**LOMPART, Albert, WABISZCZEWICZ, Michał, KOSAREWICZ, Albert, WOŹNIAK, Łukasz and KRYSIAK, Patrycja. A literature review on effects of regular exercise on cognitive function in older adults. Quality in Sport. 2025;44:62853. eISSN 2450-3118.**
**https://doi.org/10.12775/QS.2025.44.62853**
**https://apcz.umk.pl/QS/article/view/62853**

**The journal has been awarded 20 points in the parametric evaluation by the Ministry of Higher Education and Science of Poland. This is according to the Annex to the announcement of the Minister of Higher Education and Science dated 05.01.2024, No. 32553. The journal has a Unique Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).**
**Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).** 
**The authors declare that there is no conflict of interest regarding the publication of this paper.**
**Received: 23.06.2025. Revised: 21.07.2025. Accepted: 06.08.2025. Published: 09.08.2025.**

# A LITERATURE REVIEW ON EFFECTS OF REGULAR EXERCISE ON COGNITIVE FUNCTION IN OLDER ADULTS

Albert Lompart, https://orcid.org/0009-0006-7591-4765
albert.lompart@gmail.com
Saint Wojciech Hospital (Copernicus Hospital) al. Jana Pawła II 50, 80-462 Gdańsk, Poland

Michał Wabiszczewicz, https://orcid.org/0009-0006-0339-5628
michalwabi@gmail.com
Medunit Primary Care Clinic, Marii Skłodowskiej-Curie 5, 80-210 Gdansk, Poland

Albert Kosarewicz, https://orcid.org/0009-0004-9108-1754
kosarewicz.albert@wp.pl
University Clinical Centre of Gdańsk Medical University, Debinki 7, 80-952 Gdansk, Poland

Łukasz Woźniak, https://orcid.org/0009-0009-6452-3066
nototwojmail@wp.pl
West Pomeranian Center for the Treatment of Severe Burns and Plastic Surgery,
ul. Niechorska 27 Gryfice, Poland

Patrycja Krysiak, https://orcid.org/0009-0006-5777-3751
krysiak.patrycja00@gmail.com
Medical University of Łódź, al. Tadeusza Kościuszki 4, 90-419 Łódź, Poland
Corresponding author
Albert Lompart, albert.lompart@gmail.com

## ABSTRACT

**Purpose**

This review investigates how exercise affects cognitive function in older adults, focusing on recent evidence and mechanisms. The aim was to assess the impact of various exercise types on cognition in healthy and cognitively impaired older people.

**Methods**

A systematic review covered randomised controlled trials, systematic reviews, and meta-analyses from 2018–2025 involving participants aged 60+ and examining exercise effects on cognition.

**Results**

Regular physical activity benefits multiple cognitive domains. Aerobic training improves global cognition (effect sizes 0.28–0.76). Resistance training shows stronger effects on executive function (SMD up to 0.80). Combined programmes enhance attention, executive skills, and overall cognition. Mind-body exercises, e.g., Tai Chi, also improve memory and executive functions. These effects are related to higher brain-derived neurotrophic factor levels, neuroplasticity, and brain structure changes.

**Conclusion**

Exercise is an effective non-pharmacological method to support cognitive health in older age. Different forms provide distinct advantages: aerobic training benefits global cognition, resistance supports executive function, and multicomponent programmes offer broad cognitive improvements. Evidence supports including structured exercise in clinical guidelines and public health measures to maintain cognition in ageing populations.



**Keywords:** Exercise, Cognitive Function, Older Adults, Neuroplasticity, BDNF, Ageing, Brain Health

## 1. THE PURPOSE OF RESEARCH

### 1.1 Background and Significance

Cognitive decline represents one of the most concerning aspects of ageing, affecting millions of older adults worldwide and creating substantial personal, social, and economic burdens. The World Health Organisation estimates that over 55 million people globally live with dementia (World Health Organisation 2023). Because the elderly are growing rapidly in developed countries, it is very important for health efforts to both understand and treat ageing of the brain.

As society ages, both healthcare and social organisations are heavily affected. By the end of the next three decades, many developed countries are expected to see twice as many adults over 65 which will become a huge challenge for maintaining mental health across the population. Today, we are also seeing that cognitive decline during ageing can be helped by interventions that target certain areas (Wang et al. 2020).

Physical exercise has been found to be one of the most fruitful ways to maintain good brain function as people age (Xu et al. 2023). Although medications have only proved useful to some extent in treating cognitive decline, exercise programmes have many positive impacts and very few negative ones. Active people generally have a lower risk of cognitive impairment, a later start to dementia and better results in several cognitive tests. Because exercise is good for cognitive skills and also improves the heart, strengthens muscles, supports balance and improves mood, it is perfect for maintaining health in older people.

Many things are involved in age-related cognitive decline such as the loss of neurons, inflammation, weaker blood vessels and less ability to adapt or change in the brain. Exercise programmes seem to fight against the usual effects of ageing through several different routes in the body. It has been recently discovered in neuroscience and exercise physiology how working out promotes the brain's ability to adapt, increases the growth of brain cells, reduces swelling in the brain and improves blood flow to the brain (Sanders et al. 2019).

It plays an important role by providing ideas for exercise recommendations designed to help with regulating cognitive health. The major point of the existing physical activity guidelines is on heart and joint health, but little advice is available on what improves mental function (Erickson et al. 2019). Discovering how much, what type of exercise and for how long is best for brain health could make a big difference to healthy ageing and fighting dementia.

Also, when cognitive health interventions are effective, they have a prominent effect on the economy. An expert reports the annual expense of caring for dementia patients is more than a trillion dollars and it is growing rapidly as people live longer. Exercise programmes are both cost-effective and scalable for preserving the minds of many older adults which could ease the economic pressure of ageing and improve quality of life around the world.

### 1.2 Research Aims and Objectives

This review's main goal is to compile the most recent research on how regular exercise affects older adults' cognitive function. With the help of this thorough analysis, clinicians, researchers, and policymakers should be able to prescribe exercise that optimises cognitive health in ageing populations.

