Effects of nocturnal-diurnal sleep patterns and social participation factors on memory-related disorders in middle-aged and older adults

Keywords
social participation, CHARLS, sleep patterns, memory-related disorders, middle□aged and older adults

Abstract
Introduction
To investigate whether there is an association between nocturnal-daytime sleep patterns as well as social participation and memory-related categories of diseases in the middle-aged and elderly population in China.

Material and methods
This study was based on data from the Peking University China Health and Aging Tracking Survey (CHARLS), and a total of 19,023 study participants were analyzed in the year 2018 according to the inclusion and exclusion criteria. Logistic regression models were used to explore the relationship between different night-time-daytime sleep patterns, social participation, and memory-related categories of disorders step by step with adjustments for different covariates, and the odds ratios (ORs) and 95% confidence intervals (95% CI) were obtained.

Results
Logistic regression models gradually adjusted for confounding with nighttime sleep duration >5 h and daytime sleep duration ≤30 min group, Going to a sport, social, or other club activity and social participation as the protective factors of memory-related class of diseases. Stratified analyses found that among males, people living in rural areas, and married people, the group with >5 h of nighttime sleep and ≤30 min of daytime sleep was a protective factor for memory-related classes of diseases. Among women, people living in urban areas, and married people, social participation was a protective factor for memory-related diseases.

Conclusions
Nighttime sleep time >5 h, daytime sleep time ≤30 min group, and social participation are independent protective factors for memory-related class disorders in older adults.
Keywords: sleep patterns, social participation, memory-related disorders, CHARLS, middle□aged and older adults

Title page

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Keywords: CHARLS; Middle-aged and older adults; Nighttime sleep duration; Social participation; Memory-related disorders

Introduction

Dementia, brain atrophy, and Parkinson's disease, which are increasingly prevalent as populations age[1, 2]. These conditions lead to significant cognitive decline, loss of independence, and heightened healthcare costs, thus imposing a substantial economic burden on society[3]. Current diagnostic and therapeutic strategies predominantly revolve around cognitive assessments, pharmacological interventions, and lifestyle modifications; however, these approaches often do not substantially alter disease trajectory or enhance long-term patient outcomes. Consequently, there is an urgent need to investigate alternative protective factors that may mitigate the risk of developing these debilitating conditions.

Memory-related disorders such as Alzheimer's disease, cerebral atrophy, and Parkinson's disease are closely linked to sleep duration in middle-aged and older adults. Numerous studies have

focused on the association between nighttime sleep duration or daytime sleep duration and memory-related disorders[4-6]. However, there is a gap in the literature regarding the combined impact of both nighttime and daytime sleep patterns on memory-related disorders in this population. It highlighted the need for further research to explore the specific contributions of nocturnal and diurnal sleep patterns to these disorders.

Social participation refers to maintaining social relationships and engaging in social activities. It is one of the three major social policies advocated by the World Health Organization for active aging[7, 8]. Social participation has been shown to have significant effects on both physical and mental health outcomes in middle-aged and older adults[9]. Maintaining cognitive function and preventing cognitive decline is a key focus in the field of aging research. Research has suggested that social participation may play a protective role in cognitive function and memory-related disorders in older adults. Engaging in social activities and maintaining social connections may help to reduce the risk of cognitive decline and improve overall cognitive function[10, 11]. However, more research is needed to explore the specific effects of social participation on memory-related disorders in middle-aged and older adults.

This observational study aims to investigate the effects of nocturnal-diurnal sleep patterns and social participation on memory-related disorders in middle-aged and older adults. By examining the relationship between social participation and cognitive functioning, this study seeks to provide valuable insights into the potential benefits of maintaining social relationships and engaging in social activities for cognitive health in later life.

Method:

The dataset utilized in this investigation originates from the China Health and Retirement Longitudinal Study (CHARLS), which was executed by Peking University[12]. This extensive nationwide survey program was initiated by the National Development Research Institute (NDRI) at Peking University and encompassed 150 counties across 28 provinces, including autonomous regions and municipalities directly governed by the central authority of China. In summary, participants aged middle-aged and older were randomly chosen for the baseline survey, which was conducted from June 2011 to March 2012, employing a sampling methodology where the probability of selection was directly proportional to the population size. For the purposes of this analysis, data from the year 2018 were utilized. The CHARLS project received ethical approval from the Ethics Committee of the Faculty of Medicine at Peking University. Furthermore, the Biomedical Ethics Review Board of Peking University granted approval for the CHARLS study (IRB00001052-11015), and all participants provided their written informed consent. The dataset and associated information pertinent to this study are accessible for download via the CHARLS project website.

