi; Japan[27]	- Training group: N: 24, Age: 70.6 ± 5.9 - Control group: N: 24, Age: 68.2 ± 6.2	Dual-task	1080	MMSE, TMT	Memory, Executive functions
Polito; Italy[28]	- Training group: N: 38, Age: 73.8 ± 1.2 - Control group: N: 39, Age: 73.8 ± 1.3	Cognitive stimulation	1000	MMSE, MOCA, Corsi test	MMSE, MOCA, Corsi test
Linde, Germany[29]	- Physical group: N: 13, Age: 65.59 ± 3.74 - Cognitive group: N: 15, Age: 68.28 ± 2.02 - Combined group: N: 11, Age: 66.56 ± 3.20 - Control group: N: 11, Age: 66.56 ± 3.20	Physical activity, cognitive activity, mixed physical and cognitive activity training	1920	A subtest of the Leistungs-Prüf- System 50 +, D2 test of attention, TMT A-B, The word list test	Concentration, cognitive speed
Ballesteros; Spain[30]	- Training group: N: 17, Age: 68.8 ± 5.15 - Control group: N: 13, Age: 69.2 ± 5.91	Video game training	1200	Cross-modal oddball task, WCST, Jigsaw puzzle task, Corsi, Rey-Osterrieth complex figure test	Cross-modal oddball task, WMS, SPF-IL
Nouchi; Japan[31]	- Training group: N: 32, Age: 66.75 ± 4.61 - Control group: N: 32, Age: 67.9 ± 6.7	Combination exercise	360	ST and r-S, LFT, CFT, LM, FS-N, DS-F and DS-B, D-CAT, Cd and SS, JART	Executive functions, episodic memory
Lee; Singapore[32]	For all participants: N: 31, Age: 65.1 ± 2.9	Card-matching memory training	720	RBANS	-
Teixeira; 2013 Brazil[33]	- Training group: N: 21, Age: 68.21 ± 28.4 - Control group: N: 20, Age: 67.9 ± 1 6.7	Square-stepping exercise	1920	Modified card sorting test, MMSE, Digit Span, Toulouse-Pierón	Cognitive, concentrated attention, mental flexibility
Shatil; USA[34]	- Cognitive training: N: 33, Age: 80 ± 5.43 Cognitive and physical training: N: 29, Age: 79 ± 5.49 No cognitive and no physical training: N: 29, Age: 81 ± 5.25 No cognitive and physical training: N: 31, Age: 79 ± 5.76	The separate and combined cognitive and physical training	1920	The cogniFit	Working memory, long-term memory
Nouchi; Japan[35]	- Training group: N: 14, Age: 68.86 ± 2.07 - Control group: N: 14 , Age: 69.31 ± 2.82	Brain training group, playing tetris group	300	MMSE, FAB, TMT-B, D-CAT, DS	Executive function

Table 1. Continued.