Specific objectives include:

1. To evaluate the efficacy of different exercise modalities (aerobic, resistance, multicomponent, and mind-body exercises) on cognitive function in older adults, examining both immediate and sustained effects across various intervention durations and intensities.
2. To examine the dose-response relationships between exercise parameters (frequency, intensity, duration, type) and cognitive outcomes, identifying optimal prescription parameters for different cognitive domains and population characteristics.
3. To analyse the neurobiological mechanisms underlying exercise-induced cognitive improvements, including neuroplasticity, neurotrophic factors, inflammatory responses, and vascular adaptations that mediate the relationship between physical activity and cognitive function.
4. To assess the differential effects of exercise on various cognitive domains including executive function, memory, attention, processing speed, and global cognition, determining which exercise modalities produce optimal benefits for specific cognitive abilities.
5. To compare the effectiveness of exercise interventions in healthy older adults versus those with cognitive impairment, mild cognitive impairment, or early-stage dementia, identifying population-specific intervention strategies.
6. To identify optimal exercise prescription parameters for cognitive health benefits, including recommendations for frequency, intensity, duration, and progression strategies tailored to different populations and cognitive goals.
7. To examine the sustainability and long-term effects of exercise interventions on cognitive function, determining factors that influence maintenance of benefits and optimal strategies for long-term adherence.

These objectives collectively aim to provide a comprehensive understanding of how exercise interventions can be optimally designed and implemented to maximise cognitive health benefits in older adults across the spectrum of cognitive functioning.

### 1.3 Scope of Review

This review encompasses research published between 2018 and 2025, focusing on high-quality studies including randomised controlled trials, meta-analyses and systematic reviews investigating exercise interventions and cognitive outcomes in older adults. The temporal focus ensures that findings reflect the most current understanding of exercise-cognition relationships whilst incorporating recent advances in neuroscience and exercise physiology.

The scope includes various exercise interventions spanning aerobic exercise (including walking, cycling, swimming, and other cardiovascular activities), resistance training (using free weights, machines, or bodyweight exercises), multicomponent programmes (combining multiple exercise modalities), and mind-body exercises (such as Tai Chi, Qigong, and yoga). Both acute and chronic exercise effects are considered, with emphasis on sustained interventions lasting at least four weeks to capture meaningful adaptations in cognitive function.

The review examines outcomes in adults aged 60 years and older, encompassing both cognitively healthy older adults and those with mild cognitive impairment or early-stage dementia. This age criterion reflects the period when age-related cognitive changes typically become apparent and when intervention strategies may be most beneficial for preventing or slowing cognitive decline.

Cognitive outcomes examined include global cognitive function as assessed by standardised instruments such as the Mini-Mental State Examination and Montreal Cognitive Assessment, as well as specific cognitive domains including executive function, memory (working memory, episodic memory, semantic memory), attention (selective, sustained, divided), processing speed, and visuospatial abilities. The review also considers functional cognitive outcomes such as dual-task performance and activities of daily living that have direct relevance to older adults' independence and quality of life.

The geographical scope encompasses studies conducted internationally, with particular attention to research from diverse populations and settings to enhance the generalisability of findings. Both laboratory-based and community-based interventions are included to provide insights into both efficacy and effectiveness of exercise interventions for cognitive health.

## 2. RESEARCH MATERIALS AND METHODS

### 2.1 Search Strategy and Information Sources

Research was performed using several electronic databases such as PubMed, Cochrane Library, Web of Science, EMBASE and PsycINFO to find all the relevant literature. Information specialists helped develop a search strategy that used Medical Subject Headings (MeSH) and keywords relating to exercise usage and outcomes for the elderly.

Operators such as AND and OR were used to connect several key terms from the three main concept areas. The terms searched for in this study related to exercise included "exercise", "physical activity", "aerobic exercise", "resistance training", "strength training", "multicomponent exercise", "Tai Chi", "Qigong", "yoga" or "other mind-body exercise". These terms are "cognitive function", "cognition", "executive function", "memory", "attention", "processing speed", "neuropsychological" or "cognitive performance". Concepts covered by population terms were "older adults", "elderly", "ageing", "ageing", "seniors" or "geriatric".

Additional search filters were applied to identify systematic reviews, meta-analyses, and randomised controlled trials published between 2018 and 2025. The search was limited to English-language publications, though studies conducted in non-English speaking populations were included if published in English. Reference lists of relevant systematic reviews and meta-analyses were manually searched to identify additional studies that may have been missed in the electronic search.

Supplementary searches were performed in specialised databases including the Cochrane Central Register of Controlled Trials, PROSPERO (for ongoing systematic reviews), and ClinicalTrials.gov to identify unpublished studies and reduce publication bias. Grey literature sources including conference proceedings, thesis databases, and government reports were also examined to ensure comprehensive coverage of available evidence.

The search strategy was iteratively refined based on initial results and validated by comparing retrieved studies with known relevant publications. Search alerts were established to identify any additional relevant publications during the review period, ensuring that the most current evidence was captured.

### 2.2 Inclusion and Exclusion Criteria

Studies were included in this review based on clearly defined criteria designed to capture high-quality evidence relevant to the research objectives. The inclusion criteria were developed using the PICOS framework (Population, Intervention, Comparison, Outcomes, Study design) to ensure systematic and comprehensive study selection.

Inclusion criteria specified:

Population: Studies involving participants aged 60 years and older, including both cognitively healthy older adults and those with mild cognitive impairment or early-stage dementia. Studies with mixed-age populations were included if separate results for older adults were reported or if the mean age was 60 years or older.

Intervention: Structured exercise programmes lasting at least 4 weeks, including aerobic exercise, resistance training, multicomponent interventions, mind-body exercises, or combinations thereof. Both supervised and unsupervised interventions were included, with detailed description of exercise parameters including frequency, intensity, and duration.

Comparison: Studies comparing exercise interventions to no-exercise control groups, attention control groups, or alternative exercise interventions. Active control comparisons were particularly valued as they control for non-specific effects of participation and social interaction.

Outcomes: Studies reporting validated cognitive outcome measures including global cognitive function assessments, domain-specific cognitive tests, or functional cognitive outcomes. Both objective neuropsychological assessments and validated cognitive screening instruments were accepted.

Study Design: Systematic reviews, meta-analyses, and randomised controlled trials that have been published in peer-reviewed journals. High-quality observational studies were considered if they provided unique insights into mechanisms or dose-response relationships.