Nighttime sleep duration was assessed by the question, “During the past month, how many hours of actual sleep did you get on average per night?”, which specifically refers to actual sleep duration rather than time spent in bed. Daytime napping was measured by the question, “During the past month, how long did you take a nap after lunch?” . To evaluate the combined effects, sleep patterns were categorized into four groups: (1) short night sleep (≤5 h) with short nap (≤30 min); (2) short night sleep (≤5 h) with long nap (>30 min); (3) normal night sleep (>5 h) with short nap (≤30 min); and (4) normal night sleep (>5 h) with long nap (> 30 min). The 5-hour threshold for nighttime sleep was adopted as it is a cutoff for increased risks of chronic diseases (e.g., hypertension and multimorbidity) among middle-aged and older Chinese populations[13]. The 30-

minute nap cutoff was used to distinguish "power naps" from prolonged naps associated with adverse metabolic outcomes[14]. For social activity participation, respondents were asked whether they had engaged in any of the following eight activities in the past month: visiting friends and relatives, board games and recreation, unpaid help, physical activity, club activity, voluntary and charitable activities, unpaid care for others, and continuing education. Participation in any of the eight activities was categorized as participation in social activities, and ultimately, participation in social activities was divided into two categories, i.e., non-participation in social activities and participation in social activities[15]. Memory-related disorders, encompassing Alzheimer's disease, brain atrophy, and Parkinson's disease, were identified based on physician-diagnosed conditions. Following established protocols in large-scale epidemiological cohorts, participants were asked whether a healthcare professional had ever informed them of having these specific conditions. This self-reported medical diagnosis approach is a standard metric in the CHARLS database. Extensive validation studies have demonstrated that such self-reported data maintain high consistency with objective clinical records and medical claims[16-19].

The exclusion criteria applied in this study were as follows: Participants with missing information on memory related diseases(n = 420). Participants with missing information on social participation (n = 15). Participants with missing information on age (n = 64). Aged <45 years (n = 292). Absence of data regarding covariates (n = 1). Consequently, a final cohort comprising 19024 participants who satisfied these criteria was established (see Fig. 1). This study adhered to the cohort study reporting guidelines set forth by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE).

Continuous variables were expressed as the mean ± standard deviation, while categorical data were represented as counts accompanied by percentages. Statistical analyses were performed utilizing EmpowerStats (X&Y Solutions, Inc., Boston, MA) and R software version 3.6.1. A two-sided alpha level of 0.05 was established. Comparisons between groups of continuous variables were carried out using the T-test, and chi-squared tests were employed for categorical variables.

Logistic regression modeling was used to explore the associations of the nocturnal and daytime sleep patterns and social participation for having a memory-related disorder. Multiple models were constructed, each adjusted for a different set of covariates, to gain insight into how these covariates affect the observed associations. Subgroup analyses were used to examine the associations of the nocturnal and daytime sleep patterns and social participation with memory-related disorders across sociodemographic characteristics. To assess the potential impact of unmeasured confounding (e.g., past medical history or exercise habits), E-value analysis was performed for variables that showed significant associations in the logistic regression models. The E-value is defined as the minimum strength of association that an unmeasured confounder would need to have with both the exposure and the outcome, conditional on the measured covariates, to fully explain away the observed risk ratio[20]. A higher E-value indicates that a stronger unmeasured confounder would be required to nullify the observed effect, thereby reflecting the robustness of the findings against potential omitted variable bias

