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

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Abstract

Introduction: The aim of the study was 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 older population in China.

Material and methods: This study was based on data from the China Health and Retirement Longitudinal Study (CHARLS), and a total of 19,023 study participants who met the inclusion and exclusion criteria were included in the 2018 analysis. 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 with sequential adjustment for potential confounders identified nighttime sleep duration > 5 h combined with daytime sleep duration ≤ 30 min, participation in sports, and participation in social or other club activities as factors associated with lower odds of memory-related 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 associated with lower odds of memory-related disorders. Among women, people living in urban areas, and married people, social participation was associated with lower odds of memory-related diseases.

Conclusions: Nighttime sleep time > 5 h, daytime sleep time ≤ 30 min group, and social participation are associated with lower odds of memory-related disorders in older adults.

Key words: CHARLS, middle-aged and older adults, nighttime sleep duration, social participation, memory-related disorders.

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Introduction

Dementia, brain atrophy, and Parkinson's disease are increasingly prevalent as populations age [1, 2]. These conditions can lead to significant cognitive decline, loss of independence, and increased 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 factors associated with a lower 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 napping duration and memory-related disorders [4–6]. However, there is a gap in the literature regarding the combined association of nighttime and daytime sleep patterns with memory-related disorders in this population. Further research is needed to clarify the associations of nocturnal and daytime sleep patterns with 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 association between social participation and memory-related disorders in middle-aged and older adults.

This observational study aims to investigate the associations of nighttime and daytime sleep patterns and social participation with 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.

Material and methods

The dataset used in this investigation originates from the China Health and Retirement Longitudinal Study (CHARLS), conducted 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, middle-aged and older participants 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 2018 were used. 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 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 par-

ticipation 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); age < 45 years (n = 292); absence of data regarding covariates (n = 1). Consequently, a final cohort comprising 19,024 participants who satisfied these criteria was established (Figure 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 using EmpowerStats (X&Y Solutions, Inc., Boston, MA) and R software version 3.6.1. A two-sided α level of 0.05 was established. Comparisons between groups of continuous variables were carried out using the T-test, and χ^2 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.

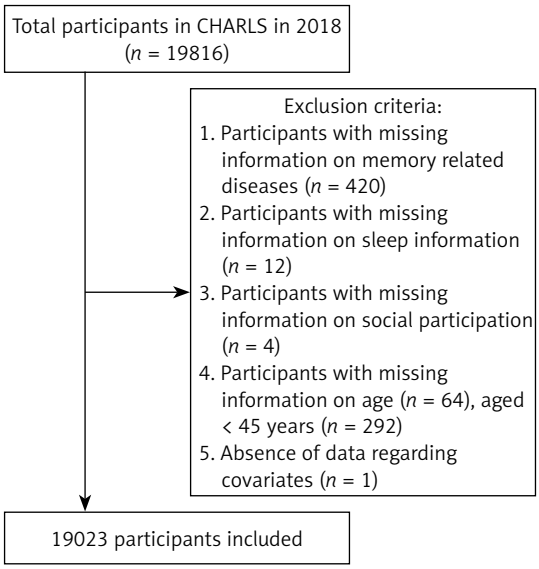


Figure 1. Flowchart of participant selection

Results

In Table I, 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).

Table I. Patient characteristics

Characteristic	Memory-related diseases		*P*-value
	No	Yes	
Age (mean ± SD)	61.422 ±10.026	69.422 ±10.309	< 0.001
Sex (%)			0.366
Female	9,716 (52.287%)	221 (50.113%)	
Male	8,866 (47.713%)	220 (49.887%)	

Table I. Cont.

Characteristic	Memory-related diseases		*P*-value
	No	Yes	
Living region (%)			0.920
Urban region	7,460 (40.146%)	176 (39.909%)	
Rural region	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%)	
Smoking 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%)	
Participation in sports, social clubs, or other clubs			
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%)	
Nocturnal and daytime sleep patterns (%)			< 0.001
[1] Nighttime sleep (≤ 5 h)	3,739 (20.1%)	113 (25.6%)	
with daytime napping (≤ 30 min)			
[2] Nighttime sleep (≤ 5 h)	2,197 (11.8%)	78 (17.7%)	
with daytime napping (> 30 min)			
[3] Nighttime sleep (> 5 h)	6,668 (35.9%)	115 (26.1%)	
with daytime napping (≤ 30 min)			
[4] Nighttime sleep (> 5 h)	5,979 (32.2%)	135 (30.6%)	
with daytime napping (> 30 min)			

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 ≤ 5 h at night and napped ≤ 30 min 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.

In Table II, 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 odds 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, sex, 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 association persisted, with an OR of 0.666 (95% CI: 0.510–0.871, p = 0.003).

Table III assesses the associations of social participation and its specific components with memory-related disorders across three models. Social participation showed a consistent and significant inverse association 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, sex, and region in Model 2, the association 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, participation in sports, social clubs, or other clubs demonstrated the strongest inverse association. In Model 1, this activity was associated with lower odds of the outcome (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 suggest that overall social participation and participation in club activities are associated with lower odds of 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, social participation, and club activity were 2.37, 1.88, and 3.73, respectively. These relatively high E-values suggest that an unmeasured confounder would need to be associated with both the exposure and the outcome by risk ratios of at least the corresponding magnitude, conditional on measured covariates, to explain away the observed associations, subject to the assumptions of the E-value method.