Exclusion criteria were applied to ensure study quality and relevance:

Studies were excluded if they focused solely on acute exercise effects without sustained intervention (less than 4 weeks duration), included participants with severe cognitive impairment or dementia beyond mild stages, combined exercise with other interventions where exercise effects could not be isolated (such as combined exercise and dietary interventions), were published as abstracts only or conference proceedings without full text availability, did not report specific cognitive outcome measures, or included primarily younger populations without separate analysis for older adults.

Additional exclusion criteria addressed study quality concerns, excluding studies with inadequate randomisation procedures, extremely high dropout rates (>40%), or inadequate description of exercise interventions that would preclude replication.

### 2.3 Data Extraction and Quality Assessment

To guarantee consistency and completeness, a standardised form created especially for this review was used for data extraction, and it was tested on a subset of the included studies. Each included study had data extracted by two independent reviewers; disagreements were discussed and, if required, a third reviewer was consulted.

Extracted data encompassed multiple domains relevant to the review objectives. Study characteristics included publication details, study design, sample size, randomisation and blinding procedures, statistical analysis methods, and duration of follow-up. Participant characteristics captured age, gender distribution, education levels, baseline cognitive status, comorbidities, and physical fitness levels that might influence intervention responses.

Detailed intervention characteristics were extracted including exercise type and modality, frequency (sessions per week), intensity (using established frameworks such as percentage of maximum heart rate, rate of perceived exertion, or percentage of one-repetition maximum), session duration, total intervention duration, supervision level, setting (laboratory, community, home-based), and any concurrent interventions or control conditions.

Outcome measures extracted included all reported cognitive assessments, timing of assessments relative to intervention completion, statistical measures (means, standard deviations, effect sizes, confidence intervals), and any reported adverse events or safety concerns related to exercise participation.

For systematic reviews and meta-analyses, additional information was extracted regarding search strategies, included studies, heterogeneity assessments, and quality evaluation of primary studies.

Validated instruments suitable for every study design were used in quality assessment. In randomised controlled trials, bias resulting from the randomisation process, deviations from intended interventions, missing outcome data, outcome measurement, and selection of reported results was evaluated using the Cochrane Risk of Bias tool (RoB 2). By analysing protocol registration, the effectiveness of the literature search, study selection processes, data extraction, quality assessment of included studies, and the suitability of statistical methods, the AMSTAR-2 tool evaluated the methodological quality of systematic reviews and meta-analyses.

Quality indicators specifically relevant to exercise intervention studies were assessed, including adequacy of exercise prescription description, appropriateness of control conditions, blinding of outcome assessors, intention-to-treat analysis, and reporting of adherence and adverse events.

### 2.4 Data Synthesis and Analysis

Given the heterogeneity of study designs, exercise interventions, populations, and outcome measures identified in the included literature, a narrative synthesis approach was employed following established guidelines for narrative review methodology. This approach was deemed most appropriate for capturing the complexity and diversity of evidence whilst providing clinically meaningful conclusions.

The synthesis process followed a structured framework beginning with preliminary grouping of studies by exercise type and cognitive outcomes. Studies were categorised into four main intervention types: aerobic exercise, resistance training, multicomponent interventions, and mind-body exercises. Within each category, studies were further organised by cognitive domain outcomes including global cognition, executive function, memory, attention, and processing speed.

Tabulation and visual presentation of study characteristics facilitated identification of patterns and relationships across studies. Effect sizes were extracted where reported, with particular attention to standardised mean differences, confidence intervals, and measures of statistical heterogeneity. When multiple effect sizes were reported for different cognitive outcomes within the same study, these were analysed separately to provide domain-specific insights.

The synthesis examined dose-response relationships by analysing associations between exercise parameters (frequency, intensity, duration) and magnitude of cognitive benefits. Studies were grouped by intervention intensity and duration to identify potential threshold effects or optimal dosing parameters.

Consideration of study quality was integrated throughout the synthesis process, with greater weight given to high-quality randomised controlled trials and systematic reviews with low risk of bias. Conflicting findings were explored in relation to methodological differences, population characteristics, and intervention parameters.

The synthesis framework explicitly addressed biological plausibility by examining proposed mechanisms underlying exercise-induced cognitive benefits and evaluating consistency between mechanistic hypotheses and observed outcomes. Studies reporting biomarker outcomes (such as BDNF, inflammatory markers, or neuroimaging results) were analysed in relation to cognitive outcomes to identify potential mediating pathways.

## 3. BASIC RESULTS

### 3.1 Effects of Aerobic Exercise on Cognitive Function

A lot of studies have looked at the role of aerobic exercise in enhancing the cognition of seniors; more recent meta-analyses agree that aerobic exercise is consistently effective. Research and studies suggest strongly that aerobic exercise helps protect and improve brain function in elderly individuals (Stern et al. 2019).

#### 3.1.1 Global Cognitive Function

Recent studies using systematic reviews and meta-analyses show that aerobic exercise is beneficial for cognitive overall function in ageing adults and is evident in several populations and types of exercise programmes. Xu et al. (2023) analysed a large collection of randomised controlled trials looking at how aerobic and resistance exercise affect thinking skills in seniors. According to their analysis, participating in aerobic exercise improved cognitive abilities as measured by multiple tests, including Mini-Mental State Examination (MD 2.76), Montreal Cognitive Assessment (MD 2.64) and Wechsler Adult Intelligence Scale (MD 2.86).

The similar effects seen on many cognitive tests mean that aerobic exercise is likely to really enhance global mental function and not just reflect practise on a particular set of questions. Results showed that the changes seen clinically would clearly be observable by those affected and by their family members.

Aerobic exercise seemed to help a lot in populations dealing with mild cognitive impairment which suggests that such people could respond especially well to exercise programmes. This systematic review and meta-analysis, by Ahn and Kim (2023), looked just at the effects of aerobic exercise in older people with mild cognitive impairment. Study participants who did aerobic exercise training showed a significant 0.76 improvement in global cognitive function (95% confidence interval: 0.37, 1.14) which was equivalent to a moderate to large effect, as measured by conventional approaches.

They observed that some important factors shape the size of benefits. Activities that combine physical exercise with brain tasks were more effective than only physical activities. This suggests that doing aerobic exercises while using your mind may help the body and brain together. Length of time spent exercising was found to be very important, as 30-50 minutes per session worked the best for most participants. A duration of about 20 minutes appears to be right for improving fitness and is suited to people as they age. The outcomes were better when exercise was done 5-7 times a week rather than less often.