Result

Figure 1. Flowchart of participant selection

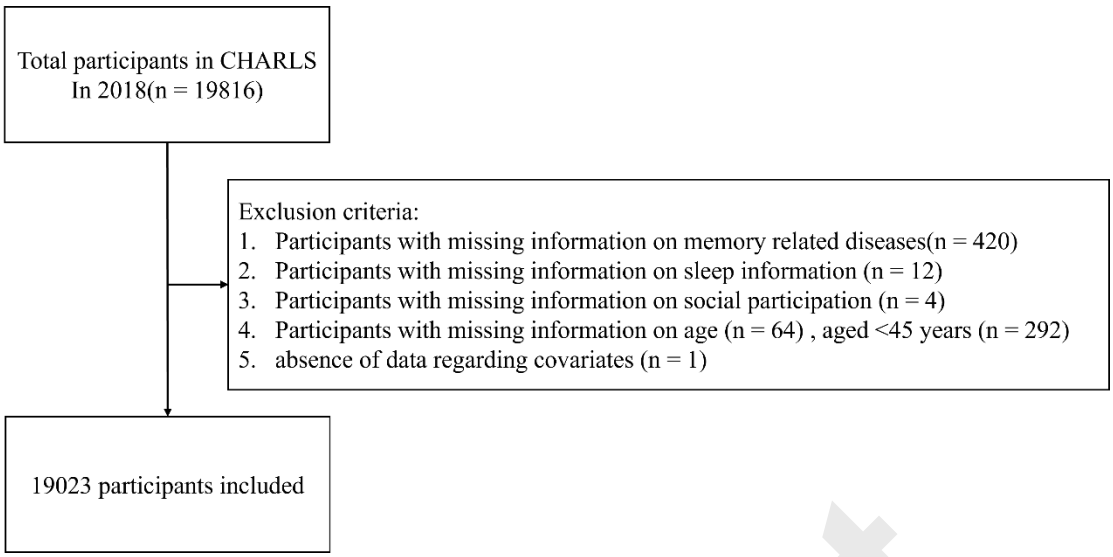

Table 1. Patient Characteristics

Characteristic	Memory related diseases		*P*-value
	No	Yes	
Age (Mean ± SD)	61.422 ± 10.026	69.422 ± 10.309	<0.001
Gender (%)			0.366
Female	9,716 (52.287%)	221 (50.113%)	
Male	8,866 (47.713%)	220 (49.887%)	
Living region (%)			0.920
Urban Community	7,460 (40.146%)	176 (39.909%)	
Rural Village	11,122 (59.854%)	265 (60.091%)	
Marital status (%)			<0.001
Non-married	2,697 (14.514%)	126 (28.571%)	
Married	15,885 (85.486%)	315 (71.429%)	
Smoke status (%)			0.195
No	10,686 (57.507%)	240 (54.422%)	
Yes	7,896 (42.493%)	201 (45.578%)	
Education status (%)			0.002
Illiterate	4493 (24.179%)	139 (31.519%)	
Primary school	8396 (45.184%)	185 (41.950%)	
Middle school or above	5,693 (30.637%)	117 (26.531%)	
Drinking status (%)			<0.001
No	12,204 (65.676%)	345 (78.231%)	
Yes	6,378 (34.324%)	96 (21.769%)	
Social participation (%)			<0.001
No	9,459 (50.904%)	271 (61.451%)	
Yes	9,124 (49.096%)	170 (38.549%)	

Interacting with friends			
No	12288 (66.129%)	317 (71.882%)	0.012
Yes	6294 (33.871%)	124 (28.118%)	
Playing Mahjong, chess, or cards			
No	15470 (83.253%)	386 (87.528%)	0.017
Yes	3112 (16.747%)	55 (12.472%)	
Providing help to family, friends, or neighbors who did not pay for the help			
No	15978 (85.986%)	396 (89.796%)	0.022
Yes	2604 (14.014%)	45 (10.204%)	
Going to a sport, social, or other club activity			
No	17343 (93.332%)	430 (97.506%)	<0.001
Yes	1239 (6.668%)	11 (2.494%)	
Participating in a community-related organization			
No	18128 (97.557%)	432 (97.959%)	0.588
Yes	454 (2.443%)	9 (2.041%)	
Doing volunteer or charity work			
No	18259 (98.262%)	436 (98.866%)	0.335
Yes	323 (1.738%)	5 (1.134%)	
The nocturnal and daytime sleep patterns (%)			<0.001
[1]nighttime sleep(≤5 h) with daytime napping(≤30 min)	3,739 (20.1%)	113 (25.6%)	
[2]nighttime sleep(≤5 h)	2,197 (11.8%)	78 (17.7%)	

with daytime napping(> 30 min)		
[3]nighttime sleep(> 5 h) with daytime napping(≤30 min)	6,668 (35.9%)	115 (26.1%)
[4]nighttime sleep(> 5 h) with daytime napping(> 30 min)	5,979 (32.2%)	135 (30.6%)

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In table 1, we compared the differences between patients diagnosed with memory-related disorders and undiagnosed individuals. *P*-values denote the statistical significance of differences between participants with and without memory-related diseases. The data show that the mean age was higher in the diagnosed group compared to undiagnosed group, a difference that was significant ($P < 0.001$). Although the sex ratio did not differ significantly between the two groups ($P = 0.366$), married status presented a significant difference, with the unmarried proportion being higher in the diagnosed group ($P < 0.001$). In addition, the proportion of illiteracy was higher in the diagnostic group, while the proportion of literacy above middle school was lower, which was significant ($P = 0.006$). Regarding drinking habits, non-drinkers accounted for a larger proportion in the diagnostic group ($P < 0.001$). Regarding social participation, the proportion of those who did not participate in social activities was significantly higher in the diagnostic group ($P < 0.001$). Finally, among the variables related to sleep duration and distribution, individuals who slept $\leqslant$ 5 hours at night and napped $\leqslant$ 30 minutes during the day were more represented in the diagnostic group , a characteristic that was also significant ($P < 0.001$). Interacting with friends, playing mahjong, chess, or playing cards, providing assistance to family, friends, or neighbors who have not paid for help, and participating in sports, social, or other club activities show significant differences between groups.