First author and country	Participants	Trainings	Period of time(min)	Scales	Outcomes (significant training effect)
Becerra; Mexico[36]	- Training group: N: 7, Age: 65.8 ± 2.4 - Control group: N: 7, Age: 67 ± 4.9	Neurofeedback		WAIS, NEUROPSI	Memory
Richmond; USA[37]	- Training group: N: 21, Age: 66 - Control group: N: 19, Age: 66	Working memory	600	Digit span, Reading span, Raven's, test of every day attention	CVLT, everyday attention
Zelinski; USA[38]	- Training group: N: 242m, Age: 75.6 ± 6.6 - Control group: N: 245, Age: 75.0 ± 6.3	Computerized program	2400	RBAN, RAVLT, Word list delayed recall, Rivermead, RBMT, DS-B	Memory, attention
Muscari; Italy[39]	Training group: N: 60, Age: 68.8 2.5 Control group: N: 60, Age: 69.6 2.8	Endurance exercise training	8640	MMSE	-
Taylor- Piliae USA[40]	Tai Chi group: N: 37, Age: 70.6 ± 5.9 Western exercise: N: 39, Age: 68.5 ± 5.0 Control group: N: 56, Age: 68.2 ± 6.2	Tai Chi, Western exercise	60 min	Animal-naming test, DS	Cognition
Smith; 2009 USA[41]	- Training group: N: 242, Age: 75.6 ± 6.6 - Control group: N: 245. Age: 75.0 ± 6.3	Computerized program	2400	RAVLT, Word list delayed recall, Rivermead, RBMT, DS-B	Memory, Attention
Uchida; 2008 Japan[42]	- Training group: N: 51, Age: 75.2 ± 3.8 - Control group: N: 47, Age: 75.6 ± 4.	The cognitive training	2700	FAB, DST	FAB, DST
Valentijn; Netherlands[43]	- Collective training: N: 53, Age: 69.32 ± 7.77 - Individual training: N: 43, Age: 68.07 ± 6.58 - Control group: N: 43, Age: 68.30 ± 8.03	Memory training (collective and individual)		VVLT, The short-story test, MMSE	Delayed recall
Noice; USA[44]	- Theater group: N: 44, Age: 73.02 ± 6.04 - Visual Arts group: N: 44, Age: 72.41 ± 6.04 - Control group: N: 36, Age: 75.81 ± 5.41	The theater training, The visual arts training	810	Word recall task, problem-solving, listening span task	Word recall, Memory span
Fabre; France[45]	- Aerobic training group: N: 8, Age: 65.4 ± 2.2 - Mental training group: N: 8, Age: 67.5 ± 1.2 - Aerobic and mental training group: N: 8, Age: 64.9 ± 1.4 - Control group: N: 8, Age: 65.7 ± 1.5	The separate and combined aerobic and mental training	480	The BEC 96 questionnaire, The Wechsler memory scale	Logical memory, Memory quotient
Lajeunesse; Canada[46]	- Training group: N: 12, Age: 71.96 ± 6.20 - Control group: N: 12, Age: 71.67 ± 6.33	Prospective memory computer- based cognitive rehabilitation	600-1200	MoCA, Digit Symbol, The Symbol Cancellation Test, Digit Span, The Color- Word Interference Test	Retrospective memory

The MMSE: Mini-Mental State Examination, The JART: Japanese version of the National Adult Reading Test, CD: Digit symbol coding, SS: Symbol search, D-CAT: Digit cancellation task, ST: Stroop task, rST: reverse Stroop task, DS-F: The digit span forward, DS-B: the digit span backward, RBANS: The Repeatable Battery for the Assessment of Neuropsychological Status, COWAT: Controlled Oral Word Association Test, TMT: The trail-making test, DSST: Digit Symbol Substitution Test, AVLT: Auditory Verbal Learning Test, CWIT: The Color-Word Interference Test, LM: The logical memory, WMS: Wechsler Memory Scale Logical Memory, CANTAB: The Cambridge Neuropsychological Test Automated Battery, RAVLT: The Rey Auditory Verbal Learning Test, WCST: The Wisconsin Card Sorting Test, RCFT: The Rey Osterrieth Complex Figure Test, LFT: The letter fluency task, CFT: The category fluency task, FS-N: First and Second names, VVLT: The Visual Verbal, RBMT: River mead Behavioral Memory Test, LNS: letter-number sequencing.

