

Nutrition & exercise for brain health: Enhancing cognitive function and neuroplasticity

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Abstract

This editorial examines the relationship between nutrition, physical activity, and brain health, emphasizing their effects on cognitive function and mental well-being. Evidence supports a balanced diet – rich in antioxidants, omega-3 fatty acids, polyphenols, and patterned after the Mediterranean-DASH Intervention for Neurodegenerative Delay (MIND) diet – as crucial for sustaining neural structure, function, and plasticity. Similarly, regular exercise has been shown to enhance mood, attention, memory, and overall cognitive performance. However, despite these demonstrated benefits, the precise neurobiological mechanisms through which diet and exercise influence brain health remain unclear. This article explores both the efficacy of these interventions and the challenges involved in optimizing them for long-term cognitive resilience.

Key words: cognitive function, mental health, exercise, nutrition, brain health

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Highlights

- Nutrition and exercise synergy enhances brain health and neuroplasticity: Combined diet and physical activity fortify brain structure, synaptic function, and learning capacity.
- Antioxidants, omega-3 fatty acids, polyphenols, and the MIND diet boost cognitive function: These key nutrients reduce oxidative stress and support memory, attention, and executive performance.
- Regular physical activity elevates mood, attention, memory, and overall cognitive performance: Aerobic and resistance training increase cerebral blood flow and neurotrophic factors for sharper thinking.
- Mechanistic insights still emerging on diet- and exercise-driven brain benefits: Ongoing research aims to unravel the molecular pathways linking nutritional compounds and exercise stimuli to neural health.

Introduction

In recent decades, a broad range of academic studies has shown interest in the mind–body relationship and published a number of empirical studies in this field.¹ The “mind–body connection” refers to the complex interplay between mental and physical well-being. Efficient bidirectional communication between the brain and body is vital for maintaining physiological homeostasis. The human organism comprises intricately connected systems that work in concert to regulate this balance and underpin both behavior and cognition.² This concept highlights on interaction of thoughts, emotions, and actions on our bodies and vice versa.³ Some factors such as psychological therapy, diet, exercise, and sleep significantly affect cognitive function and emotional stability, psychological status and physical health.⁴ For example, psychological therapy can improve quality of life and wellbeing.⁵ A healthy nutrition influences both mental and physical well-being and increases disease resistance.⁶

The capacity of neurons to modify the strength and structure of their synaptic connections in response to internal and external stimuli underlies the brain’s adaptive ability, a phenomenon known as neuroplasticity. A growing body of evidence indicates that physical activity (PA) enhances cognitive processes, such as memory and attention, in both children and adults.^{7,8} Studies have reported that brain capillaries improve and regulate these effects by supplying angiogenic growth factors such as the vascular endothelial growth factor (VEGF), brain-derived neurotrophic factor (BDNF), and the growth and differentiation factor 11 (GDF11), and induce genes responsible for neuroplasticity.^{9,10} Dietary regimens that emphasize caloric restriction may delay the onset of age-related diseases and slow the biological aging process.^{11,12}

Preventive policies and health promotion programs are crucial for healthy aging. As the elderly population grows, these strategies help support their well-being and decrease pressure on healthcare and pension systems. This change in population structure is linked to a higher disease burden and increased healthcare costs.^{13,14} Eating healthy foods with anti-aging properties is important for supporting healthy aging and reducing the risk of chronic diseases.¹⁵

This editorial explores the mind–body connection by examining how diet and exercise influence brain function. It synthesizes mounting evidence that lifestyle choices, specifically balanced nutrition and regular physical activity, are fundamental to cognitive health, emotional resilience, and overall quality of life. By reviewing the latest research, the letter advocates for lifestyle modifications that may slow biological aging and reduce the risk of age-related diseases, underscoring the critical interplay between mental and physical well-being.