149 **Table 2. Association between the nocturnal and daytime sleep patterns and memory related diseases**

The nocturnal and daytime sleep patterns	Model 1			Model 2			Model 3		
	OR[1]	(95% CI[1])	*P*-value	OR[1]	(95% CI[1])	*P*-value	OR[1]	(95% CI[1])	*P*-value
Nighttime sleep(≤5 h) with daytime napping(≤30 min)		Reference			Reference			Reference	
Nighttime sleep(≤5 h) with daytime napping(> 30 min)	1.175	(0.877, 1.576)	0.280	1.113	(0.827, 1.498)	0.480	1.117	(0.830, 1.504)	0.465
Nighttime sleep(> 5 h) with daytime napping(≤30 min)	0.571	(0.439, 0.742)	<0.001**	0.672	(0.514, 0.877)	0.003**	0.666	(0.510, 0.871)	0.003**
Nighttime sleep(> 5 h) with daytime napping(> 30 min)	0.747	(0.580, 0.962)	0.024*	0.776	(0.599, 1.005)	0.055	0.783	(0.605, 1.015)	0.065

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Notes: *$P < 0.05$, **$P < 0.01$; [1]OR = Odds Ratio, CI = Confidence Interval；Model 1 : no covariates were adjusted; Model 2 : adjusted for age, gender, and region；Model 3 : adjusted for age, gender, region, marital status, education, smoke status, and drinking status.

In Table 2, the group with nighttime sleep ≤ 5 h and daytime napping ≤ 30 min was used as the reference. The results indicated that the pattern of nighttime sleep > 5 h with daytime napping ≤ 30 min was significantly associated with a reduced risk of memory-related diseases. Specifically, this group presented an OR of 0.571 (95% CI: 0.439–0.742, $P < 0.001$) in Model 1 without adjustment for covariates. After adjusting for age, gender, and living region in Model 2, the association remained significant with an OR of 0.672 (95% CI: 0.514–0.877, $P = 0.003$). In the fully adjusted Model 3, which further accounted for marital status, education, smoking, and drinking habits, the protective effect persisted with an OR of 0.666 (95% CI: 0.510–0.871, $P = 0.003$).

Table 3. Association between social participation and memory related diseases

Characteristics	Model 1			Model 2			Model 3		
	OR[1]	(95% CI[1])	*P*-value	OR[1]	(95% CI[1])	*P*-value	OR[1]	(95% CI[1])	*P*-value
Social participation									
No		Reference			Reference			Reference	
Yes	0.650	(0.536, 0.790)	<0.001**	0.767	(0.630, 0.934)	0.008**	0.779	(0.639, 0.950)	0.014*
Interacting with friends									
No		Reference			Reference			Reference	
Yes	0.764	(0.619, 0.942)	0.012*	0.859	(0.695, 1.063)	0.162	0.875	(0.707, 1.083)	0.220
Playing Mahjong, chess, or cards									
No		Reference			Reference			Reference	
Yes	0.708	(0.533, 0.942)	0.018*	0.798	(0.597, 1.067)	0.128	0.803	(0.599, 1.075)	0.141
Providing help to family, friends, or neighbors who did not pay for the help									
No		Reference			Reference			Reference	
Yes	0.697	(0.511, 0.952)	0.023*	0.985	(0.717, 1.352)	0.924	1.023	(0.744, 1.406)	0.890
Going to a sport, social, or other club activity									
No		Reference			Reference			Reference	
Yes	0.358	(0.196, 0.653)	<0.001**	0.462	(0.252, 0.848)	0.013*	0.464	(0.253, 0.853)	0.013*

Notes: **P* < 0.05, ***P* < 0.01; [1]OR = Odds Ratio, CI = Confidence Interval； Model 1 : no covariates were adjusted; Model 2 : adjusted for age, gender, and region； Model 3 : adjusted for age, gender, region, marital status, education, smoke status, and drinking status.

