Original Article

Principles and Practice of Clinical Research
A GLOBAL JOURNAL OF CLINICAL RESEARCH

Impact of Physical Activity Level on Memory in the Older Adult Population in the United States: A Cross-Sectional Study

Alice Liriano[1], Ana Isabella Bencosme[2], Angélica Furzán[3], Bruno Cateb[4], Carla Arias[5], Carolina Matté Dagostini[6*], Claudia Meireles[7], Daniel Musse Gomes[8], Daniela Jorquera[9], David Moros[10], Erlando Mendez[11], Giovanna Oliveira dos Santos[12], Hanan Alshareef[13], Jazmin Insfran[14], Jorge Pastrana[15], Komwudh Konchalard[16], Lucas Koji Uchiyama[17], Marcos Brioschi[13], Marcos Ramirez[13], Mario Diego Teles Correia[18], Matheus Machado Rech[19], Mayra Muñoz[20], Natalia Rodriguez[21], Nelia Sanchez-Crespo[22], Nicole Mannis[23], Olumide Adeniyi[24], Pascal Gaechter[25], Rodrigo Mariano[13], Silvia Castro Piedra[26], Tatiana Dus[13]

1 Pontificia Universidad Católica Madre y Maestra, Santiago, Dominican Republic; **2** Pontificia Universidad Católica Madre y Maestra, Santiago, Dominican Republic; **3** Universidad de Ciencias Médicas (UCIMED), San José, Costa Rica; **4** Faculdade de Medicina São Leopoldo Mandic (SLMandic), Campinas, Brazil; **5** Eugenio Espejo Specialty Hospital (HEEE); **6** Universidade Federal de Ciências da Saúde de Porto Alegre (UFCSPA), Porto Alegre, Brazil.; **7** Universidade de São Paulo (USP), São Paulo, Brazil; **8** Instituto D'Or de Ensino e Pesquisa, Rio de Janeiro, Brazil.; **9** Clínica Alemana Santiago, Chile. Facultad de medicina UDD, Santiago, Chile; **10** Heart, Vascular and Thoracic Institute, Cleveland clinic, Ohio, USA; **11** Instituto Tecnológico de Santo Domingo (INTEC), Santo Domingo, Dominican Republic; **12** Núcleo de Pesquisa e Ensino IBCC Oncologia, São Paulo, Brazil; **13** Principles and Practice of Clinical Research, Harvard T. H. Chan School, USA; **14** Universidad del Pacífico, Asuncion, Paraguay; **15** Instituto Politécnico Nacional, Ciudad de México, Mexico; **16** Queen Savang Vadhana Memorial Hospital, Thai Red Cross Society, Thailand; **17** Faculdade de Medicina da Universidade de São Paulo, São Paulo, Brazil; **18** Real Hospital Português, Recife, Brazil; **19** University of Caxias do Sul (UCS), Caxias do Sul, Brazil; **20** Universidad San Martín de Porres (USMP) - Facultad de Medicina, Lima, Perú; **21** Transplant surgery, Massachusetts General Hospital, MA, USA; **22** CenexelRCA, Florida, USA; **23** Faculdade São Leopoldo Mandic (SLMANDIC), Campinas, Brazil.; **24** Obafemi Awolowo University Teaching Hospitals Complex, Ile-lfe, Nigeria; **25** University of Basel, Basel, Switzerland; **26** Instituto Tecnológico de Costa Rica, Cartago, Costa Rica.

Abstract

Background: *Physical activity (PA) is widely associated with improved cognitive function, including memory, in older adults. However, the extent to which this relationship varies across age groups and is influenced by other health and lifestyle factors remains unclear. This study examined the association between physical activity levels and self-reported memory problems in adults aged 50 to 85 years, using a nationally representative dataset to assess the relationship between physical activity levels and self-reported memory problems in adults aged 50 to 85 years, stratified by age groups.*

Methods: *This exploratory cross-sectional study used the NHANES 2005-2006 dataset. The relationship between memory problems and activity levels was assessed across middle-aged (50–64 years) and elderly (65–85 years) groups. Multivariate analysis was adjusted for potential confounders, and age was tested as an effect modifier.*