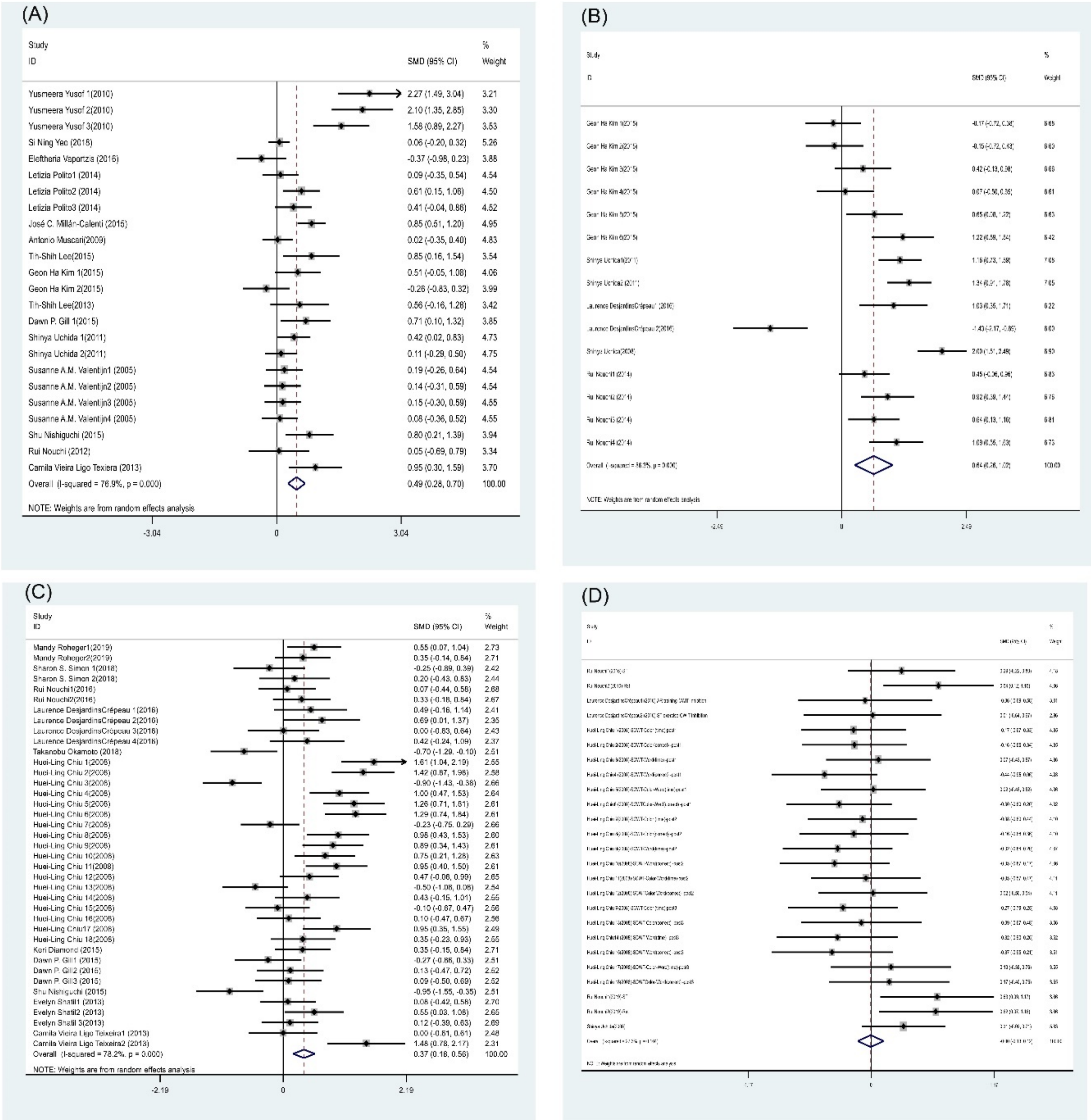

Figure 2. Effect of interventions on cognition (A); executive function (B); set shifting (C) and inhibition (D)

memory (pooled MD: 1.98; 95% CI = 1.20 to 2.77, $I^2 = 92\%$, $P = 0.001$) (Figure 4C) of older adults people. But with high heterogeneity and no effect on verbal memory (Figure 4D).

Discussion

As our aim was to investigate the role of physical and mental training as a potential preventive training to improve cognitive function and its sub-domain decay in older persons and also evaluate the quality of available evidence, the analyses prepared explicit evidence that the training had a 'large' effect on the improvement of episodic memory. Also, we found that the training had a 'small to larger' effect size in cognition, executive function, reasoning, working memory, and memory.