Table 3 assesses the impact of social participation and its specific components on the risk of memory-related disorders across three models. Social participation showed a consistent and significant protective effect in all models. In the unadjusted model (Model 1), the OR for the social participation group compared to the reference group was 0.650 (95% CI: 0.536–0.790, $P < 0.001$). After adjusting for age, gender, and region in Model 2, the protective effect remained significant with an OR of 0.767 (95% CI: 0.630–0.934, $P = 0.008$). In the fully adjusted Model 3, which further accounted for marital status, education, and smoking and drinking status, the OR was 0.779 (95% CI: 0.639–0.950, $P = 0.014$). Furthermore, among the specific types of activities, going to a sport, social, or other club activity demonstrated the most substantial protective effect. In Model 1, this activity was associated with a significant reduction in risk (OR: 0.358, 95% CI: 0.196–0.653, $P < 0.001$). This association persisted in the fully adjusted Model 3, with an OR of 0.464 (95% CI: 0.253–0.853, $P = 0.013$). These findings consistently suggest that both overall social participation and specific engagement in club activities are independent protective factors against memory-related disorders. Sensitivity analysis using E-values yielded robust results for the primary significant predictors. Specifically, the E-values for nighttime sleep (> 5 h) with short napping ($\le$ 30 min), social participation, and club activity were 2.37, 1.88, and 3.73, respectively. These relatively high E-values suggest that any unmeasured confounding factors would need to have substantial association strengths (ranging from 1.88 to 3.73) with both the exposures and the memory-related disorders to negate the observed findings.

Table 4. Subgroup analysis of nighttime and daytime sleep patterns, social participation in memory related diseases.

Subgroup Characteristic	Nighttime sleep(> 5 h) with daytime napping(⩽30 min)	Social participation	Going to a sport, social or other club activity
	OR[1](95% CI[1]) *P*-value	OR[1](95% CI[1]) *P*-value	OR[1](95% CI[1]) *P*-value
Gender (%)			
Female	0.706 (0.488, 1.020) 0.064	0.670 (0.505, 0.889) 0.006**	0.485 (0.236, 0.997) 0.049*
Male	0.609 (0.413, 0.900) 0.013*	0.900 (0.680, 1.191) 0.460	0.398 (0.126, 1.260) 0.117
Living region (%)			
Urban Community	0.678 (0.437, 1.051) 0.083	0.659 (0.479, 0.907) 0.011*	0.342 (0.139, 0.844) 0.020
Rural Village	0.659 (0.470, 0.925) 0.016*	0.879 (0.682, 1.134) 0.321	0.677 (0.298, 1.540) 0.353
Marital status (%)			
Non-married	1.065 (0.646, 1.754) 0.806	0.847 (0.583, 1.229) 0.382	0.640 (0.198, 2.071) 0.457
Married	0.551 (0.401, 0.755) <0.001**	0.756 (0.598, 0.957) 0.020*	0.415 (0.204, 0.847) 0.016*

Notes: *$P < 0.05$, **$P < 0.01$; [1]OR = Odds Ratio, CI = Confidence Interval；covariates were adjusted.

Table 4 elucidates the findings of the stratified analyses conducted. It was observed that social participation serves as a protective factor against memory-related diseases within the female demographic ($P = 0.006$), the urban community ($P = 0.011$), as well as among married individuals ($P = 0.020$). The study also found that sleeping more than five hours at night while taking no more than a thirty-minute nap during the day was protective against memory-related disorders in a group of male($P = 0.012$), Rural Village($P = 0.016$), and married individuals($P < 0.001$). Women living in urban areas and married individuals who participate in sports clubs have a lower risk of developing memory related diseases.

Discussion

Understanding memory-related diseases is crucial due to their profound impact on individuals and society. Our research offers advantages such as using a well-defined population and reliable measures of sleep and social participation. Key findings from this study reveal that adequate nighttime sleep and limited daytime sleep, along with active social involvement, may serve as protective factors against dementia, brain atrophy, and Parkinson's disease.

By examining variables such as age, marital status, educational level, drinking habits, social engagement, and sleep patterns, the study seeks to identify significant distinctions that could enhance early detection and intervention strategies. The findings highlight the potential for targeted approaches in addressing the complex interplay of these factors in the context of memory disorders, thereby contributing to the broader understanding of risk factors and promoting timely therapeutic interventions. Previous research has often focused on singular aspects, such as age or education level, without considering the interconnectedness of various social determinants. Our findings, particularly the significant associations between lower literacy rates, increased age, and diminished social participation with the prevalence of memory disorders, align with the conclusions drawn by other studies that highlight the multifactorial nature of cognitive decline in aging populations[21].

