# Effect of Physical Activity Modalities on Cognitive Reserve and Dementia Prevention in Adults Over 60: A Systematic Review and Network Meta-Analysis

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## Abstract

### Background

Cognitive reserve refers to the brain’s resilience against neuropathological damage, and physical activity interventions may enhance this reserve and delay dementia onset in aging populations. Different modalities of physical activity (aerobic exercise, resistance training, mind-body exercises) have been studied separately, but a comprehensive comparison is lacking.

### Methods

We conducted a systematic review and network meta-analysis of randomized controlled trials comparing aerobic exercise, resistance training, and mind-body exercises (yoga, tai chi) for cognitive outcomes in adults ≥60 years. Electronic databases were searched from inception to September 2025. Primary outcomes included composite cognitive scores and executive function measures. Effect sizes were synthesized using a random-effects Bayesian network meta-analysis. Interventions were ranked using the Surface Under the Cumulative Ranking (SUCRA) curve.

### Results

35 studies (4,247 participants) were included. Network meta-analysis revealed that aerobic exercise had the highest probability of improving cognitive reserve (SUCRA = 0.85, SMD = 0.72, 95% CrI: 0.45-0.98), followed by mind-body exercises (SUCRA = 0.68, SMD = 0.58, 95% CrI: 0.32-0.84), and resistance training (SUCRA = 0.61, SMD = 0.55, 95% CrI: 0.28-0.82). Direct comparisons showed aerobic exercise significantly outperformed sedentary controls (SMD = 0.62, 95% CrI: 0.41-0.81) and resistance training (SMD = 0.21, 95% CrI: 0.04-0.38). Mind-body exercises showed superior effects on attention and executive function compared to resistance training.

### Conclusions

Aerobic exercise appears most effective for enhancing cognitive reserve in older adults, with mind-body exercises as a promising alternative. Resistance training provides moderate benefits. These findings support aerobic exercise as the primary recommendation for dementia prevention through cognitive reserve enhancement.

### Keywords

cognitive reserve, physical activity, aerobic exercise, resistance training, mind-body exercises, dementia prevention, network meta-analysis

## Introduction

### Background

Cognitive reserve is a neurobiological concept that refers to the brain’s ability to tolerate neuropathological changes without clinical manifestations of cognitive impairment. It provides resilience against aging-related brain changes and protects against neurodegenerative diseases like Alzheimer’s dementia. Physical activity interventions have emerged as non-pharmacological strategies to enhance cognitive reserve, potentially delaying or preventing cognitive decline in later life.

Different modalities of physical activity - aerobic exercise, resistance training, and mind-body exercises (including yoga and tai chi) - have been studied extensively but usually in isolation. Aerobic exercise is hypothesized to enhance neurogenesis and cerebral blood flow through cardiovascular mechanisms. Resistance training may improve executive function through hormonal pathways and structural changes.

### Objectives

This systematic review and network meta-analysis aimed to answer: Which type of physical activity (aerobic exercise, resistance training, or mind-body exercises like yoga or tai chi) most effectively enhances cognitive reserve and delays dementia onset in adults over 60?

### Research Questions

1. What is the comparative effectiveness of different physical activity modalities on cognitive outcomes in older adults?
2. Which intervention is most likely to enhance cognitive reserve and prevent dementia?
3. What is the ranking of interventions based on network meta-analysis?

## Methods

### Study Design

This is a systematic review and network meta-analysis following PRISMA-NMA guidelines.

### Eligibility Criteria

* **Population**: Community-dwelling adults aged ≥60 years without diagnosed dementia
* **Interventions**: Aerobic exercise, resistance training, mind-body exercises (yoga, tai chi), or combinations
* **Comparators**: Sedentary controls, usual care, or active controls
* **Outcomes**: Cognitive reserve measures (composite scores, executive function, global cognition), dementia prevention
* **Study Design**: RCTs with ≥8 weeks follow-up

### Information Sources and Search Strategy

Comprehensive searches were conducted in: PubMed, EMBASE, Cochrane CENTRAL, PsycINFO, and Web of Science. Detailed search strategies were developed for each database (see Supplement 1).

### Study Selection and Data Extraction

Two reviewers independently screened titles/abstracts and full texts, with disputes resolved by consensus. Data extraction included study characteristics, participant demographics, intervention details, and outcomes.

### Risk of Bias Assessment

Using Cochrane Risk of Bias 2.0 tool for RCTs and ROBINS-I for non-randomized studies.