These findings expand prior evidences from a meta-analysis of the single or multi-component physical and mental trainings on cognitive functions. Based on this study and previous results, all types of physical and mental training have been demonstrated to improve cognitive function of healthy aging population.[47] Our findings also extend the previous findings of the systematic review on the separate and combination of the brain and physical training benefits on improving cognitive functioning in older population,[47,48] while we found studies which claimed the opposite.[49,50] Several possible mechanisms may underlie training-induced enhancements of efficiency that are closely connected to neuroplasticity

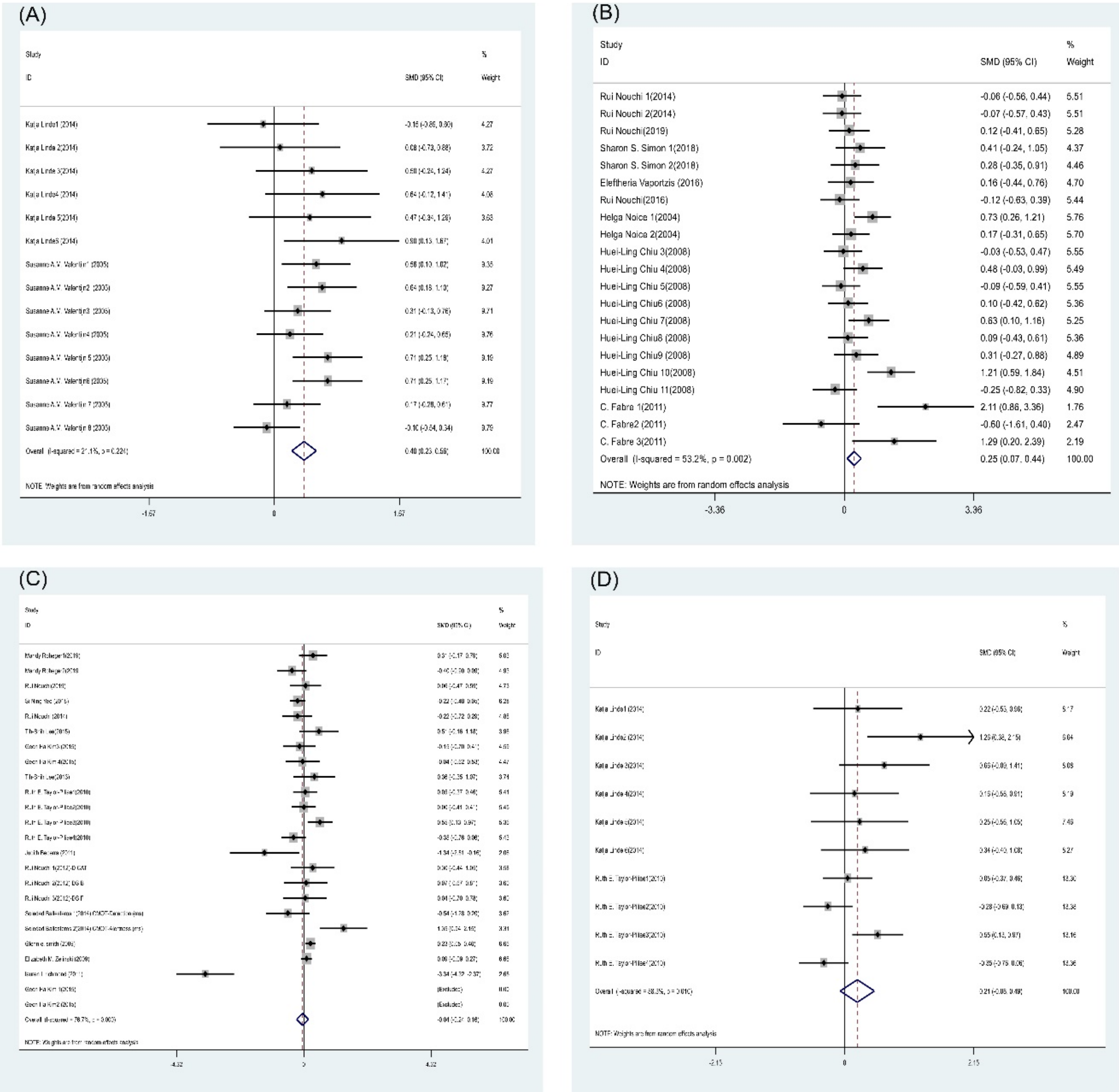

Figure 3. Effect of interventions on reasoning (A), working memory (B), attention (C), and selective attention (concentration) (D)

, chemical transmitter, and change in neuromodulator of central pathway, selectively increasing angiogenesis, synaptogenesis, and neurogenesis.[51] The heterogeneity of the reviewed studies makes the results be interpreted cautiously.