The implications of our findings hold significant potential for clinical practice and policy formulation. Identifying the demographic and lifestyle characteristics that predispose individuals to memory-related disorders can guide targeted screening efforts, ultimately leading to earlier diagnosis and intervention. For instance, the observed higher prevalence of memory disorders among individuals with lower literacy rates emphasizes the necessity for educational initiatives aimed at improving cognitive resilience. Furthermore, the strong association between poor sleep patterns and cognitive impairments suggests that sleep hygiene interventions could be integrated into treatment plans for patients diagnosed with memory disorders, potentially mitigating cognitive decline[22]. These findings underline the importance of adopting a holistic approach to treatment, which acknowledges the interplay between lifestyle factors and cognitive health.

Nighttime sleep duration and daytime nap duration have a significant effect on cognitive function in older adults. Particularly in the Chinese elderly population, researchers found a U-shaped relationship between nighttime sleep duration and mild cognitive impairment (MCI)[23]. These findings emphasize the importance of appropriate nighttime sleep versus daytime naps in preventing and delaying cognitive decline. Sleep of more than 5 hours at night ensures the integrity of the underlying sleep cycle, especially slow wave sleep (SWS), which plays a key role in synaptic steady state regulation and metabolic waste removal[24].Control of daytime nap time in less than 30 minutes has a clear cognitive compensatory advantage. Studies have confirmed that ≤30 minutes of nap can effectively relieve subjective drowsiness, improve positive mood, and not trigger significant sleep. Improved memory encoding capability in inert conditions[25]. The combination effectively relieves daytime sleep stress without interfering with the output of endogenous circadian rhythms. This strategy both reduces the accumulative risk of beta-amyloid and optimizes neurophysiological stability, thus Knowledge functions produce synergistic protective effects[26]. Consistent with existing literature recommending regular, adequate nocturnal sleep and limited daytime nap duration for older adults[27], our findings reinforce these patterns within the Chinese context. Notably, compared to Western studies that emphasize sleep continuity, Chinese older adults exhibit a higher prevalence of short daytime napping, a behavior likely influenced by deeply rooted cultural habits. Furthermore, the protective effects of social participation observed in this study reveal significant

disparities across gender and urban-rural settings. The unique family structures and social models inherent to China underline the critical importance of localized interventions. Such findings suggest that public health strategies must move beyond universal guidelines to incorporate socio-cultural and demographic nuances to effectively combat memory-related diseases.

Social engagement, another important factor, has also been suggested to have a protective effect against memory disorders. Social engagement provides cognitive stimulation and emotional support, which helps maintain and enhance cognitive functioning in older adults. Studies have shown that older adults with high levels of social engagement have slower rates of cognitive decline and are associated with a lower risk of memory-based disorders[28, 29]**.**Among men, people living in rural areas, and married people, nighttime sleep duration of more than 5 hours combined with daytime naps of no more than 30 minutes was recognized as a protective factor for memory-related classes of disorders. This finding echoes previous research that proper nighttime sleep and daytime naps have a positive impact on cognitive functioning[30-32]. Social engagement was found to be a protective factor for memory-related disorders among women, urban-dwelling populations, and married individuals. This may be related to the ability of social engagement to provide cognitive stimulation and emotional support, thereby maintaining and enhancing cognitive functioning. Physical activity is the most important modifiable risk factor in preventing Alzheimer's disease and related dementia. Those who actively participate in sports clubs are more likely to maintain physical activity, thereby reducing their risk of developing memory related diseases[33-35]. Existing research suggests that gender and living environment may regulate the health effects of sleep and social engagement through bio-psycho-social mechanisms. Women are more susceptible to social support buffer stress[36]. Urban residents are dense in social resources, so that social participation is more effective, thus playing a stronger protective role[37].

Despite the insights provided, several limitations must be acknowledged. First, the cross-sectional design precludes the establishment of temporal causality between sleep patterns, social participation, and memory-related disorders. Future research utilizing longitudinal cohorts is warranted to more rigorously validate these causal pathways. Second, variables were derived from self-reported data, which may introduce recall or social desirability bias. Incorporating objective measures, such as polysomnography or clinical diagnostic records, in future studies would further enhance the precision and reliability of the findings.

Nevertheless, these findings emphasize that protective factors for memory-related disorders may vary significantly across populations and lifestyle habits. Therefore, these differences must be integrated into the development of public health prevention strategies to ensure interventions are effectively targeted. For instance, for men and rural-dwelling older adults, priority should be given to optimizing sleep quality and daytime napping habits. Conversely, for women and urban-dwelling older adults, fostering social participation and community engagement may yield more substantial neuroprotective benefits.