Brain health

The cerebrum, the largest part of the brain, is responsible for higher cognitive functions such as memory, reasoning, and complex thought.¹⁶ The brainstem controls fundamental processes such as breathing, heartbeat, and digestion, while the cerebellum organizes movement and balance.¹⁷ The brain utilizes interconnected neuronal networks, linked by synapses, to transmit electrical impulses and facilitate communication both among its various regions and with the rest of the body. The brain can process sensory data, start movements, control emotions, and oversee all physiological processes that are required for survival.¹⁸ Despite its capabilities, the brain has several difficulties, especially as people age. Cognitive decline – a gradual deterioration of memory, learning, and reasoning abilities – is a common concern.¹⁹ Although aging is a primary contributor, lifestyle factors, genetic predisposition, and disease can accelerate this decline.²⁰ Mood disorders such as anxiety and depression can have a major effect on brain function. These disorders may also affect the structure and function of the brain, especially in areas such as the amygdala and prefrontal cortex.²¹ Neurodegenerative diseases – such as Alzheimer’s, Parkinson’s, and Huntington’s – pose significant threats to brain health. These conditions are characterized by progressive neuronal degeneration, resulting in declines in both motor function and cognitive abilities.²² For example, Alzheimer’s disease is characterized by the accumulation of aberrant proteins in the brain that disrupt neuronal communication, leading to memory

loss, disorientation, and other cognitive deficits.²³ Although aging is the primary risk factor, lifestyle choices, environmental exposures, and genetic predisposition also play significant roles in disease development.

The effects of nutrition on brain health

Nutrition has an important role for developing the brain and its functions. Diets containing sugar, unhealthy fats and/or too many calories can cause damages in brain function.²⁴ These types of diets increase stress in the brain and decrease its ability to adapt. An ideal nutrition is essential for brain function. It has been accepted that having breakfast helps children perform better in school.²⁵ Children who ate breakfast did better and made fewer mistakes than those who skipped it. As people age, cognitive abilities, such as memory and processing speed, naturally decline. Nutrition not only influences brain structure but also affects its function.²⁶ Antioxidants can positively influence cognitive performance and overall brain function.

In our study, we demonstrated that *Spirulina platensis*, a potent source of antioxidants, protects adolescent rats from oxidative stress.²⁷ Treatment with *S. platensis* increased expression of brain-derived neurotrophic factor (BDNF) and key antioxidant enzymes, thereby mitigating stress-induced damage.²⁷ Molecular factors like BDNF and VEGF can influence broader brain systems involved in thinking and emotional regulation, linking body activity to brain function.²⁸ Antioxidants can play protective roles during critical periods of adolescence. In our study, *Spirulina platensis* ameliorated scopolamine-induced memory deficits by attenuating oxidative stress, as evidenced by reduced malondialdehyde (MDA) levels.²⁹ Additional studies have examined how *S. platensis* modulates apolipoprotein E (APOE) and reticulon-4 (RTN4) protein expression in the rat prefrontal cortex.³⁰ Polyphenols are powerful antioxidants found in foods like fruits, tea, red wine, cocoa, and coffee.³¹ These nutrients may protect brain cells from damage caused by harmful toxins, reduce brain inflammation, and help improve memory, learning, and brain function.³² It has been shown that polyphenols decrease stress and inflammation in the brain, increase protective signals, and promote the production of proteins that help protect brain cells.³³ It was also reported that green tea extract and polyphenols increased brain activity in the prefrontal cortex in the human brain.³⁴ In a separate study, we demonstrated that quercetin nano-phytosomes significantly attenuated inflammation in rodent models of multiple sclerosis.³⁵ We also demonstrated that gingerol produces significant antidepressant-like effects through modulation of the serotonergic system.³⁶ Conversely, our group reported that high white and brown sugar consumption significantly decreased the concentration of brain-derived neurotrophic factor in animal models.³⁷ In our studies,

nutritional interventions, such as *S. platensis*, quercetin nano-phytosomes, and phenolic compounds, demonstrated neuroprotective effects by attenuating oxidative stress and inflammation and by supporting neurotransmitter function. These compounds increased BDNF levels and cognitive performance in animal models.^{27,29,35} In contrast, high intake of refined sugars adversely affected brain-derived neurotrophic factor levels.³⁷ In sum, our findings underscore the pivotal role of nutrition in modulating brain function, particularly during critical developmental and aging periods.