Results: *Among 3,277 participants, 22% were classified as less active. In unadjusted analyses, less active individuals had significantly higher odds of memory problems in both the middle-aged (OR = 2.15; 95% CI: 1.27–3.63; $p = 0.004$) and elderly groups (OR = 1.67; 95% CI: 1.01–2.75; $p = 0.042$). These associations were attenuated and no longer statistically significant after adjusting for confounders. Sleep disorders were significantly associated with memory problems in both age groups, while depression and lower education were significant only in the elderly.*

Conclusion: *While physical activity shows a potential protective association with memory problems—particularly in middle-aged adults—this relationship appears to be influenced by other health and lifestyle factors. Age-specific interventions that address sleep quality, mental health, and education may be more effective in supporting cognitive health in older populations.*

Introduction

Memory, a domain of cognitive function, is the capacity to store information, which is vital for learning and survival (Zlotnik & Vansintjan, 2019). Memory is influenced by various factors throughout a person's lifespan, particularly aging (Zlotnik & Vansintjan, 2019). Risk factors for memory problems and cognitive decline include family history and aging. It is well documented that the ability to remember tends to decline with aging and is related to a change in anatomical brain structure, such as a decrease in the size of the hippocampus and frontal cortex (O'shea et al., 2016). However, potentially modifiable factors, such as diet, physical activity, and social engagement, are non-pharmacological strategies that can be used to prevent a premature memory decline and stabilize or enhance cognition (De la Rosa et al., 2020; Dominguez et al., 2021). Lifestyle changes during the pre-symptomatic stages of cognitive impairment may delay progression to a more severe condition, such as dementia, in one-third of cases (De la Rosa et al., 2020).

Physical activity (PA) has been extensively studied due to its favorable relationship with physical and mental health (Mammen & Faulkner, 2013). Lately, there is robust evidence that it protects higher cognitive function, such as memory. Regular physical activity has been associated with slower cognitive decline and better memory performance (Mammen & Faulkner, 2013). It has also been found in younger populations that PA improves memory and enhances cognitive attributes, resulting in a delay in the onset of memory problems at later stages in life (Tian et al., 2022). According to de Souza-Talarico et al. (2007), in older adults, PA has been linked with improvements in working memory, especially in those who regularly exercise. There is also a connection between exercise and its depression-reducing quality, with recent studies starting to mitigate how exercise can help in cognitive decline brought about by this mental condition (Schuch & Stubbs, 2019).

Although physical activity has been associated with enhanced memory in both younger and older adults, less attention has been paid to whether this relationship extends across the entire lifespan or if critical periods exist where the association between physical activity and memory plays a particularly significant role. Given the consistent evidence that episodic memory in older adults rapidly declines after about 60–65 years (Nyberg et al., 2012), there is a gap in understanding how physical activity might influence memory in the aging population before and after this threshold. The current study assessed the relationship between physical activity levels and memory problems across different age ranges. This age range allows us to infer the potential of physical activity as a protective factor against memory problems in different age groups and to examine various factors that may contribute to its protective effect against memory problems in older adults.

*Corresponding author: carolina.dagostini-2024@ppcr.org
Received: November 1, 2024 **Accepted:** November 4, 2024
Published: September 26, 2025
Editor: Felipe Fregni
Reviewers: Anna Skotny, Giorgia Luthi
Keywords: memory, cognition, exercise, aging, cross-sectional studies
DOI: https://doi.org/10.21801/ppcrj.2025.112.3

Materials and Methods

Study Design and Database Details

This exploratory cross-sectional study was conducted from July to October 2024 and analyzed data from NHANES 2005-2006. Participants aged 20 to 85 years were included, and information on diet, physical activity, environmental exposures, chronic conditions, and lifestyle factors were provided. Resources from the National Center for Health Statistics (NCHS) are available at http://www.cdc.gov/nchs/nhanes.htm. Further exclusions for incomplete covariate data resulted in a final sample of 3,277 subjects.

Participants were grouped by age: 20–49 years, 50–64 years, and 65 years and older, based on the cognitive and morphological changes that are presented in the different age ranges (Murman, 2015; Nyberg et al., 2012). Studies show the same type of categorization into young adulthood, middle adulthood, and old adulthood (Kraal, 2021; Stern et al., 2019).