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Conflict of interest

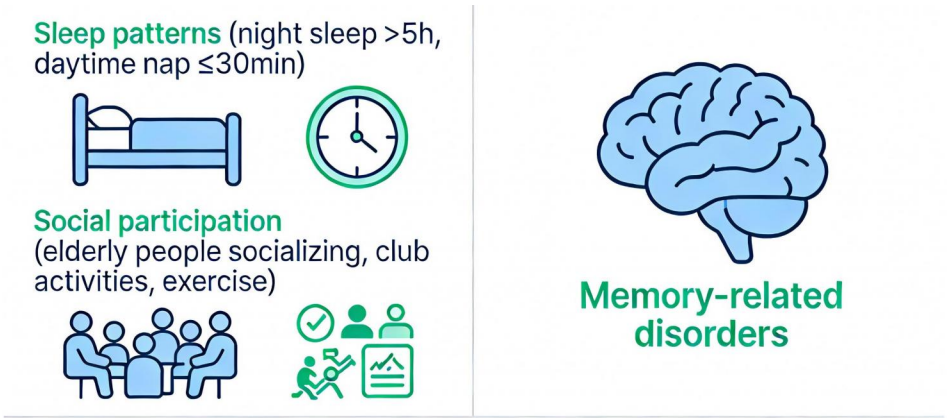
The authors declare no conflict of interest.

Reference:

1. Ware, C., et al., *Does Second Language Learning Promote Neuroplasticity in Aging? A Systematic Review of Cognitive and Neuroimaging Studies.* Front Aging Neurosci, 2021. **13**: p. 706672.
2. Laganiere, J., et al., *An engineered zinc finger protein activator of the endogenous glial cell line-derived neurotrophic factor gene provides functional neuroprotection in a rat model of Parkinson's disease.* J Neurosci, 2010. **30**(49): p. 16469-74.
3. Baik, D., et al., *Prevalence and patterns of the concurrent use of anticholinergics for the motor symptoms of Parkinson's disease and acetylcholinesterase inhibitors in Parkinson's disease patients with dementia: a cross-sectional study using Korea National Health Insurance claims data.* BMC Geriatr, 2022. **22**(1): p. 609.
4. Li, J., et al., *Daytime Napping and Cognitive Health in Older Adults: A Systematic Review.* J Gerontol A Biol Sci Med Sci, 2023. **78**(10): p. 1853-1860.
5. Ellenbogen, J.M., et al., *Interfering with theories of sleep and memory: sleep, declarative memory, and associative interference.* Curr Biol, 2006. **16**(13): p. 1290-4.
6. Ju, Y.E., et al., *Sleep quality and preclinical Alzheimer disease.* JAMA Neurol, 2013. **70**(5): p. 587-93.
7. Marmot, M., et al., *Relative contribution of early life and adult socioeconomic factors to adult morbidity in the Whitehall II study.* J Epidemiol Community Health, 2001. **55**(5): p. 301-7.
8. Ouyang, Y., et al., *The influence of sports participation on body image, self-efficacy, and self-esteem in college students.* Frontiers in psychology, 2020. **10**: p. 3039.
9. Bogaert, S., et al., *Impact of Gender and Feature Set on Machine-Learning-Based Prediction of Lower-Limb Overuse Injuries Using a Single Trunk-Mounted Accelerometer.* Sensors (Basel), 2022. **22**(8).
10. House, J.S., C. Robbins, and H.L. Metzner, *The association of social relationships and activities with mortality: prospective evidence from the Tecumseh Community Health Study.* Am J Epidemiol, 1982. **116**(1): p. 123-40.
11. Hsu, H.C., *Does social participation by the elderly reduce mortality and cognitive impairment?* Aging Ment Health, 2007. **11**(6): p. 699-707.
12. Zhao, Y., et al., *Cohort profile: the China Health and Retirement Longitudinal Study (CHARLS).* Int J Epidemiol, 2014. **43**(1): p. 61-8.
13. Wang, Y., et al., *Effects and differences of sleep duration on the risk of new-onset chronic disease conditions in middle-aged and elderly populations.* Eur J Intern Med, 2023. **107**: p. 73-80.
14. Yang, Y.B., et al., *To nap or not? Evidence from a meta-analysis of cohort studies of habitual daytime napping and health outcomes.* Sleep Med Rev, 2024. **78**: p. 101989.
15. Levasseur, M., et al., *Scoping study of definitions of social participation: update and co-construction of an interdisciplinary consensual definition.* Age

