

The Fundamental Role of Dietary Habit, Physical Activity, and Sleep Pattern on Amyloid-Beta and Tau Pathology

Sri Sahasra Bikumala¹, Sheene Martin²

¹Rouse A, 3320 Mongolian Dr, Leander, Texas, 78641, United States;

²University of North Carolina Chapel Hill, 5317 Mason Farm Rd, Chapel Hill, North Carolina 27517, United States

ABSTRACT

Alzheimer's disease (AD) is a debilitating neurodegenerative disease that affects an estimated 24 million adults over the age of 65 worldwide. Categorized by memory loss, cognitive decline, and behavioral changes, AD imposes profound personal and societal burdens. Despite extensive research, there is no cure, as there exists a 100% mortality rate once the disease has progressed. Age is the most prominent risk factor for developing AD; however, diet, physical activity, and disrupted sleep patterns contribute to disease progression. An improper diet of nutritional imbalances can contribute to inflammation and increase reactive oxygen species leading to AD progression. Physical activity offers numerous overall health benefits and provide a distinct positive impact on Alzheimer's disease by enhancing cognitive function. Additionally, sleep disturbances are commonly reported among AD patients. There is now evidence to support sleep disruption as an early marker of AD while also significantly contributing to the progression of AD. Improving diet, physical activity, and sleep patterns may have positive outcomes for AD patients and reduce the burden on their families and caretakers, promoting a healthier family environment. This review synthesizes current evidence on how diet, physical activity, and sleep patterns contribute to AD progression and highlight how approaches in these areas can improve the quality of life of AD patients by introducing preventative strategies.

Keywords: Behavioral and Social Sciences; Neuroscience; Alzheimer Disease; Physical Activity; Sleep pattern

INTRODUCTION

Alzheimer's disease (AD) is a debilitating neurodegenerative disorder that consistently progresses

after the initial diagnosis of progressive cognitive deterioration. Alzheimer's disease is caused by the accumulation of Amyloid-beta plaques and Tau protein neurofibrillary tangles in the brain, leading to significant brain damage and blocking of synaptic communication (1). These plaques and tangles affect the hippocampus, a region of the brain crucial for controlling memory. The abnormal build-up of these proteins cause neuronal function to decline and disrupt neuronal connections, eventually leading to synaptic failure and cerebral atrophy. As these changes spread through the brain, they

Corresponding author: Sri Sahasra Bikumala, E-mail: sahasrabytes@gmail.com.

Copyright: © 2025 Sri Sahasra Bikumala et al. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Received March 23, 2025; **Accepted** April 29, 2025
<https://doi.org/10.70251/HYJR2348.3316>

cause shrinkage, damaged brain tissue, and visually smaller brains sizes. Alzheimer's disease often manifests through profound memory loss and cognitive impairments such as personality change, behavioral shifts, difficulty with comprehension, and jumbled speech. Additionally, individuals with AD may also experience hallucinations, delusions, and paranoia (2).

Although a person's genetic profile, lifestyle, and or environmental factors may increase the risk of developing AD, the probability of developing AD varies from person to person. For example, an individual carrying the APOE4 allele is at an increased risk of developing the disease in the future, unlike APOE2, which serves as a protective factor against developing AD (3). Additional environmental factors can include constantly being exposed to toxins from air pollution consisting of heavy metals like lead and mercury, which can further exacerbate inflammation in the brain, thus contributing to disease progression (4).

This review will dive into evidence-based strategies to slow the progressions of AD through dietary changes, increased physical activity, and restorative sleep (Table 1). Dietary adjustments such as the addition of a Mediterranean diet, which includes fruits, vegetables, whole grains, and healthy fats protect against inflammation in the brain. Furthermore, the implication of physical activity such as yoga or daily walking enhances the health of brain cells and blood flow. Additionally, maintaining quality sleep and a consistent sleep schedule allows the brain to utilize the glymphatic system to remove brain toxins. Implementing these aspects into a daily routine can delay cognitive decline, slow the progression of AD, and

improve the quality of life specifically targeted toward those diagnosed with AD.

In conclusion, focusing on factors like diet, physical activity, and sleep patterns can serve as a protective factor for AD patients. With no current treatment for AD, investigating these changes in lifestyle acts as a guide and aid. The lifestyle factors mentioned in this review can productively be changed or enhanced to reduce overall inflammation in the body and inhibit the adverse effects of the progression of Alzheimer's disease.