The primary analysis assessed the relationship between memory problems and exercise levels across the three age groups, after adjusting for potential confounders in the multivariate analysis. The final model included age group as an effect modifier, and the model fit was tested against the multivariate model.

Outcomes and Exposures

The main outcome was memory problems or confusion, which participants reported as either "yes" or "no." The primary exposure was physical activity level, categorized as "less active" and "equally active or more active" compared to others of the same age. Potential confounders included gender, education, sleep disorders, depression, stroke history, and alcohol use. Educational levels were classified into three categories: less than high school, high school graduate, and some college or higher. Diagnosed

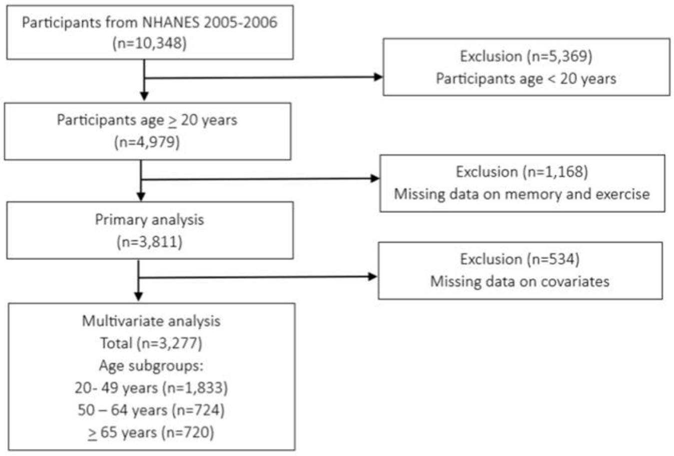

Figure 1: *Participant selection flow chart.*

sleep disorders and stroke history were recorded based on the participants' reports. Depression was assessed using the Patient Health Questionnaire-9 (PHQ-9), with scores ranging from 0 to 27; higher scores indicate more severe depression symptoms. Alcohol use was defined as consumption of at least 12 drinks per year.

Statistical Analysis

Descriptive statistics included mean and standard deviation for continuous variables and frequency and percentage for categorical variables. Univariate logistic regression was used to estimate the odds ratio (OR) of memory problems among physically active participants across age groups. For multivariate analysis, covariates were added to assess the relationship between memory issues and exercise levels, with adjustment for potential confounders. The final model incorporates age group as an effect modifier. To evaluate the models, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were used. Statistical significance was set at $p < 0.05$ for all analyses conducted using STATA 18BE software (StataCorp, College Station, TX, USA).

Results

Sample Characteristics

A total of 3,277 participants were included, with baseline characteristics in Table 1. Participants were classified based on their physical activity levels compared to their peers; 22.1% were less active, and 77.8% were more active or at the same level. Memory problems were observed in 8.45% of the participants who reported experiencing memory problems.

Unadjusted Model

In the unadjusted analysis, participants less physically active aged 20–85 presented 32% higher odds of memory problems compared to active ones (95% CI: 1.01–1.70, $p = 0.042$). Less active elderly individuals had 67% higher odds (95% CI: 1.02–2.75, $p = 0.043$), while among the middle-aged individuals, the OR was 2.15 times higher (95% CI: 1.28–3.63, $p = 0.004$). (Figure 2)

Adjusted Models

In the adjusted model with a focus on the 50–64 years old group, less active individuals had 76% higher odds of memory issues (95% CI: 0.95–3.26, $p = 0.071$). Sleep was the only significant confounder in this age group ($p < 0.001$). For the elderly aged 65–85 years, participants who were less active had 74% the odds of having memory problems (95% CI: 0.92–3.28, $p = 0.087$). Important confounders in this age group were sleep disorders ($p < 0.001$) and depression level ($p < 0.05$). Stroke history, gender, and alcohol consumption did not show significant association with memory in both age groups.

Testing for age groups as an effect modifier, less active middle-aged people showed approximately twice the odds of presenting memory issues (OR = 2.15; 95% CI: 1.04–4.43, $p = 0.039$). This association was not significant for less active elderly (OR = 2.00; 95% CI: 0.96–4.19, $p = 0.06$). The probability of memory problems in older age groups is shown in Figure 3.