Ageing, 2022. **51**(2).
16. Ni, X., et al., *Association between the triglyceride glucose-body mass index and memory-related diseases: A nationwide cohort study.* Public Health, 2025. **239**: p. 136-141.
17. Chen, C., et al., *Network analysis of chronic disease among middle-aged and older adults in China: a nationwide survey.* Front Public Health, 2025. **13**: p. 1551034.
18. Tao, H., et al., *Synergistic impact of air pollution and artificial light at night on memory disorders: a nationwide cohort analysis.* BMC Public Health, 2025. **25**(1): p. 1591.
19. Zhang, Z., et al., *The evolution of comorbidities in chronic diseases among Chinese middle-aged and elderly people: Evidence from the CHARLS (2015-2020).* PLoS One, 2025. **20**(8): p. e0329372.
20. VanderWeele, T.J. and P. Ding, *Sensitivity Analysis in Observational Research: Introducing the E-Value.* Ann Intern Med, 2017. **167**(4): p. 268-274.
21. Hayward, M.D., et al., *The Importance of Improving Educational Attainment for Dementia Prevalence Trends From 2000 to 2014, Among Older Non-Hispanic Black and White Americans.* J Gerontol B Psychol Sci Soc Sci, 2021. **76**(9): p. 1870-1879.
22. Phillips, A.J.K., E.B. Klerman, and J.P. Butler, *Modeling the adenosine system as a modulator of cognitive performance and sleep patterns during sleep restriction and recovery.* PLoS Comput Biol, 2017. **13**(10): p. e1005759.
23. Gao, L., et al., *Activities of Daily Living and Depression in Chinese Elderly of Nursing Homes: A Mediation Analysis.* Psychol Res Behav Manag, 2023. **16**: p. 29-38.
24. Franken, P. and D.J. Dijk, *Sleep and circadian rhythmicity as entangled processes serving homeostasis.* Nat Rev Neurosci, 2024. **25**(1): p. 43-59.
25. Leong, R.L.F., et al., *Influence of mid-afternoon nap duration and sleep parameters on memory encoding, mood, processing speed, and vigilance.* Sleep, 2023. **46**(4).
26. Gao, C., et al., *Timing and intraindividual variability of daytime napping and Alzheimer's disease in older adults.* Commun Med (Lond), 2025. **5**(1): p. 219.
27. Ellender, C.M., et al., *Australasian Sleep Association 2024 guidelines for sleep studies in adults.* Sleep, 2024. **47**(10).
28. Colcombe, S. and A.F. Kramer, *Fitness effects on the cognitive function of older adults: a meta-analytic study.* Psychol Sci, 2003. **14**(2): p. 125-30.
29. Ellwardt, L., et al., *Does loneliness mediate the relation between social support and cognitive functioning in later life?* Soc Sci Med, 2013. **98**: p. 116-24.
30. Lovato, N. and L. Lack, *The effects of napping on cognitive functioning.* Progress in brain research, 2010. **185**: p. 155-166.
31. Leong, R.L.F., J.C. Lo, and M.W.L. Chee, *Systematic review and meta-analyses on the effects of afternoon napping on cognition.* Sleep Medicine Reviews,

2022. **65**: p. 101666.
32. Dutheil, F., et al., *Napping and cognitive performance during night shifts: a systematic review and meta-analysis.* Sleep, 2020. **43**(12): p. zsaa109.
33. Salisbury, D.L., et al., *The MN RIDE pilot: feasibility of a synchronous, remotely delivered, aerobic exercise training program for rural-dwelling adults with subjective cognitive decline.* Rural Remote Health, 2023. **23**(4): p. 8351.
34. Gasquoine, P.G., *Effects of physical activity on delayed memory measures in randomized controlled trials with nonclinical older, mild cognitive impairment, and dementia participants.* Journal of clinical and experimental neuropsychology, 2018. **40**(9): p. 874-886.
35. Tsukita, K., H. Sakamaki-Tsukita, and R. Takahashi, *Long-term effect of regular physical activity and exercise habits in patients with early Parkinson disease.* Neurology, 2022. **98**(8): p. e859-e871.
36. Oh, D.J., et al., *Association of Low Emotional and Tangible Support With Risk of Dementia Among Adults 60 Years and Older in South Korea.* JAMA Netw Open, 2022. **5**(8): p. e2226260.
37. Zutter, C. and A. Stoltz, *Community gardens and urban agriculture: Healthy environment/healthy citizens.* Int J Ment Health Nurs, 2023. **32**(6): p. 1452-1461.



Sleep pattern and social participation as protective factors