THE BENEFITS OF A MEDITERRANEAN-STYLE DIET ON ALZHEIMER'S DISEASE

Diet plays a crucial role in overall health and chronic disease progression, affecting cholesterol levels and blood pressure. Inflammation and neuronal damage are often driven by the accumulation of amyloid-beta plaques, resulting in significant cognitive decline. Inflammation and oxidative stress, often precipitated by poor dietary habits, are a central mechanism in Alzheimer's disease that can potentially progress (5). Moreover, an individual's diet can influence their risk of developing conditions such as diabetes, obesity, and heart disease in conjunction with AD. Western-style diets majorly characterized by red meats, saturated fats, and sugar, have been consistently linked to a increased risk of developing Dementia (6). Refining diets and the management of the nutrients the body consumes can serve as a measure to prevent the progression of inflammation in AD.

The recommended diets emphasize polyunsaturated

Table 1. Dietary adjustments, physical activity, and sleep quality have all been associated with changes In Alzheimer's disease pathology and cognitive outcome

Intervention Type	Sample Size	Amyloid/Tau Pathology	Cognitive Income	Reference
Mediterranean Diet	Middle-aged adults (N ≈ 50)	Lower amyloid-beta deposition	Better glucose metabolism and cognitive aging	(9)
MIND Diet	Older adults (N = 923)	Not directly measured	Slower cognitive decline	(14)
Physical activity	N = 5,925 elderly women	Linked to reduced amyloid/tau buildup	Improved cognition and reduced AD risk	(10)
Sleep quality	Review/Experimental models	Disrupted sleep impairs amyloid/tau clearance	Cognitive impairment linked to poor sleep	(18)

The Mediterranean based diets such as the MIND diet have been linked to lower amyloid-beta deposition and slower cognitive decline. Physical activity is associates with reduced amyloid/tau buildup therefore improving cognition and reducing the risk of developing Alzheimer's disease in the fu. During sleep, the brain engages in a vital role of cleaning amyloid and tau proteins, sleep disturbance impair clearance, contributing to cognitive impairment.

fatty acids rich in neuroprotective nutrients found in plant and animal foods such as salmon, nuts, and seeds (7). Notably, The Mediterranean diet, the DASH diet, and the MIND diet are all rich in polyunsaturated fatty acids, and have demonstrated protective effects for reducing inflammation in the brain. A Mediterranean diet contains rich nutrients from whole grains, fruit, vegetables, and seafood. This diet consists of lean protein such as fish, whole grains, and vegetables that improve vascular health. Red meats, which are high in saturated fats and added sugar, are best limited in a brain-healthy diet. Instead, diets rich in anti-inflammatory food can comprise fruits, vegetables, and omega-3 fatty acids are essential in promoting neuroprotective health. The DASH diet (dietary approaches to stop hypertension) includes low-fat dairy products, fish, beans, nuts, and vegetable oils. This diet lowers blood pressure by limiting sodium intake, fatty meats, full-fat dairy, and sugar-sweetened beverages, and instead includes food rich in potassium, calcium, magnesium, fiber, and protein. The MIND diet (Mediterranean-DASH intervention for neurodegenerative delay diet) combines elements from both the DASH and Mediterranean diets, reducing high blood pressure and lowering the risk of developing Dementia, emphasizing green leafy vegetables, whole grains, beans, and nuts (8).

In one study, consisting of 30 to 60-year-olds, an examination was held to identify the effect of a higher compared to a lower adherence to a Mediterranean-style diet showing relation to amyloid-beta plaques in observing dietary factors of brain aging, a symptom in the development of AD (9). Results showed a decrease in glucose metabolism and a higher amyloid deposition for the group with a lower adherence to a Mediterranean diet. Other studies suggest that the MIND diet slows cognitive decline with age, showing that it is neuroprotective and related to brain health (10). Together, these data highlight the benefits of the diets described in decreasing the risk of developing AD.

Diet, including Mediterranean elements, significantly impacts an individual's overall health and progression of AD, making it evident that we need more oversight in everyday consumption. Specific diets, such as one containing high sources of fatty meats, full-fat dairy, and sugar-sweetened beverages, majorly found in Western-style diets, can lead to the development of inflammation in the brain. Alternative diets, all under the Mediterranean category, reduce the risk of developing AD pathologies such as tau tangles and amyloid-beta plaques, emphasizing the intake of vegetables and seafood. The study of nutrient-specific and ketogenic effects on inflammation is

still ongoing and crucial to forming a solid meal-targeted approach toward AD patients and medical facilities.