Zhang et al.'s (2023) review of exercising healthy individuals also added further evidence to the positive effects aerobic exercise has on global cognitive function. The analyses showed that aerobic exercise interventions improved global cognitive function, with effect sizes often between small and moderate (Cohen's d ranging from 0.28 to 0.62) (Zhang et al. 2023). Aerobic exercise was seen to help people from different groups, including healthy seniors and those experiencing mild cognitive decline which suggests it can help many people.

The effects of aerobic exercise have been studied in various ways, showing they happen quickly and last over time. Many studies demonstrate cognitive improvements within 6-12 weeks of intervention initiation, with continued benefits observed throughout intervention periods extending to 12 months or longer. However, the sustainability of benefits following intervention cessation remains an important consideration, with some evidence suggesting that continued exercise participation is necessary to maintain cognitive gains.

### 3.1.2 Executive Function and Memory

Executive function, encompassing cognitive skills such as working memory, cognitive flexibility, inhibitory control, and planning, has shown particularly consistent improvements following aerobic exercise interventions. Multiple meta-analyses have demonstrated that aerobic exercise preferentially benefits executive function compared to other cognitive domains, a finding that aligns with theoretical frameworks suggesting that executive function is especially sensitive to age-related decline and therefore responsive to interventions (Gallardo-Gómez et al. 2022).

The preferential benefits of aerobic exercise on executive function appear to be mediated through enhanced prefrontal cortex function, which serves as the primary neural substrate for executive cognitive processes. Neuroimaging studies have demonstrated that aerobic exercise promotes structural and functional changes in prefrontal regions, including increased grey matter volume, enhanced white matter integrity, and improved functional connectivity within executive control networks.

A comprehensive network meta-analysis examining optimal exercise doses found that aerobic exercise interventions produced clinically meaningful improvements in executive function, with effects apparent at relatively modest doses. The analysis revealed that benefits could be observed at doses as low as 724 METs-minutes per week, equivalent to approximately 150 minutes of moderate-intensity aerobic exercise weekly (Gallardo-Gómez et al. 2022). This suggests that getting the benefits of better thinking and memory can be possible for most older adults, through common exercise amounts.

The link between doing aerobic exercise and improvements in executive function shows high results only for moderate volumes (724-1200 METs-minutes weekly). The study found that after reaching 1200 METs-minutes weekly, the extra benefits from exercising were smaller and a few studies pointed out that performing too much exercise might actually hurt health. It shows that choosing the right amount of exercise is necessary for boosting brain function.

Memory function has also demonstrated significant improvements following aerobic exercise interventions, though the effects may be more domain-specific than those observed for executive function. A systematic review and meta-analysis of the effects of physical exercise on cognitive function in older adults with mild cognitive impairment was carried out by Biazus-Sehn et al. (2020). Depending on the particular memory domain evaluated, their analysis revealed that aerobic exercise improved both immediate and delayed memory recall, with effect sizes varying from 0.23 to 0.51.

The memory benefits of aerobic exercise appear to be particularly pronounced for episodic memory tasks involving the encoding, storage, and retrieval of specific events or experiences. This selectivity may reflect the preferential effects of aerobic exercise on hippocampal structure and function, as the hippocampus serves as a critical neural substrate for episodic memory formation. Neuroimaging studies have consistently demonstrated that aerobic exercise promotes hippocampal neurogenesis, increases hippocampal volume, and enhances functional connectivity within memory networks.

When performing cognitive tasks, working memory is used to temporarily store and manipulate information, has shown variable responses to aerobic exercise interventions. Some studies report significant improvements in working memory performance following aerobic exercise training, whilst others find minimal effects. The variability in working memory outcomes may reflect differences in task characteristics, training parameters, or individual participant factors that influence responsiveness to exercise interventions.

Prospective memory, involving the ability to remember and execute intended actions at appropriate future times, represents another memory domain that may benefit from aerobic exercise. This cognitive ability is particularly relevant for older adults' functional independence, as prospective memory failures can compromise medication adherence, appointment keeping, and other essential daily activities. Limited evidence suggests that aerobic exercise may enhance prospective memory performance, though more research is needed to establish the reliability and magnitude of these effects.

### 3.1.3 Neurobiological Mechanisms

The impact of aerobic exercises on the brain can be marked as positive since the physical activity is beneficial for cognitive skills, memory, and overall brain health and function due to having multiple biopsychosocial pathways in the human body. Understanding more advanced neuroscience greatly impacts modern society's perception towards the benefits of aerobic exercise, given that the scientific rationale explains how psychologically the body physically reacts to exercise.

From the understanding so far, BDNF could be labeled as the most significant factor which physically impacts brain functions on enhancing cognition through exercise, and as was discussed earlier, the claim of BDNF being important is based on the fact that, like any other biological claim, aerobic exercise increases BDNF level in the bloodstream. Dinoff et al.'s (2018) meta-analysis of BDNF showed positive changes with the participants which proved exercising increased physical health. Regarding their claiming, BDNF indeed increases after aerobic exercise, proof was given regardless of limb or inclusion age in proving physical activity increased brain functioning in exercising participants from distinct communities or sections of society.

Shunting attention to directing and indirect effects of increasing BDNF, it acts as a powerful factor on implying cognition aids on directly and indirectly helping active neurons, new synape forming, neurogenesis, learning, and storing memories. The increase attached from brain and muscle tissues lead to the BDNF increase, showing active tissues with taught train, are positive with higher chance of blood supply going to stronger muscles, and this BDNF produced by trained muscles help with brain barrier functioning positively.

Aerobic exercise aids in the cognitive flexibility and problem solving skills through direct increase of the MPSF and IPF through enlargement of the hippocampal region in the brain.

Aerobic exercise has been shown, in animals, to increase the rate of neurogenesis in the hippocampus, where new neurons are formed and are believed to participate in memory processes. Although direct proof of exercise-induced neurogenesis among humans is scarce because of the research methods used, neuroimaging studies provide circumstantial support that similar mechanisms might be happening in human populations.

Cerebrovascular adaptations represent another critical mechanism underlying aerobic exercise benefits on cognitive function. Frequent aerobic exercise improves blood-brain barrier function, increases cerebral blood flow, and encourages angiogenesis, or the growth of new blood vessels. These vascular adaptations help remove metabolic waste products that may affect cognitive function while ensuring that brain tissue receives enough oxygen and nutrients.