Testing for the fitness of the models, including age as an effect modifier, yields AIC and BIC values of 1707.45 and 1786.68, respectively. These are compared to the model without effect modification

Characteristic	All participants	Young (20 -49 years)	Middle age (50 -64 years)	Elderly (65 years and above)
Number of participants (%)	3,277	1,833 (55.9)	724 (22.1)	720 (22.0)
Age (years): mean ± SD	48.32 ± 19.11	33.8 ± 8.7	57.0 ± 4.5	74.5 ± 6.5
Level of physical activities: no. (%)				
Less active	726 (22.2)	446 (24.3)	174 (24.0)	106 (14.7)
Same or more active	2,551 (77.8)	1,387 (75.7)	550 (76.0)	614 (85.3)
Memory problems: no. (%)	252 (7.7)	117 (6.4)	56 (7.7)	79 (11.0)
Gender: no. (%)				
Male	1,595 (48.7)	857 (46.8)	364 (50.3)	374 (51.9)
Female	1,682 (51.3)	976 (53.2)	360 (49.7)	346 (48.1)
Education level: no. (%)				
Less than high school	889 (27.1)	445 (24.3)	189 (26.1)	255 (35.4)
High school or equivalence	760 (23.2)	394 (21.5)	165 (22.8)	201 (27.9)
Some college or higher	1,628 (49.7)	994 (54.2)	370 (51.1)	264 (36.7)
Sleep problems: no. (%)	238 (7.3)	130 (7.1)	56 (7.7)	52 (7.2)
PHQ-9 score: mean ± SD	2.73 ± 3.72	2.8 ± 3.6	3.1 ± 4.4	2.3 ± 3.0
History of stroke: no. (%)	125 (3.8)	15 (0.8)	34 (4.7)	76 (10.6)
Alcohol consumption: no. (%)	1,003 (30.6)	517 (28.2)	229 (31.6)	257 (35.7)

PHQ-9 = Patient Health Questionnaire-9

Table 1: *Baseline characteristics of the participants.*

for the middle-aged group (AIC: 385.80; BIC: 431.65 respectively) and the elderly group (AIC: 475.53; BIC: 521.32 respectively).

Discussion

This study demonstrated that lower PA levels are significantly associated with memory problems among adults aged 50–85 years, with the strongest association observed in the middle-aged group. These findings align with previous research indicating that PA slows cognitive decline and improves memory (Mammen & Faulkner, 2013). The pronounced association in middle-aged individuals suggests that this period represents a critical window for the protective effects of PA, warranting further investigation. PA during early and mid-adulthood independently resulted in better memory levels and slower memory decline in later life. In early adulthood, PA indirectly benefits later-life memory through higher mid-adult stage (Kraal, 2021).

The univariate analyses revealed that less active middle-aged and elderly individuals presented higher odds of memory issues. These findings support the effect of physical exercise on preventing memory problems. Maintaining moderate PA levels can protect memory (Craik, 2012), and regular PA significantly reduces cognitive decline (Mammen & Faulkner, 2013), improves memory functions (Ruscheweyh et al., 2011), and promotes hippocampal plasticity. It has been demonstrated that aerobic exercise increases cortical thickness and brain-derived neurotrophic factor (BDNF), enhancing neurogenesis and memory throughout a lifespan (Cassilhas et al., 2016; Stern et al., 2019); also, it increases gray and white matter in the prefrontal cortex and temporal lobe, supporting executive control and spatial memory (Erickson et al., 2011).

The diminished association in the elderly group may be a result of a ceiling effect of age-related neurodegeneration, where the benefits of physical activity are limited by underlying neuropathology or comorbidities. Alternatively, this may reflect reverse causality, wherein individuals with early cognitive symptoms are less likely to engage in regular physical activity. Given the cross-sectional design of this study, we cannot determine the directionality of the observed relationships.