INCREASED PHYSICAL ACTIVITY BENEFITS AD PATIENTS

Exercise offers a wide range of benefit, including the potential to slow the progression of dementia and Alzheimer's disease. Physical activity not only strengthens the body physically but also serves as a therapeutic strategy for reducing the risk of AD. It has also been shown to support cognitive function, allowing adults to maintain mental clarity as they age (11). Overall, physical activity strengthens the endurance of cells and tissues to oxidative stress, neurotrophin synthesis, which controls the function of neurons in both the peripheral and central nervous system, memory improvement, and brain plasticity both of which are crucial in neural network arrangement.

Physical activity can be divided into two categories, aerobic and strength-building, both of which offer unique health benefits. Aerobic activity benefits brain health, resulting in consistent heart, lung, and blood circulation. On the other hand, strength-building activity exercises the major muscles groups of the body, such as those in the limbs and back, assisting in blood sugar level regulation, which can reduce the risk of diabetes, a known risk factor for Dementia.

Studies have shown that physical exercise can reduce the risk of developing dementia by 28% and Alzheimer's disease by 45%, highlighting its significant role in reducing brain inflammation (12). These conclusions came from a variety of 16 studies, all targeted towards physical exercise in relation to Dementia, a risk factor in AD. One 14-year-long study of a German population showed a lower risk of AD and increased performance on neuropsychological tests after participating in consistent physical activity (13). In addition, another study with a population of 5925, predominantly white women, was less likely to experience cognitive decline after physical activity, supporting the conclusion that having an active life style can prevent Dementia (14). One study from the University of Wisconsin had results suggesting that individuals over the age of 60 who perform 30 minutes of moderate exercise five days a week have a lower risk of developing AD, memory loss, and cognitive problems (15). Furthermore, physical engagement can strengthen the hippocampus, making it more active and efficient during learning and memory in AD.

Additionally, physical exercise has been found to

reduce the risk of developing cardiovascular disease and increase cerebral blood flow. Cardiovascular healthily a significant role in supporting brain function, as an efficient cardiovascular system enhances blood flow while reducing hypertension and inflammation in the brain (16). Consistent circulation can nourish brain cells and help them thrive allowing them to receive sufficient oxygen and nutrients. Moreover, physical activity can help reduce levels of stress hormones, playing a role in decreasing inflammation. Exercise promotes growth factors within the brain, supporting the repair and regeneration of the cells.

Physical activity is recognized for its benefits to overall health. Specifically, in AD, physical activity, both aerobic and strength-building exercises of less intensive, moderate, and vigorous levels, can offer meaningful cognitive and neurological advantages. These exercises can consist of yoga, walking, riding a bike, jogging, dancing, swimming, and pilates, all of which can be integrated into daily routines to help reduce the risk of developing AD (17). Research in the involvement of specific sports or structures programs that meet recommended activity levels for individual with AD may further enhance quality of life. A beneficial routine can consist of involvement in a 30-minute morning walk and yoga or light stretching. Although physical activity is beneficial, further research is required in order to better understand its precise role in AD treatment and prevention.

SLEEP PATTERNS AND THE PROGRESSION OF ALZHEIMER'S DISEASE

Sleep plays a vital role in influencing an individual's risk of developing AD. Poor sleep, characterized by an inconsistent circadian rhythm, frequent waking, and sleep loss during the night has been linked to the accumulation of beta-amyloid and tau proteins in the brain. As we age, we experience a decline in the quantity and quality of sleep, which may impair memory processing and hinder performance in cognitive tasks (18).

The brain engages in a cleansing process during deep sleep that clear amyloid and tau proteins. Without sufficient quality sleep for the body, the brain can not initiate this crucial cleansing process, essentially allowing the buildup of harmful proteins. Specifically, Alzheimer's disease patients report numerous sleep disturbances, thus linking sleep and AD. In one study, cognitively normal middle-aged individuals had their sleep objectively recorded using actigraphy in order to monitor human activity and rest for two weeks. Researchers found a

correlation between Amyloid deposition and poor sleep quality during the preclinical stages of AD (19).