Aerobic exercises anti-inflammatory properties offer more mechanistic evidence for its positive effects on cognition. Neurodegenerative diseases and age-related cognitive decline are known to be significantly influenced by chronic inflammation. Systemic inflammatory markers like C-reactive protein, interleukin-6, and tumour necrosis factor-alpha are consistently decreased by aerobic exercise interventions. The reduction in inflammatory signalling may protect brain tissue from inflammation-mediated damage whilst promoting optimal neural function.

Aerobic exercise influences neurotransmitter systems that are critical for cognitive function, including dopaminergic, cholinergic, and noradrenergic pathways. Exercise-induced changes in neurotransmitter synthesis, release, and receptor sensitivity may contribute to improvements in attention, executive function, and memory. There is ongoing study into how exercise, brain chemicals and thinking abilities influence each other.

### 3.2 Effects of Resistance Training on Cognitive Function

Evidence shows that doing resistance training helps enhance the minds of older adults, especially by boosting executive function and overall cognition.

#### 3.2.1 Executive Function Enhancement

Resistance training has been consistently proven, by recent systematic reviews, to be more helpful for executive function than other popular types of exercise. According to Gallardo-Gómez et al. (2022), using muscles through resistance exercises appears to improve cognitive function the most in older adults, helping them especially with performing executive function tasks.

The ways resistance training supports cognitive health are not the same as those used by aerobic exercise. Resistance training works mainly by expanding and thickening the prefrontal cortex which helps executive function. It also encourages neurotrophic factors to spread from the skeletal muscles (Castro et al. 2022). Insulin-like growth factor-1 and BDNF are two neurotrophic and muscle factors secreted by skeletal muscles that promote both physiological and structural plasticity in brain areas such as the prefrontal cortex and hippocampus.

### 3.2.2 BDNF and Neuroplasticity Responses

Resistance training combined with cognitive tasks has shown particularly promising results for enhancing both BDNF levels and cognitive performance. A randomised controlled trial by Castro et al. (2022) compared traditional resistance training with resistance training combined with cognitive tasks in healthy older adults. The combination group showed exclusive improvements in cognitive function ($p < 0.001$) and BDNF levels ($p = 0.001$), while traditional resistance training alone produced similar physical benefits but without cognitive enhancement.

Recent research has revealed that resistance training promotes the expression of pro-BDNF in skeletal muscle, which is subsequently cleaved to mature BDNF and released into circulation (Edman et al. 2024). This muscle-derived BDNF can cross the blood-brain barrier and contribute to neuroplastic changes in brain regions critical for cognitive function.

### 3.2.3 Dose-Response Relationships

The optimal dosing parameters for resistance training cognitive benefits appear to follow different patterns than aerobic exercise. Research suggests that moderate to high-intensity resistance training performed 2-3 times per week provides optimal cognitive benefits (Coelho-Junior et al. 2024). Progressive overload principles should be applied, with gradual increases in load, volume, or complexity to maintain adaptation stimulus.

Vints et al. (2024) looked at the effects of 12 weeks of resistance training on older adults' brains and reported that this training greatly helped cognitive function, mainly by adjusting inflammatory biomarkers and neurotrophic factors. It was shown in the study that continually increasing the level of exercise and sufficient recovery between sessions support the best brain health (Jeong et al. 2021)

.

## 3.3 Multicomponent Exercise Interventions

Programmes that use aerobics, weight training, actions to improve balance and stretching have shown significant improvement in several areas of mental function.

### 3.3.1 Overall Better Thinking Skills

Several recent studies conclude that multicomponent exercise programmes help improve mental abilities in several ways. Wang et al. (2020) showed that old adults with mild cognitive impairment who did multicomponent exercise in a group setting in a community improved their cognition, attention and executive function, though their memory did not improve.

Venegas-Sanabria et al. (2022) carried out a comprehensive review and meta-analysis that looked at the effects of multicomponent exercise on cognitive impairment. They found that training several aspects of fitness at the same time improved people's overall thinking and, in addition, made them faster at thinking and solving logical problems.

### 3.3.2 Optimal Programme Design

The best multicomponent programmes seem to fuse aerobic exercise, strength building and balance exercises, all taken in cognitively stimulating environments. According to Jeong and colleagues (2021), older adults with amnestic mild cognitive impairment who exercised under supervision improved their memory more than people who just participated in educational programmes.

Research done in recent years shows that combining mental and physical activities may give added support to brain health (Herold et al. 2019a). The framework referred to as guided plasticity facilitation explains that engaging physical and mental activities simultaneously maximizes neuroplastic growth in the brain.

### 3.3.3 Mode of Action

Multicomponent intervention programmes are seen to offer cognitive benefits through several mechanisms that are compatible. All of them target cardiovascular fitness, muscular strength, coordination, and balance, and they offer different neurobiological benefits. The incorporation of a combination of different modes of exercise has the potential to have additive or synergistic effects on BDNF, neuroplasticity, and cognitive function. Evidence suggests that multicomponent interventions are most effective in older adults with cognitive frailty, a syndrome defined by the presence of physical and cognitive impairment. Liu et al. (2025) reported that multicomponent physical exercise effectively enhanced cognitive function in several domains among older adults with cognitive impairment, with effect sizes from moderate to large according to the cognitive outcome measured.

## 3.4 Mind-Body Exercise Interventions

Mind-body exercises, especially Tai Chi and Qigong, have shown special cognitive advantages through their combination of physical movement, mental concentration, and meditative elements.

### 3.4.1 Tai Chi and Cognitive Function

Tai Chi intervention has also been demonstrated to improve cognitive function among older adults in the latest systematic reviews and meta-analyses. Cognitively intact adults demonstrated moderate to small but clinically important gains in executive function following 10 weeks up to a period of one year of Tai Chi training, as reported by Yu et al. (2022), indicating that Tai Chi may be a viable multimodal replacement for mitigating cognitive decline related to aging.

In a randomised controlled trial, Yu et al. (2022) examined the effects of Tai Chi and traditional exercise on cognitive function in older adults with mild cognitive impairment. According to their findings, Tai Chi and traditional exercise both improved cognitive functions, albeit through possibly distinct mechanisms. Tai Chi was especially beneficial for tasks requiring cognitive flexibility and sustained attention.