Adherence to the Mediterranean-DASH Intervention for Neurodegenerative Delay (MIND) diet has been associated with superior cognitive performance, independent of common neuropathological changes. The MIND diet can increase cognitive resilience in the elderly.³⁸ It was also reported that the MIND diet intervention could reverse the destructive effects of obesity on cognition and brain structure in healthy obese women.³⁹ A systematic review indicated that adherence to the MIND diet is linked to improved cognitive function in older adults, positioning it as a superior dietary strategy for preserving cognitive performance in this population.⁴⁰ A recent study found that greater adherence to the French version of the MIND diet is associated with a lower risk of dementia and preservation of white matter microstructure.²⁷ These studies suggest the MIND diet is a promising nutritional method for protecting brain health in aging populations.

The effects of exercise on brain health

Exercise has an important role in improving brain function. It has been reported that combining exercise and eating habits is the best way to support brain health.⁴ There are studies reporting the positive effects of physical activity on mental health.^{41,42} Physical activity improves mental health outcomes and helps to improve mood, self-esteem, stress, and cognitive function.⁴³ Exercise enhances mood, boosts self-esteem, and reduces stress. Exercise also stimulates the body's production of endogenous opioids and endocannabinoids.⁴⁴ Regular physical activity enhances cognitive function, lowers stress hormone levels, and helps regulate appetite-related hormones. In our study, voluntary exercise enhanced cognitive performance, elevated hippocampal BDNF levels, and promoted neuroanatomical remodeling in stressed female rats.⁴⁵ In a separate study, we demonstrated that voluntary exercise—administered alone or combined with *Spirulina platensis* microalgae supplementation—reduced oxidative stress and elevated BDNF expression in the adolescent rat brain.⁴⁵ Furthermore, voluntary exercise enhanced cognitive performance, increased hippocampal BDNF levels, and promoted neuroanatomical remodeling in the hippocampus of stressed female rats. These findings emphasize the synergistic

benefits of nutrition and physical activity on brain health. Physical exercise has been shown to accelerate reaction times in older adults and enhance executive functions mediated by the prefrontal cortex.⁴⁶ High-intensity exercise has been shown to impair cognitive performance and decrease oxygenation in the prefrontal cortex compared with moderate exercise or rest.⁴⁷ Although physical activity usually enhances executive function in older adults, excessively high intensity may have the opposite effect.

Challenges and future directions

Several studies have investigated the effects of exercise and diet on brain health, but several important questions remain unanswered. A major challenge is the complexity of the brain, as numerous factors affect its structure and function. This makes it difficult to identify the exact effects of specific foods or types of physical activity. In addition, individual differences in genetics, lifestyle, and environment make it hard to apply findings to everyone. Future research should aim to identify specific nutrition and exercise plans that support brain health. Another challenge is the need for extensive, long-term research to provide stronger evidence of the relation between exercise, diet, and brain health. Most current studies are observational data or short-term trials, which makes it difficult to determine a clear cause-and-effect relationship. Long-term randomized controlled trials examining the effects of nutrition and physical activity are needed to generate robust, reliable evidence. Although the mental health benefits of physical activity are well recognized, the specific types and amounts of exercise that best support brain function remain unclear. More research is needed to identify the most effective routines for different age groups and health conditions, especially in relation to cognitive decline and neurodegenerative diseases. However, the relationship between them requires deeper investigation.

Conclusions

This editorial emphasizes the important role that exercise and diet play in maintaining cognitive performance and brain health. Diet and regular physical activity can improve mood, memory, mental well-being, and overall brain function. This editorial highlights how nutrition, particularly antioxidant-rich diets such as the MIND regimen, and moderate exercise support brain health by reducing oxidative stress, elevating neurotrophic factors like BDNF, and enhancing cognitive function. Together, they offer a synergistic approach to preserving brain function throughout life. Although challenges persist, such as the need for personalized interventions and long-term clinical trials, the growing body of evidence underscores the value of healthy nutrition and regular exercise for

preserving cognitive function and mitigating age-related decline. Future research on these interactions will inform the development of targeted strategies to optimize brain health and enhance quality of life across the lifespan.

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