Poor sleep has been connected with both the loss of brain cells and reduced brain function. Similarly, researchers at the University of California conducted a study that involved 101 older adults with poor sleep quality detected through EEG (electroencephalogram), which increased beta-amyloid levels in the cortex and tau in the medial temporal lobe (20). Additionally, as Tau aggregates in the brain, there has been evidence of decreased NREM sleep in the cycle. Sleep disturbances have been shown to correlate negatively with cognitive function and functional impairment in patients with AD; furthermore, poor sleep quality and efficiency have encouraged the progression of cognitive dysfunction and the development of AD pathology (18).

The significance of sleep in the development of amyloid-beta plaques in AD is crucial to understanding, considering that sleep is a quality time for disposing of the toxic amyloid plaques and tau proteins. The timing of amyloid protein clearance is crucial, emphasizing the significance of maintaining consistent, good-quality sleep without significant disturbances.

CONCLUSION

Alzheimer's disease affects millions of people across the world, leading to an individual having cognitive, behavioral, and memory problems, additionally creating a burden to AD caregivers who have to care for their family members. Currently, having no treatment or cure, AD may be prevented with a change of daily lifestyle habits. The progression of AD can be indirectly halted or reversed with the improvement of dietary regimen, physical activity, and sleep. Studies have shown that following one of three diets recommended, including MIND, DASH, and Mediterranean, performing at least 30 minutes of physical activity daily, and getting good quality sleep fundamentally contribute to lowering the risk of developing AD.

However, further research is needed to clarify the long-term efficacy of these interventions, especially in diverse populations. Limitations in current studies include small sample sizes, limited follow-up durations, and reliance on self-reported data. Future studies should aim to include more diverse participants, control for confounding factors, and examine combined lifestyle interventions in randomized controlled trials. Continued exploration into these modifiable factors may guide public health policy and clinical recommendations to reduce AD burden globally.

ACKNOWLEDGEMENTS

Sheene Martin, University of North Carolina Chapel Hill, 5317 Mason Farm Rd, Chapel Hill, North Carolina 27517, United States, shen.c7@gmail.com.

FUNDING SOURCES

No external funding was provided for the research or writing of this article.

DECLARATION OF CONFLICT OF INTERESTS

The author(s) declare that there are no conflicts of interest regarding the publication of this article