Table IV presents the results of the subgroup analyses. Social participation was associated with lower odds of memory-related diseases among women (p = 0.006), urban residents (p = 0.011), and married individuals (p = 0.020). Nighttime sleep duration >5 h combined with daytime napping ≤ 30 min was associated with lower odds of memory-related disorders among males (p = 0.012), rural residents (p = 0.016), and married individuals (p < 0.001). Participation in sports, social clubs, or other clubs was associated with lower odds of memory-related diseases among women (p = 0.049), urban residents (p = 0.020), and married individuals (p = 0.016).

Table II. Association between nocturnal and daytime sleep patterns and memory-related diseases

The nocturnal and daytime sleep patterns	Model 1			Model 2			Model 3		
	OR	(95% CI)	*P*-value	OR	(95% CI)	*P*-value	OR	(95% CI)	*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

**P < 0.05, **P < 0.01; OR – odds ratio, CI – confidence interval; Model 1: no covariates were adjusted; Model 2: adjusted for age, sex, and region; Model 3: adjusted for age, sex, region, marital status, education, smoking status, and drinking status.*

Table III. Association between social participation and memory-related diseases

Characteristics	Model 1			Model 2			Model 3		
	OR	(95% CI)	*P*-value	OR	(95% CI)	*P*-value	OR	(95% CI)	*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	0.708	(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
Participation in sports, social clubs, or other clubs									
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*

**P < 0.05, **P < 0.01; OR – odds ratio, CI – confidence interval; Model 1: no covariates were adjusted; Model 2: adjusted for age, sex, and region; Model 3: adjusted for age, sex, region, marital status, education, smoking status, and drinking status.*

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 napping, along with active social involvement, may be associated with lower odds of 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 associations that could inform 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 informing timely interventions. Previous research has often focused on individual 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 and 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 may be relevant to clinical practice and policy formulation. Identifying demographic and lifestyle characteristics associated with 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 highlights the potential value of educational initiatives aimed at improving cognitive resilience. Furthermore, the observed association between sleep patterns and memory-related disorders suggests that sleep hygiene interventions could be considered in preventive or supportive care for patients diagnosed with memory disorders, potentially supporting cognitive health [22]. These findings underline the importance of adopting a holistic approach to cognitive health, which acknowledges the associations with lifestyle factors.

Nighttime sleep duration and daytime nap duration are associated with cognitive function in older adults. Particularly in the Chinese older 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 duration and daytime napping habits in

Table IV. Subgroup analysis of nighttime and daytime sleep patterns and social participation in relation to memory-related diseases

Subgroup characteristic	Nighttime sleep (> 5 h) with daytime napping (≤ 30 min)			Social participation			Participation in sports, social clubs, or other clubs		
	OR	(95% CI)	*P*-value	OR	(95% CI)	*P*-value	OR	(95% CI)	*P*-value
Sex (%)									
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 region	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 region	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*

**P < 0.05, **P < 0.01; OR – odds ratio, CI – confidence interval; covariates were adjusted.*

maintaining cognitive health. Sleep of more than 5 h at night may help maintain the integrity of the underlying sleep cycle, especially slow wave sleep (SWS), which plays a key role in synaptic homeostasis and metabolic waste removal [24]. Limiting daytime naps to less than 30 min may offer cognitive benefits. Studies have confirmed that naps lasting ≤ 30 min can effectively relieve subjective drowsiness and improve positive mood, without causing substantial subsequent sleep inertia [25]. The combination may help relieve daytime sleep pressure without interfering with endogenous circadian rhythms. This strategy has been hypothesized to reduce the accumulation of beta-amyloid and support neurophysiological stability, potentially benefiting cognitive function [26]. Consistent with existing literature recommending regular, adequate nocturnal sleep and limited daytime nap duration for older adults [27], our findings are consistent with these recommendations 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 cultural habits. Furthermore, the associations between social participation and memory-related disorders observed in this study varied across sex and urban-rural settings. The unique family structures and social models in China underline the critical importance of localized interventions. Such findings suggest that public health strategies could incorporate socio-cultural and demographic nuances to help address 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 help 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 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 h combined with daytime naps of no more than 30 min was associated with lower odds of memory-related disorders. This finding is consistent with previous research suggesting that adequate nighttime sleep and daytime naps may benefit cognitive functioning [30–32]. Social engagement was found to be associated with lower odds of 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 an important modifiable risk factor for Alzheimer's disease and related dementias. Those who actively participate in sports clubs are more likely to maintain physical activity, thereby potentially reducing their risk of developing memory-related diseases [33–35]. Existing research suggests that sex and living environment may modify the health effects of sleep and social engagement through biopsychosocial mechanisms. Women may be more susceptible to the stress-buffering effects of social support [36]. Urban residents have greater access to social resources, which may enhance the benefits of social participation [37].

Despite the insights provided, several limitations must be acknowledged. First, the cross-sectional design precludes the establishment of temporal relationships or causal effects between sleep patterns, social participation, and memory-related disorders. Future research utilizing longitudinal cohorts is warranted to investigate these associations over time. 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 suggest that associations with memory-related disorders may vary significantly across populations and lifestyle habits. Therefore, these differences may warrant consideration in the development of public health prevention strategies to ensure interventions are effectively targeted. For instance, for men and rural-dwelling older adults, sleep duration and daytime napping habits could be investigated as potential intervention targets. Conversely, for women and urban-dwelling older adults, social participation and community engagement could be explored as potential intervention targets.

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Ethical approval

Not applicable.

Conflict of interest

The authors declare no conflict of interest.

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