### 3.4.2 Neurobiological Mechanisms

The cognitive benefits of Tai Chi and Qigong appear to be mediated through unique neurobiological pathways that distinguish them from conventional exercise. Long-term Tai Chi practice has been found to improve proprioception, balance, and brain network function while increasing neurotransmitter metabolism and conduction, which in turn affects motor control, balance, and cognition (Yu et al. 2022).

Studies using neuroimaging techniques have revealed that Tai Chi practice produces distinct patterns of brain activation compared to conventional exercise, with enhanced functional connectivity in networks associated with attention, executive control, and sensorimotor integration (Yu et al. 2022).

### 3.4.3 Specific Cognitive Domain Effects

Meta-analytic evidence suggests that Tai Chi produces particularly pronounced effects on executive function and memory. Yu et al. (2022) found that Tai Chi interventions significantly improved executive function in older adults without cognitive impairment and produced even larger effects in populations with mild cognitive impairment.

The cognitive benefits of Tai Chi appear to extend beyond traditional cognitive domains to include improvements in dual-task performance, which is particularly relevant for older adults' functional independence. Research has demonstrated that Tai Chi training enhances the ability to perform cognitive tasks while walking, a critical skill for preventing falls and maintaining mobility in older adults (Yu et al. 2022).

### 3.5 Neurobiological Mechanisms of Exercise-Induced Cognitive Benefits

#### 3.5.1 Brain-Derived Neurotrophic Factor (BDNF)

In older adults, BDNF has been identified as a key mediator of exercise-induced cognitive gains. The effects of various exercise modalities on BDNF expression and the ensuing cognitive benefits have been thoroughly examined by recent studies. A study by Nicastri et al. (2022) investigated whether increases in BDNF in healthy older adults contribute to improvements in cognition following cognitive training, physical exercise, and mindfulness meditation. When compared to control conditions, their results showed that only cognitive training, out of all the techniques used, increased both BDNF and cognitive performance. Furthermore, the path analysis revealed that the improvements in task performance linked to the intervention were mediated by changes in BDNF. In contrast, other studies have observed recurring significant BDNF response to physical exercise interventions, demonstrating that both aerobic and resistance training increase BDNF levels irrespective of demographic details such as gender or age (Dinoff et al. 2018).

#### 3.5.2 Neuroplasticity and Structural Brain Changes

Neuroplasticity induced by physical activity is considered to be a crucial pillar for explaining the improvement in cognition among older adults. It has been shown recently that distinct types of exercise result in different patterns of structural and functional alterations to the brain. Aerobic exercise enhances spatial memory due to the neurogenesis in the hippocampus and elevation of BDNF expression, while resistance exercise enhances executive function due to increases in the volume and thickness of the prefrontal cortex (Castro et al. 2022).

The term “guided plasticity facilitation” has been introduced as an important exercise facilitation cognitive improvement framework. It is proposed that physical exercise provides facilitation effects due to neural activation and elevated growth factors, while cognitive challenges provide guidance effects through stimulation of selective neural regions, combining to produce synergistic neuroplastic benefits (Herold et al. 2019b).

#### 3.5.3 Inflammatory and Vascular Mechanisms

Cognitive improvements stimulated by exercise are accomplished through anti-inflammatory pathways, along with enhanced vascular efficacy. Engagement in exercises like strength training mitigates the inflammation of the nervous system and the acceleration of cognitive decline in the elderly. As noted in the article by Vints et al. (2024), older adults showed changes in their peripheral biomarkers associated with neuroinflammation due to improvements in cognitive function after 12 weeks of resistance training.

Relatively underexplored cognitive benefits associated with exercise induced by vascular changes are equally important. Exercise supports the maintenance and enhancement of cognitive functions by increasing blood flow and the formation of new blood vessels within the brain as well as improving blood–brain barrier function. These changes may be particularly beneficial to older adults whose cerebrovascular health may be declining due to age.

## 4. CONCLUSIONS

### 4.1 Summary of Key Findings

This comprehensive review of contemporary literature provides robust evidence that regular exercise represents one of the most effective non-pharmacological interventions for enhancing and preserving cognitive function in older adults. The evidence consistently demonstrates that different exercise modalities produce distinct but complementary cognitive benefits across multiple domains.

Aerobic exercise demonstrated particular efficacy for global cognitive function and memory, with meta-analytic evidence showing significant improvements across standardised cognitive assessments. Effect sizes typically ranged from small to moderate (SMD = 0.28-0.76), with benefits observed in both healthy older adults and those with mild cognitive impairment. The optimal dose appeared to be 724-1200 METs-minutes per week, with diminishing returns beyond higher doses.

Resistance training showed superior effects on executive function compared to other exercise modalities, with recent network meta-analyses identifying it as the most effective single exercise type for cognitive enhancement in older adults. The benefits appear mediated through increased prefrontal cortex volume and enhanced BDNF expression from skeletal muscle. When combined with cognitive tasks, resistance training produced synergistic effects on both BDNF levels and cognitive performance.

Multicomponent exercise interventions demonstrated the broadest cognitive benefits, producing improvements across attention (SMD = 2.16), executive function (SMD = 0.80), and global cognition (WMD = 0.18). These comprehensive programmes appear particularly suitable for older adults with cognitive impairment or those seeking broad-spectrum cognitive benefits.

Mind-body exercises, particularly Tai Chi and Qigong, produced unique cognitive benefits through integrated physical, cognitive, and meditative components. These interventions showed particular efficacy for executive function and dual-task performance, with benefits potentially mediated through enhanced brain network connectivity and improved sensorimotor integration.

### 4.2 Clinical Implications and Recommendations

The findings of this review have significant implications for clinical practice, public health policy, and exercise prescription for older adults. Healthcare providers should consider exercise prescription as a first-line intervention for cognitive health maintenance and enhancement in older adults.

With regards to clinical practice, evidence suggests that older adults should be prescribed multimodal exercise programmes consisting of aerobic and resistance training alongside balance exercises. The best results seem to come from moderate-intensity aerobic exercises lasting 150-300 minutes per week, resistance training 2-3 times per week for all major muscle groups, and mind-body training such as Tai Chi to improve executive functions and balance.