The current study shows a critical extension to the body of literature by examining physical activity and mental training on cognitive function and displays small to large improvements in executive function and small to medium improvement within 3 sub-domains of executive function. Similar to this review, several systematic reviews and training studies have shown an improvement in executive function through aerobic and stretch exercise training,[52] traditional mental training,[53] and cognitive-motor training.[54] This is in contrast to Shah et al[55] that did not demonstrate the post-intervention benefits of a combined mental and physical training for executive functions. Limited sample size, differences in the outcome measures, and types of training may be responsible. It may also be assumed that the type of physical activity may be more determinative than the intensity of physical activity in this sub-domain of cognitive function because the training time is equal in both studies.

In addition, the finding of this meta-analysis is comparable to those of the review in terms of the effects of aerobic exercise and combination mind-body training on working memory as another sub-domain of executive function.[56,57] Among the eight reviewed articles, most of the articles (seven out of eight) had mental training but the greatest improvement founded in Fabre et al. study by aerobic and combined mind-body trainings. In contrast, in another meta-analysis, Guo et al showed that mixed

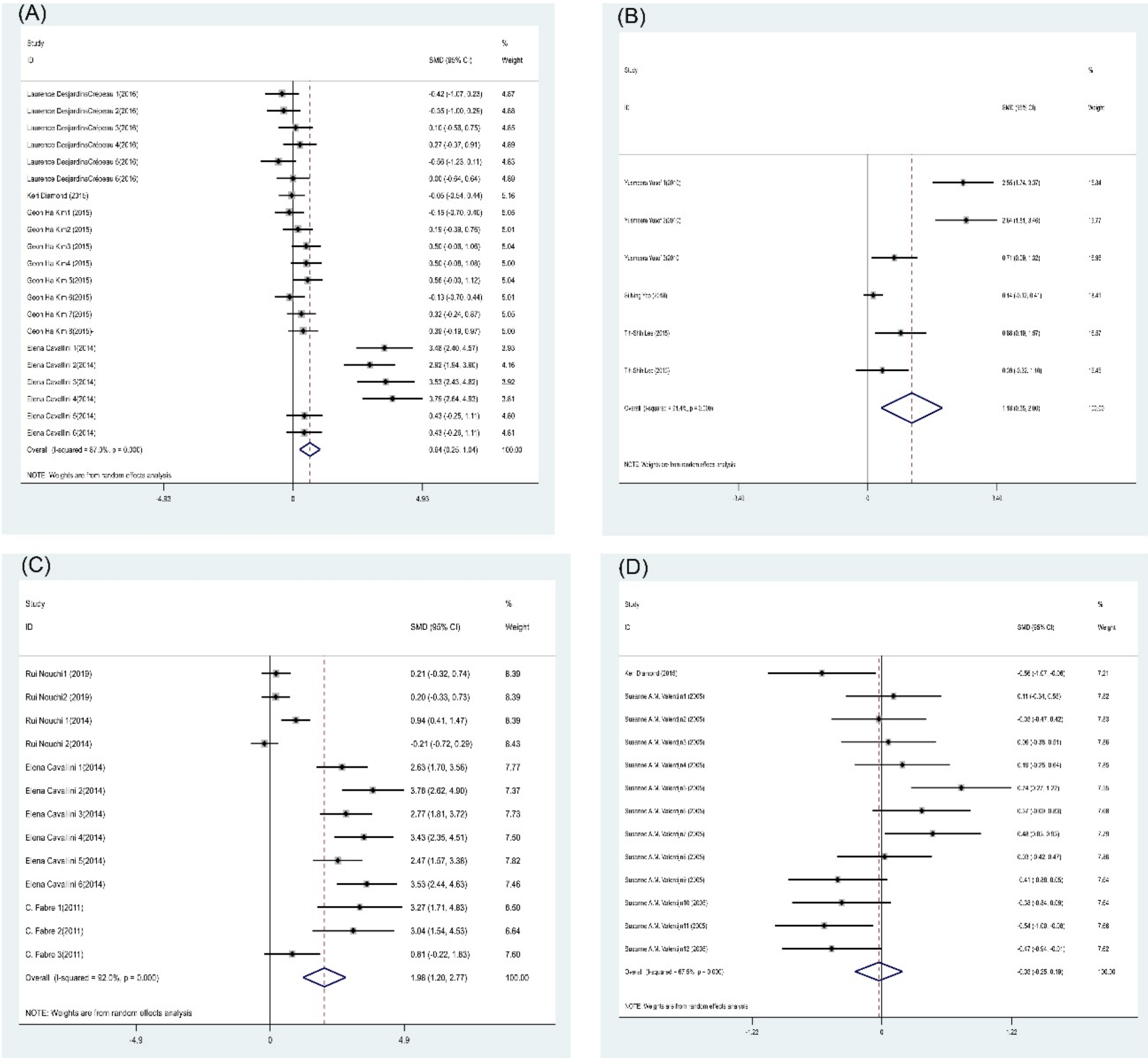

Figure 4. Effect of interventions on memory (A); Delay memory (B); Episode memory(C); Verbal memory (D)

training was not superior to physical or mental training alone on executive function.[58] However, it would be important to interpret in a cautious manner the results in view of the methodological heterogeneity of the studies. in fact, the effectiveness of physical trainings may depend on the nature and length of trainings. Physical activity may greatly increase neurogenesis in the frontal lobe, and mental exercise may decrease the number of neuronal cell deaths.[59]

The results of the current study did not show important benefits from physical activity training in memory function. In contrast, another review by Babaei et al. has shown that physical activity improved neurotrophic factors, mitochondrial biogenesis, and the release of some signaling molecules.[60] Neuromotor exercise e.g. yoga has been successful in enhancing all types of short and long-term memory in the elderly.[61] These insights can be used to develop future memory enhancement protocols for an aging population.