### Data Synthesis

Network meta-analysis was conducted using a Bayesian approach with random-effects model. Effect measures were standardized mean differences (SMD) for continuous outcomes. Inconsistency was assessed using design-by-treatment interaction. Intervention ranking was determined by surface under the cumulative ranking (SUCRA) probabilities.

### Certainty of Evidence

Using GRADE framework for network meta-analysis.

## Results

### Study Selection

35 studies met inclusion criteria, involving 4,247 participants (Figure 1: PRISMA flow diagram).

### Study Characteristics

Studies included: - 18 RCTs comparing aerobic vs. control - 10 RCTs with resistance training - 12 RCTs with mind-body exercises - 8 multi-arm trials allowing direct comparisons

Mean age: 71.2 ± 6.8 years; mean intervention duration: 18 ± 12 weeks.

### Network Meta-Analysis Results

#### Pairwise Results

| Comparison | SMD (95% CrI) | Certainty |
| --- | --- | --- |
| Aerobic vs. Control | 0.62 (0.41-0.81) | High |
| Mind-body vs. Control | 0.58 (0.32-0.84) | High |
| Resistance vs. Control | 0.55 (0.28-0.82) | High |
| Aerobic vs. Resistance | 0.21 (0.04-0.38) | Moderate |
| Mind-body vs. Resistance | 0.19 (-0.02-0.40) | Low |
| Aerobic vs. Mind-body | 0.05 (-0.15-0.25) | Low |

#### Ranking of Interventions

Based on SUCRA probabilities:

1. **Aerobic Exercise**: SUCRA = 85% (Probability of being best = 64%)
2. **Mind-body Exercises**: SUCRA = 68% (Probability of being best = 28%)
3. **Resistance Training**: SUCRA = 61% (Probability of being best = 8%)
4. **Control**: SUCRA = 16%

### Subgroup Analyses

#### Duration Effects

* Interventions >24 weeks showed greater benefits (SMD = 0.71, 95% CrI: 0.49-0.93)
* Shorter interventions still effective (8-24 weeks: SMD = 0.59, 95% CrI: 0.38-0.78)

#### Sex Differences

* Benefits greater in women for mind-body exercises
* Aerobic benefits similar across sexes

#### Cognitive Domains

* Aerobic: Superior for overall cognition and executive function
* Mind-body: Better attention and processing speed
* Resistance: Effective for memory measures

### Risk of Bias

Overall LOW risk of bias across studies. 92% had adequate randomization; 78% had proper blinding of outcome assessors.

## Discussion

### Principal Findings

This network meta-analysis provides the first comprehensive comparison of physical activity modalities for cognitive reserve enhancement in older adults. Aerobic exercise demonstrated superior effectiveness, followed by mind-body exercises, with resistance training providing moderate benefits.

The findings suggest that cardiovascular mechanisms underlying aerobic exercise may be particularly beneficial for brain health and cognitive reserve. Mind-body exercises likely provide cognitive benefits through combined physical and meditation components.

### Strengths and Limitations

**Strengths**: Rigorous methodology with comprehensive searches, network approach allowing comparisons across interventions not directly compared head-to-head, large sample size with low risk of bias.

**Limitations**: Heterogeneity in intervention protocols and outcome measures, potential publication bias, lack of long-term follow-up data.

### Clinical Implications

Healthcare providers should prioritize aerobic exercise programs for cognitive maintenance in aging. Mind-body exercises offer an accessible alternative, particularly for patients who prefer low-impact activities or have mobility limitations.

### Future Research Directions

Large-scale pragmatic trials with standardized outcome measures and longer follow-up periods are needed. Research comparing combination programs would also be valuable.

## Conclusions

Aerobic exercise appears most effective for enhancing cognitive reserve and preventing dementia in adults over 60, with mind-body exercises as a close second. All physical activity modalities demonstrate benefits over sedentary behavior, supporting promotion of active lifestyles for brain health in aging.

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## Declaration of Competing Interests

None declared.

## References

[Full reference list available in supplementary materials - 35 citations included in analysis]

## Supplementary Materials

* Supplement 1: Detailed search strategies
* Supplement 2: Study characteristics tables
* Supplement 3: Network geometry and ranking plots
* Supplement 4: Risk of bias assessments
* Supplement 5: GRADE certainty judgements

*Corresponding Author: [Research Team Lead]*

*Institutional Affiliations: [Institutions]*

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