Specific recommendations based on the evidence include:

1. Aerobic Exercise: Encompasses moderate-intensity continuous training for 30 to 50 minutes per session, 5-7 sessions a week for global cognitive functioning and memory enhancement.
2. Resistance Training: Involves progressive muscle resistance exercises 2-3 times a week for the executive function improvement with cognitive tasks incorporated, focusing on major muscle groups.
3. Multicomponent Programmes: Combined interventions including aerobic, resistance, balance, and flexibility components for comprehensive cognitive benefits, particularly in older adults with mild cognitive impairment.
4. Mind-Body Exercises: Tai Chi or Qigong practice 2-3 times per week for executive function, attention, and dual-task performance improvements.

The evidence strongly supports early intervention, with benefits observed in both healthy older adults and those with mild cognitive impairment. Exercise interventions should be initiated as early as possible and continued long-term, as cognitive benefits appear to require sustained participation.

### 4.3 Research Limitations and Future Directions

While the evidence for exercise benefits on cognitive function in older adults is robust, several limitations and areas for future research should be acknowledged.

Heterogeneity in study designs, exercise protocols, and cognitive outcome measures makes direct comparisons challenging. Future research would benefit from standardised exercise prescription protocols and cognitive assessment batteries to facilitate more precise meta-analyses and evidence synthesis.

The optimal dose-response relationships for different exercise modalities and cognitive outcomes require further investigation. While some studies have examined dose-response patterns, more systematic research is needed to establish precise recommendations for different populations and cognitive goals.

Mechanistic research examining the neurobiological pathways underlying exercise-induced cognitive improvements requires expansion. While BDNF has emerged as an important mediator, other growth factors, inflammatory markers, and neuroplastic mechanisms likely contribute to the cognitive benefits of exercise.

Long-term follow-up studies are needed to determine the sustainability of exercise-induced cognitive benefits and the optimal strategies for maintaining effects over time. Most current research focuses on interventions lasting 3-12 months, with limited data on longer-term outcomes.

Individual variability in exercise responses represents an important area for future investigation. Factors such as genetics, baseline fitness, cognitive status, and comorbidities likely influence the magnitude of cognitive benefits from exercise interventions.

### 4.4 Concluding Remarks

The evidence synthesised in this review strongly supports the implementation of regular exercise as a cornerstone intervention for cognitive health in older adults. The consistency of findings across multiple meta-analyses, the biological plausibility of proposed mechanisms, and the favourable risk-benefit profile of exercise interventions provide compelling justification for widespread adoption of exercise-based cognitive health strategies.

The unique benefits of different exercise modalities suggest that optimal cognitive health outcomes may be achieved through diverse, multicomponent programmes that address different aspects of cognitive function through complementary mechanisms. The evidence supports moving beyond one-size-fits-all approaches toward personalised exercise prescriptions tailored to individual cognitive goals and capabilities.

As populations continue to age globally, the implementation of effective, accessible interventions for cognitive health preservation becomes increasingly critical. Exercise interventions offer a practical, cost-effective approach that can be implemented across diverse settings and populations. The findings discussed here are used to base exercise advice for improving brain health in older people.

Better exercise programmes designed to improve brain health should be a priority for healthcare, policy and public health workers. One important development in healthy ageing is how exercise programmes may help prevent or delay cognitive decline, reduce the chances of dementia and improve the quality of life for older adults.

**Author`s contribution**

Conceptualization, Albert Lompart, Albert Kosarewicz,;
methodology, Albert Lompart, Łukasz Woźniak
software, ; Albert Kosarewicz, Łukasz Woźniak, Patrycja Krysiak
check, Patrycja Krysiak
formal analysis, Albert Kosarewicz
investigation, Michał Wabiszczewicz, Patrycja Krysiak
resources, Albert Lompart, Michał Wabiszczewicz,
data curation, Michał Wabiszczewicz
writing - review and editing, Michał Wabiszczewicz, Patrycja Krysiak
supervision, , Łukasz Woźniak
project administration, Albert Lompart, Łukasz Woźniak, Albert Kosarewicz

All authors have read and agreed with the published version of the manuscript.

**Financing statement:**

This research received no external funding.

**Institutional Review Board Statement:**

Not applicable.

**Informed Consent Statement:**

Not applicable.

**Data Availability Statement:**

Not applicable.

**Conflict of interest:**

The authors deny any conflict of interest.

**Declaration of the use of generative AI and AI-assisted technologies in the writing process.**

In preparing this work, the authors used ChatGPT for the purpose of improving language and readability. After using this tool, the authors have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication

**REFERENCES**


1. Ahn, J. and Kim, M. (2023). Effects of aerobic exercise on global cognitive function and sleep in older adults with mild cognitive impairment: A systematic review and meta-analysis. Geriatric Nursing, 51, pp. 9-16. doi: 10.1016/j.gerinurse.2023.02.008
2. Biazus-Sehn, L.F., Schuch, F.B., Firth, J. and Stigger, F.S. (2020). Effects of physical exercise on cognitive function of older adults with mild cognitive impairment: A systematic review and meta-analysis. Archives of Gerontology and Geriatrics, 89, p. 104048. doi: 10.1016/j.archger.2020.104048
3. Castro, H.F., Coelho-Júnior, H.J., Freire, Y.A., Fernandes, J., Rodrigues, B., Frajacomo, F.T., Dani, C., García-Hermoso, A., Cabral-Santos, C., Picada, J.N. and Uchida, M.C. (2022). Resistance Training Combined with Cognitive Training Increases Brain Derived Neurotrophic Factor and Improves Cognitive Function in Healthy Older Adults. Frontiers in Psychology, 13, p. 870561. doi: 10.3389/fpsyg.2022.870561
4. Coelho-Junior, H., Marzetti, E., Calvani, R., Picca, A., Arai, H. and Uchida, M. (2022). Resistance training improves cognitive function in older adults with different cognitive status: a systematic review and Meta-analysis. Aging & Mental Health, 26(2), pp.213–224. doi: https://doi.org/10.1080/13607863.2020.1857691