REFERENCES

1. What happens to the brain in Alzheimer's disease? National Institute on Aging. Available from: <https://www.nia.nih.gov/health/alzheimers-causes-and-risk-factors/what-happens-brain-alzheimers-disease> (accessed on 2024-06-15).
2. Alzheimer's Disease Fact Sheet. National Institute on Aging. Available from: <https://www.nia.nih.gov/health/alzheimers-and-dementia/alzheimers-disease-fact-sheet> (accessed on 2024-07-08).
3. Serrano-Pozo A, Das S, Hyman BT. APOE and Alzheimer's disease: advances in genetics, pathophysiology, and therapeutic approaches. *The Lancet Neurology*. 2021; 20 (1): 68-80. [https://doi.org/10.1016/S1474-4422\(20\)30412-9](https://doi.org/10.1016/S1474-4422(20)30412-9)
4. Bakulski KM, Seo YA, Hickman RC, Brandt D, *et al.* Heavy metals exposure and Alzheimer's disease and related dementias. *Journal of Alzheimer's Disease*. 2020; 76 (4): 1215-1242. <https://doi.org/10.3233/JAD-200282>
5. Kinney JW, Bemiller SM, Murtishaw A S, Leisgang AM, *et al.* Inflammation as a central mechanism in Alzheimer's disease. *Alzheimer's & Dementia: Translational Research & Clinical Interventions*. 2018; 4 (1): 575-590. <https://doi.org/10.1016/j.trci.2018.06.014>
6. What do we know about diet and prevention of Alzheimer's disease? National Institute on Aging. Available from: <https://www.nia.nih.gov/health/alzheimers-and-dementia/what-do-we-know-about-diet-and-prevention-alzheimers-disease> (accessed on 2024-08-03).
7. Stefaniak O, Dobrzyńska M, Drzymała-Czyż S, Przysławski J. Diet in the Prevention of Alzheimer's Disease: Current knowledge and future research requirements. *Nutrients*. 2022; 14 (21): 4564. <https://doi.org/10.3390/nu14214564>
8. Van Den Brink AC, Brouwer-Brolsma EM, Berendsen AAM, Van De Rest O. The Mediterranean, DASH, and MIND Diets Are Associated with Less Cognitive Decline and a Lower Risk of Alzheimer's Disease-A Review. *Advances in Nutrition*. 2019; 10 (6): 1040-1065. <https://doi.org/10.1093/advances/nmz054>
9. Berti V, Walters M, Sterling J, Quinn CG, *et al.* Mediterranean diet and 3-year Alzheimer brain biomarker changes in middle-aged adults. *Neurology*. 2018; 90 (20).<https://doi.org/10.1212/WNL.0000000000005527>
10. De La Rosa A, Olaso-Gonzalez G, Arc-Chagnaud C, Milan F, *et al.* Physical exercise in the prevention and treatment of Alzheimer's disease. *Journal of Sport and Health Science*. 2020; 9 (5): 394-404. <https://doi.org/10.1016/j.jshs.2020.01.004>
11. Physical activity and the risk of dementia. Alzheimer's Society. Available from: <https://www.alzheimers.org.uk/about-dementia/managing-the-risk-of-dementia/reduce-your-risk-of-dementia/physical-activity> (accessed on 2024-06-20).
12. Meng Q, Lin M-S, Tzeng I-S. Relationship between exercise and Alzheimer's Disease: A Narrative literature review. *Frontiers in Neuroscience*. 2020; 14. <https://doi.org/10.3389/fnins.2020.00131>
13. Yaffe K, Barnes D, Nevitt M, Lui L-Y, Covinsky K. A prospective study of physical activity and cognitive decline in elderly women. *Archives of Internal Medicine*. 2001; 161 (14): 1703. <https://doi.org/10.1001/archinte.161.14.1703>
14. Morris MC, Tangney CC, Wang Y, Sacks FM, *et al.* MIND diet slows cognitive decline with aging. *Alzheimer's & Dementia*. 2015; 11 (9): 1015-1022. <https://doi.org/10.1016/j.jalz.2015.04.011>
15. Exercise linked to enhanced brain function in adults at risk for Alzheimer's Disease - School of Medicine and Public Health. School of Medicine and Public Health. Available from: <https://www.med.wisc.edu/news/exercise-brain-function-tied-to-alzheimers-risk/> (accessed on 2024-08-11).
16. Nystoriak MA, Bhatnagar A. Cardiovascular effects and benefits of exercise. *Frontiers in Cardiovascular Medicine*. 2018; 5. <https://doi.org/10.3389/fcvm.2018.00135>
17. Zhang S, Zhen K, Su Q, Chen Y, *et al.* The Effect of Aerobic Exercise on Cognitive Function in People with Alzheimer's Disease: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *International Journal of Environmental Research and Public Health*. 2022; 19 (23): 15700. <https://doi.org/10.3390/ijerph192315700>
18. Wang C, Holtzman, D. M., Bidirectional relationship between sleep and Alzheimer's disease: role of amyloid, tau, and other factors. *Neuropsychopharmacology*. 2019; 45 (1): 104-120. <https://doi.org/10.1038/s41386-019-0478-5>
19. How sleep clears the brain. National Institutes of Health (NIH). Available from: <https://www.nih.gov/news-events/nih-research-matters/how-sleep-clears-brain> (accessed on 2024-07-22).
20. Van Egroo M, Koshmanova E, Vandewalle G, Jacobs HIL.

- Importance of the locus coeruleus-norepinephrine system in sleep-wake regulation: Implications for aging and Alzheimer's disease. *Sleep Medicine Reviews*. 2022; 62: 101592. <https://doi.org/10.1016/j.smr.2022.101592>
21. Ju Y-E S, McLeland JS, Toedebusch CD, Xiong, C, *et al*. Sleep quality and preclinical Alzheimer disease. *JAMA Neurology*. 2013; 70 (5): 587. <https://doi.org/10.1001/jama-neurol.2013.2334>
22. Poor sleep in middle age linked to late-life Alzheimer's-related brain changes. National Institute on Aging. Available from: <https://www.nia.nih.gov/news/poor-sleep-middle-age-linked-late-life-alzheimers-related-brain-changes> (accessed on 2024-06-30).