PA is associated with episodic memory improvement, particularly in older adults (Moutoussamy et al., 2022). Participants aged 50–64 years with lower PA levels were more likely to report memory problems, although this difference was not statistically significant. The association was weaker in participants aged 65 years and older, which may be due to accelerated memory decline and factors such as undiagnosed dementia, stress, and hypertension (Nyberg et al., 2012; Murman, 2015). Episodic memory and mental flexibility decline rapidly between ages 60 and 65, possibly diminishing

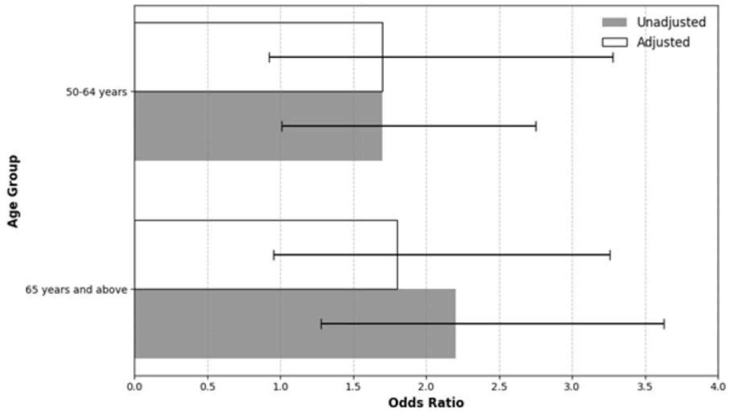

Figure 2: *Odds ratio of having memory problems among less active older adults in adjusted and unadjusted models.*

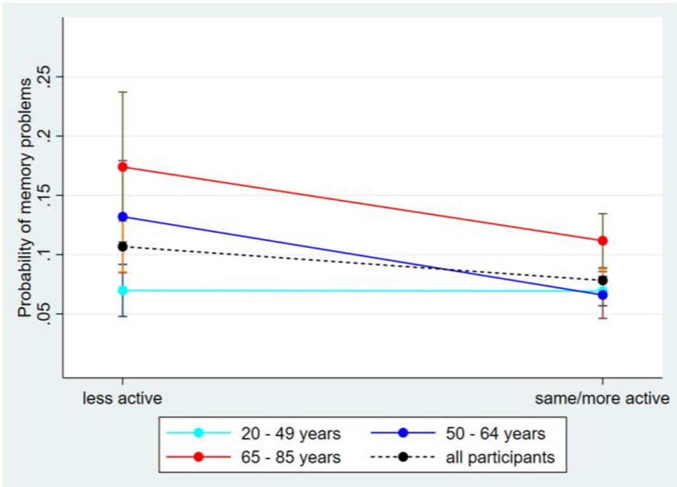

Figure 3: *Probability of having memory problems among less active adults in the adjusted model with age as an effect modifier.*

exercise's protective effects in this group.

Our study identified sleep disorders as an important confounder in older adults. This finding is consistent with a previous study (Schuch & Stubbs, 2019), which found that poor mental health and sleep quality accelerate cognitive decline. Education level is significantly linked to memory problems in the elderly, and also corresponds to epidemiologic studies on sociodemographics, which have found that higher education levels are associated with better memory (de Souza-Talarico et al., 2007; Stern, 2012). The association between depression and memory problems in elderly individuals found in this study is consistent with a previous study (Yin et al., 2024).

This study has limitations due to its cross-sectional design, reliance on subjective self-reports, and the absence of validated tools. The lack of dementia diagnosis data further restricts the interpretation of the results. Future longitudinal studies with validated tools and diverse populations are needed to confirm these findings. Other factors, such as dietary habits and metabolic syndrome, which were not included in the dataset, may further influence memory outcomes (Moreira et al., 2022), which is another limitation. The study's strengths include its large sample size and adjustments for sociodemographic factors, along with its novel focus on age-specific PA effects. The results suggest that PA interventions should be prioritized for middle-aged individuals who showed the greatest risk reduction for memory problems. For older adults, addressing additional factors such as sleep quality, education level, and depression may play a dominant role in managing cognitive health.