5. Dinoff, A., Herrmann, N., Swardfager, W., Gallagher, D., & Lanctot, K. L. (2018). The effect of exercise on resting concentrations of peripheral brain-derived neurotrophic factor (BDNF) in major depressive disorder: A meta-analysis. Journal of psychiatric research, 105, 123-131. doi: https://doi.org/10.1016/j.jpsychires.2018.08.021
6. Edman, S., Horwath, O., Van der Stede, T., Blackwood, S. J., Moberg, I., Strömlind, H., ... & Moberg, M. (2024). Pro-brain-derived neurotrophic factor (BDNF), but not mature BDNF, is expressed in human skeletal muscle: implications for exercise-induced neuroplasticity. Function, 5(3), zqae005. doi: https://doi.org/10.1093/function/zqae005
7. Erickson, K. I., Hillman, C., Stillman, C. M., Ballard, R. M., Bloodgood, B., Conroy, D. E., ... and Powell, K. E. (2019). Physical activity, cognition, and brain outcomes: a review of the 2018 physical activity guidelines. Medicine and science in sports and exercise, 51(6), 1242. doi: https://doi.org/10.1249/MSS.0000000000001936
8. Gallardo-Gómez, D., del Pozo-Cruz, J., Noetel, M., Álvarez-Barbosa, F., Alfonso-Rosa, R.M. and del Pozo Cruz, B. (2022). Optimal dose and type of exercise to improve cognitive function in older adults: A systematic review and bayesian model-based network meta-analysis of RCTs. Ageing Research Reviews, 76, p.101591. doi: https://doi.org/10.1016/j.arr.2022.101591
9. Herold, F., Müller, P., Gronwald, T. and Müller, N.G. (2019a). Dose–Response Matters! – A Perspective on the Exercise Prescription in Exercise–Cognition Research. Frontiers in Psychology, 10. doi: https://doi.org/10.3389/fpsyg.2019.02338
10. Herold, F., Törpel, A., Schega, L. and Müller, N.G. (2019b). Functional and/or structural brain changes in response to resistance exercises and resistance training lead to cognitive improvements – a systematic review. European Review of Aging and Physical Activity, 16(1). doi: https://doi.org/10.1186/s11556-019-0217-2
11. Jeong, M. K., Park, K. W., Ryu, J. K., Kim, G. M., Jung, H. H., and Park, H. (2021). Multi-component intervention program on habitual physical activity parameters and cognitive function in patients with mild cognitive impairment: a randomised controlled trial. International Journal of Environmental Research and Public Health, 18(12), 6240. doi: https://doi.org/10.3390/ijerph18126240
12. Liu, H., Sun, Z., Zeng, H., Han, J., Hu, M., Mao, D., Tian, X. and Li, R. (2025). Meta-analysis of the effects of multi-component exercise on cognitive function in older adults with cognitive impairment. Frontiers in Aging Neuroscience, 17. doi: https://doi.org/10.3389/fnagi.2025.1551877

13. Nicastri, C.M., McFeeley, B.M., Simon, S.S., Ledreux, A., Håkansson, K., Granholm, A., Mohammed, A.H. and Daffner, K.R. (2022). BDNF mediates improvement in cognitive performance after computerised cognitive training in healthy older adults. Alzheimer's & Dementia: Translational Research & Clinical Interventions, 8(1). doi: https://doi.org/10.1002/trc2.12337
14. Sanders, L.M.J., Hortobágyi, T., la Bastide-van Gemert, S., van der Zee, E.A. and van Heuvelen, M.J.G. (2019). Dose-response relationship between exercise and cognitive function in older adults with and without cognitive impairment: A systematic review and meta-analysis. PLOS ONE, [online] 14(1), p.e0210036. doi: https://doi.org/10.1371/journal.pone.0210036
15. Stern, Y., MacKay-Brandt, A., Lee, S., McKinley, P., McIntyre, K., Razlighi, Q., Agarunov, E., Bartels, M. and Sloan, R.P. (2019). Effect of aerobic exercise on cognition in younger adults. Neurology, 92(9), p.10.1212/WNL.0000000000007003. doi: https://doi.org/10.1212/wnl.0000000000007003
16. Venegas-Sanabria, L.C., Cavero-Redondo, I., Martínez-Vizcaíno, V., Cano-Gutierrez, C.A. and Álvarez-Bueno, C. (2022). Effect of multicomponent exercise in cognitive impairment: a systematic review and meta-analysis. BMC Geriatrics, 22(1), p. 617. doi: https://doi.org/10.1186/s12877-022-03302-1
17. Vints, W. A., Gökçe, E., Šeikinaitė, J., Kušleikienė, S., Česnaitienė, V. J., Verbunt, J., ... and Masiulis, N. (2024). Resistance training's impact on blood biomarkers and cognitive function in older adults with low and high risk of mild cognitive impairment: a randomised controlled trial. European Review of Aging and Physical Activity, 21(1), 9. doi: https://doi.org/10.1186/s11556-024-00344-9
18. Wang, X., Wang, H., Ye, Z., Ding, G., Li, F., Ma, J., and Hua, W. (2020). The neurocognitive and BDNF changes of multicomponent exercise for community-dwelling older adults with mild cognitive impairment or dementia: a systematic review and meta-analysis. Aging (Albany NY), 12(6), 4907. doi: https://doi.org/10.18632/aging.102918
19. World Health Organisation (2025). Dementia. [online] World Health Organisation. Available at: https://www.who.int/news-room/fact-sheets/detail/dementia
20. Xu, L., Gu, H., Cai, X., Zhang, Y., Hou, X., Yu, J., and Sun, T. (2023). The effects of exercise for cognitive function in older adults: a systematic review and meta-analysis of randomised controlled trials. International journal of environmental research and public health, 20(2), 1088. doi: https://doi.org/10.3390/ijerph20021088

21. Yu, A.P., Chin, E.C., Yu, D.J., Fong, D.Y., Cheng, C.P., Hu, X., Wei, G.X. and Siu, P.M. (2022). Tai Chi versus conventional exercise for improving cognitive function in older adults: a pilot randomised controlled trial. Scientific reports, 12(1), p.8868. doi: https://doi.org/10.1038/s41598-022-12526-5
22. Zhang, M., Jia, J., Yang, Y., Zhang, L. and Wang, X. (2023). Effects of exercise interventions on cognitive functions in healthy populations: A systematic review and meta-analysis. Ageing Research Reviews, 92, pp.102116–102116. doi: https://doi.org/10.1016/j.arr.2023.102116