This study suggests that the separate and combined aerobic and mental training can improve episodic memory in the older population. Based on the findings of Aghjayan et al[62] and Loprinzi et al[63] aerobic exercise may enhance episodic memory. Acute and long-term physical activity has also been displayed to be linked with episodic memory function. According to our finding a systematic review led by Mendonça et al.[64] Also, physical activity influences cognitive function by spreading BDNF and promoting neuronal growth and survival.[65]

The comprehensive search strategy, measuring different components of cognition, and various pieces of training were major strengths of this review. However, the limitations of the study are mentioned. First, in this study, both physical and mental training results were analyzed in a concurrent manner. As a result, the effects of any type of training cannot be identified alone. It is suggested that each type of training be considered separately for future studies.

Second, the variation in the instruments used to measure the subdomains of cognition function can be identified as a limiting factor. Third, it is very complicated to eliminate the influence of diet, medication, and social support, on the results.

Conclusion

Our findings in this systematic review and meta-analysis show that physical and mental training is a helpful way to improve the mental and executive function of older adults. As a result, emphasizing on physical and mental training programs may improve the quality of life of older adults and let them live more in an independent manner and consequently may guide healthcare providers to set up programs that let elders engage more in physical and mental training programs and also the combined physical and mental training programs may be assumed as a new strategy in the field of geriatric health and gerontology to emphasize on synergetic effects of physical exercise and mental training.

Authors' Contribution

Conceptualization: Fatemeh Adelirad, Iman Dianat.
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Writing–review & editing: Fatemeh Adelirad, Zeinab Javadivala, Vijay Kumar Chattu.

Competing Interests

The authors declare that they have no competing interests.

Ethical Approval

This study was approved by Ethical committee Tabriz University of Medical Sciences (Ethical number: IR.TBZMED.REC.1398.829).

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Supplementary Files

Supplementary file 1. Search strategy for ProQuest, PubMed, Scopus, Embase and Web of Science databases
Supplementary file 2. PRISMA Checklist for the meta-analysis.
Supplementary file 3. Funnel plot of interventions.
Supplementary file 4. Risk of bias assessment of studied.

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