Acknowledgement

We would like to express our gratitude to Prof. Felipe Fregni, Alma Tamara Sanchez Jimenez, and Fathima Minisha Juan Carlos Silva, whose guidance, encouragement, and constant supervision were crucial to elaborating these manuscripts. We also want to thank all the senior, second, and first teacher assistants and all the PPCR team for their valuable inputs in the whole process. Their patience and encouragement were crucial in the development of this work.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

References

Cassilhas, R. C., Tufik, S., & de Mello, M. T. (2016). Physical exercise, neuroplasticity, spatial learning, and memory. Cellular and molecular life sciences : CMLS, 73(5), 975–983, 2018. https://doi.org/10.1007/s00018-015-2102-0

Craik, F. I. (2012). Age-related changes in human memory. Cognitive aging (pp. 75-92). Psychology Press.

De la Rosa, A., Olaso-Gonzalez, G., Arc-Chagnaud, C., Millan, F., Salvador-Pascual, A., García-Lucerga, C., Blasco-Lafarga, C., Garcia-Dominguez, E., Carretero, A., Correas, A. G., Viña, J., & Gomez-Cabrera, M. C. (2020). Physical exercise in the prevention and treatment of Alzheimer's disease. Journal of sport and health science, 9(5), 394–404. https://doi.org/10.1016/j.jshs.2020.01.004

De Souza-Talarico, J. N., Caramelli, P., Nitrini, R., Chaves, E. C. (2007). The influence of schooling on working memory performance in elderly individuals without cognitive decline. Dementia & neuropsychologic, 1(3), 276–281. https://doi.org/10.1590/S1980-57642008DN10300009

Dominguez, L. J., Veronese, N., Vernuccio, L., Catanese, G., Inzerillo, F., Salemi, G., & Barbagallo, M. (2021). Nutrition, Physical Activity, and Other Lifestyle Factors in the Prevention of Cognitive Decline and Dementia. Nutrients, 13(11), 4080. https://doi.org/10.3390/nu13114080

Erickson, K. I., Voss, M. W., Prakash, R. S., Basak, C., Szabo, A., Chaddock, L., Kim, J. S., Heo, S., Alves, H., White, S. M., Wojcicki, T. R., Mailey, E., Vieira, V. J., Martin, S. A., Pence, B. D., Woods, J. A., McAuley, E., & Kramer, A. F. (2011). Exercise training increases size of hippocampus and improves memory. Proceedings of the National Academy of Sciences of the United States of America, 108(7), 3017–3022. https://doi.org/10.1073/pnas.1015950108

Gottesman, R. F., & Hillis, A. E. (2010). Predictors and assessment of cognitive dysfunction resulting from ischemic stroke. The Lancet. Neurology, 9(9), 895–905. https://doi.org/10.1016/S1474-4422(10)70164-2

Kraal, A. Z., Dotterer, H. L., Sharifian, N., Morris, E. P., Sol, K., Zaheed, A. B., Smith, J., & Zahodne, L. B. (2021). Physical Activity in Early- and Mid-Adulthood is Independently Associated With Longitudinal Memory Trajectories in Later Life. The journals of gerontology. Series A, Biological sciences and medical sciences, 76(8), 1495–1503. https://doi.org/10.1093/gerona/glaa252

Leasure JL, Neighbors C, Henderson CE, Young CM. Exercise and Alcohol Consumption: What We Know, What We Need to Know, and Why it is Important (2015). Front Psychiatry. 2016;6:156. doi: 10.3389/fpsyt.2015.00156. PMID: 26578988; PMCID: PMC4629692.

Machado, A. G., de Lima Dornelles, P. A., Andrade, F. M., Fiegenbaum, M., de Pádua, A. C., & de Oliveira, A. A. (2017). Depression and Memory Decline in the Elderly. Trends in Psychology, 25(4), 1829-1836.

Mammen, G., & Faulkner, G. (2013). Physical activity and the prevention of depression: a systematic review of prospective studies. American journal of preventive medicine, 45(5), 649–657. https://doi.org/10.1016/j.amepre.2013.08.001

Moreira, L., Filho, A. and de Amorim, J.S.C. (2022). Association of physical performance impairments and limitations with insufficient physical activity among older adults in Brazil: results from the national health survey. J Public Health (Berl.) 30, 781–788. https://doi.org/10.1007/s10389-020-01351-7

Moutoussamy, I., Taconnat, L., Pothier, K., Toussaint, L., & Fay, S. (2022). Episodic memory and aging: Benefits of physical activity depend on the executive resources required for the task. PloS one, 17(2), e0263919. https://doi.org/10.1371/journal.pone.0263919

Murman, D. L. (2015). The Impact of Age on Cognition. Seminars in hearing, 36(3), 111–121. https://doi.org/10.1055/s-0035-1555115

National Center for Health Statistics.

