The Effects of Physical Exercise on Memory and Cognitive Functions

Written by Navi Singh

Cognitive functions are the mental processes that allow us to think, learn, and focus. Memory, in particular, involves the encoding, storage, and retrieval of information—processes that are essential for daily activities. Emerging evidence in neuroscience research points to a strong relationship between physical health and cognitive performance. For instance, a study by Donnelly et al. highlights a strong link between regular physical exercise and improved cognitive health (Donnely, 2016). Particularly, studies show that individuals who engage in physical activity demonstrate better memory, attention, and problem-solving abilities compared to those who do not exercise. These findings are particularly relevant in the context of neurodegenerative diseases such as Alzheimer's and dementia, which involve a progressive loss of brain structure and function and significantly impair cognitive abilities such as memory. Examining the impact of physical activity on memory and cognition, and summarizing recent literature on its role in the development or prevention of neurodegenerative diseases, is therefore essential for guiding future neuroscience research.

Physical activity has been shown in several studies to reduce the risk of neurological diseases such as Alzheimer's and dementia. One of the key ways exercising benefits the brain is by enhancing brain activity through reduction of inflammation, which could impact cognitive impairment. One central mechanism involved in the regulation is brain-derived neurotrophic factor (BDNF), a protein that plays a crucial role in supporting neuronal survival, growth, and synaptic plasticity. BDNF is important for long-term potentiation, a cellular process that is essential to help with learning and memory formation, promoting the strength of connections between neurons. Exercising stimulates BDNF expression in the hippocampal pathway, which can improve memory. A recent study by Sanaeifar et. al. found that individuals who regularly engage in aerobic exercise exhibited increased levels of BDNF and reduced levels of neuroinflammation, overall improving cognitive function. (Sanaeifar, 2024).

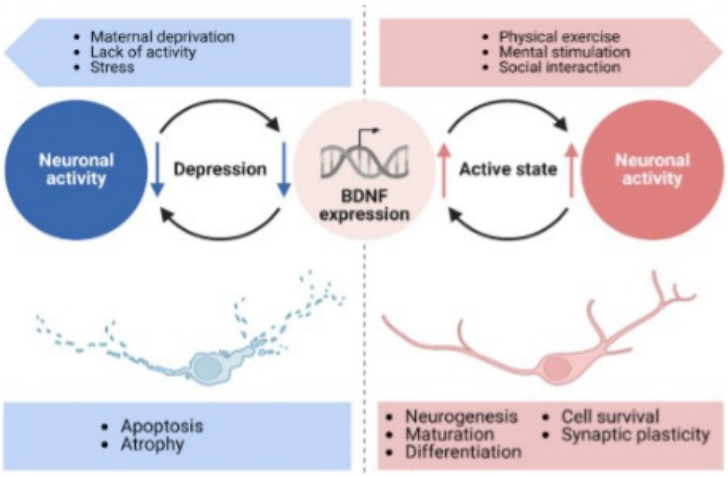

Figure 1. The impact of BDNF expression on neuronal activity in individuals who exercise and those who do not exercise (Sanaeifar, 2024)

Additionally, when individuals age, neurogenesis and synaptic plasticity naturally decline. However, studies have shown that individuals who regularly exercise maintain these essential mechanisms and preserve cognitive function at an older age. For example, a research article by Iso-Marrku demonstrated that physically active older adults had a lower risk of developing neurodegenerative diseases such as Alzheimer's and dementia. (Iso-Markku, 2022; Lopez-Ortiz, 2023). These findings show the importance of exercising daily to preserve cognitive function and prevent early-onset neurodegenerative diseases.

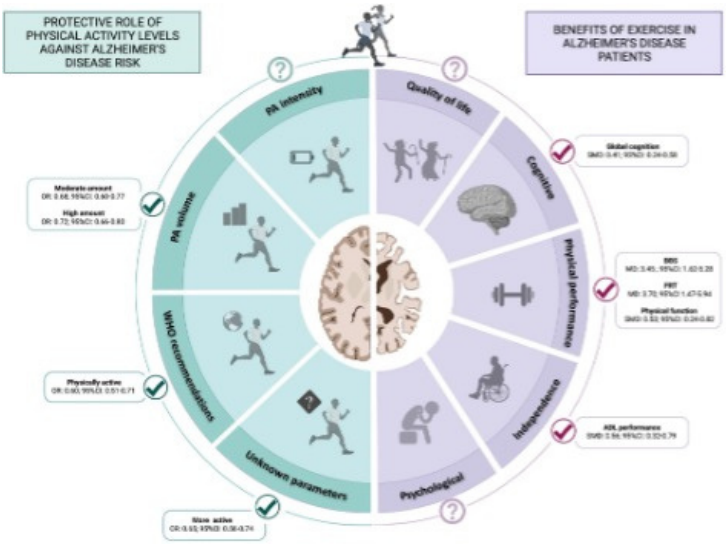

Figure 2. Benefits of exercise in prevention of Alzheimer's disease (Lopez-Ortiz, 2023)

Not only can exercise prevent neurodegenerative disease, but it also improves memory, attention, and overall cognitive activity. Research has shown that both short-term and long-term exercise can lead to cognitive improvements. Short-term exercises, like aerobic exercise, have been found to enhance working memory and attention by increasing the cerebral blood flow to the brain. Long-term exercise, on the other hand, can cause functional changes in the brain, like increasing hippocampal volume, which is an area of the brain crucial for memory processing. (Donnelly, 2016). In a review by Donnelly et. al., the authors highlighted that consistent physical activity is associated with improvements in cognition, memory, and executive function. Exercise interventions mentioned in Donnelly's review can lead to enhanced academic performance and cognitive development for adults and children. Moreover, different types of exercise have been found to impact cognition uniquely. Aerobic exercises like running have been shown to see improvements in memory and attention, whereas resistance training has been associated with better working memory and executive function. Even yoga and meditation have been shown to provide cognitive benefits in reducing stress and improving attention. Altogether, these findings suggest that exercise has a multitude of benefits:

> **Not only does it prevent cognitive decline, but it also reduces inflammation in the brain, increases hippocampal volume, and optimizes cognitive function at all ages (Voss, 2023).**

In conclusion, the evidence in the current neuroscience literature strongly supports that physical exercise has been shown to enhance memory and cognitive function and also reduce the risk of neurodegenerative diseases like Alzheimer's and dementia. Biological mechanisms, such as increased BDNF levels and reduced neuroinflammation, improve the memory and function of the hippocampus. Additionally, regular physical activity, whether short-term or long-term, preserves cognitive ability as individuals get older and prevents the onset of Alzheimer's and dementia. Any type of exercise plays a crucial role in improving memory and attention. However, there are limitations to research regarding the long-term effects of different exercise models. Future studies will show what specific types of long-term exercise are crucial and bring the most cognitive benefits. Understanding the importance of the impact of physical health on the brain can lead to more targeted interventions to help reduce the risk of cognitive decline and improve attention and memory.

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About the Author

Navi Singh is a rising Junior at the University of Illinois Urbana-Champaign, majoring in Neuroscience and minoring in Health Administration and Chemistry on the Pre-Medical track. She is an aspiring physician hoping to specialize in Neurology. She is also involved with several RSO's on campus. These include serving as Social Chair for Udaan and the Undergraduate Neuroscience Society, being a member of a Pre-Health Professional Fraternity Phi Chi, mentor for Illini Mentor Program, volunteer for Global Medical Brigades, and Research Assistant at the Kukekova lab. Navi is excited to share her first article and research with Brain Matters!