(n.d.). About the National Health and Nutrition Examination. Survey. https://www.cdc.gov/nchs/nhanes/about_nhanes.htm

Novitzke, J. (2008). Privation of Memory: What can be done to help stroke patients remember?. Journal of vascular and interventional neurology, 1(4), 122–123.

Nyberg, L., Lövdén, M., Riklund, K., Lindenberger, U., & Bäckman, L. (2012). Memory aging and brain maintenance. Trends in cognitive sciences, 16(5), 292–305. https://doi.org/10.1016/j.tics.2012.04.005

O'Shea, A., Cohen, R. A., Porges, E. C., Nissim, N. R., & Woods, A. J. (2016). Cognitive Aging and the Hippocampus in Older Adults. Frontiers in aging neuroscience, 8, 298. https://doi.org/10.3389/fnagi.2016.00298

Ruscheweyh, R., Willemer, C., Krüger, K., Duning, T., Warnecke, T., Sommer, J., Völker, K., Ho, H. V., Mooren, F., Knecht, S., & Flöel, A. (2011). Physical activity and memory functions: an interventional study. Neurobiology of aging, 32(7), 1304–1319. https://doi.org/10.1016/j.neurobiolaging.2009.08.001

Schuch, F. B., & Stubbs, B. (2019). The Role of Exercise in Preventing and Treating Depression. Current sports medicine reports, 18(8), 299–304. https://doi.org/10.1249/JSR.0000000000000620

Statistics Canada. (n.d.). Age (in single years), average age, median age, and measures of aging. https://www.statcan.gc.ca/en/concepts/definitions/age2

Stern Y. (2012). Cognitive reserve in ageing and Alzheimer's disease. The Lancet. Neurology, 11(11), 1006–1012. https://doi.org/10.1016/S1474-4422(12)70191-6

Stern, Y., MacKay-Brandt, A., Lee, S., McKinley, P., McIntyre, K., Razlighi, Q., Agarunov, E., Bartels, M., & Sloan, R. P. (2019). Effect of aerobic exercise on cognition in younger adults: A randomized clinical trial. Neurology, 92(9), e905–e916. https://doi.org/10.1212/WNL.0000000000007003

Tian, Y. M., Zhang, W. S., Jiang, C. Q., Zhu, F., Jin, Y. L., Zhu, T., Cheng, K. K., & Xu, L. (2022). Association of alcohol use with memory decline in middle-aged and older Chinese: a longitudinal cohort study. BMC psychiatry, 22(1), 673. https://doi.org/10.1186/s12888-022-04298-z

Tsapanou, A., Gu, Y., O'shea, D. M., Yannakoulia, M., Kosmidis, M., Dardiotis, E., ... & Scarmeas, N. (2017). Sleep quality and duration in relation to memory in the elderly: Initial results from the Hellenic Longitudinal Investigation of Aging and Diet. Neurobiology of learning and memory, 141, 217-225.

Yin, J., John, A., & Cadar, D. (2024). Bidirectional Associations of Depressive Symptoms and Cognitive Function Over Time. JAMA network open, 7(6), e2416305. https://doi.org/10.1001/jamanetworkopen.2024.16305

Zhao, K. X., Huang, C. Q., Xiao, Q., Gao, Y., Liu, Q. X., Wang, Z. R., Li, Y. H., & Xie, Y. Z. (2012). Age and risk of depression among the elderly: a meta-analysis of the published literature. CNS spectrums, 17(3), 142–154. https://doi.org/10.1017/S1092852912000533

Zlotnik, G., & Vansintjan, A. (2019). Memory: An Extended Definition. Frontiers in psychology, 10, 2523. https://doi.org/10.3389/fpsyg.2019.02523.