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Original Article

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Shorter sleep duration and lesser sleep efficiency are associated with poorer memory functions among non-demented, middle-aged, and older rural Indians

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Abstract

Introduction: Sleep is known to be involved in cognitive processes, such as memory encoding and consolidation, and poor sleep is a potential risk factor for dementia. This study aims to investigate the effect of sleep quality on memory functions among middle-aged and older adults from a rural Indian population.

Methods: Participants were non-demented, rural Indians (≥45 years) from an ongoing, prospective, aging cohort study, namely Srinivaspura Aging, NeuroSenescence, and COGnition (SANSCOG) study. Cross-sectional (baseline) data on seven sleep dimensions was obtained using the Pittsburgh Sleep Quality Index (PSQI). Memory functions were assessed using immediate recall, delayed recall, name-face association, and semantic association from a culturally validated, computerized, neurocognitive test battery. Linear regression models, unadjusted and adjusted for cognitive status, age, sex, and depression were used to analyze the association between each sleep dimension and the memory tests.

Results: A total of 1195 participants, with a mean age of 57.10 years, were included. Out of the seven sleep dimensions of the PSQI, only two dimensions, namely sleep duration and sleep efficiency, were significantly associated with memory functions. In the fully adjusted model, shorter sleep duration was significantly associated with poorer performance in delayed recall, and lesser sleep efficiency was significantly associated with poorer delayed recall and semantic association performance.

Conclusions: Specific sleep characteristics appear to influence memory functions in aging Indians well before the onset of dementia. In the backdrop of the non-availability of a definitive treatment for dementia, promptly identifying and addressing these problems could be an effective, community-level strategy for preventing dementia.

Key words: sleep; memory; aging; rural India

Sleep is a normal, reversible, and recurring state of bodily rest characterized by suspended voluntary physical activity and an altered state of consciousness. Sleep is essential for physical and mental well-being. The complex neurophysiological processes during sleep are critical for learning, memory, thinking, and decision-making, thus making it crucial for healthy cognitive functioning.

Several mechanisms have been postulated for the impact of sleep on cognitive health, such as its role in neuronal development and connectivity, synaptic plasticity, memory consolidation, and neuroprotection [1–3]. Furthermore, it has also been demonstrated that poor quality of sleep adversely affects cognitive functions and accelerates cognitive decline among aging individuals, thus increasing the risk of dementia. In particular, the role of sleep in memory functions has been a topic of continued research interest in the last few decades [4, 5].

Accumulating evidence indicates that sleep plays a vital role in memory functions [6, 7]. Different mechanisms have been proposed to explain how sleep influences memory processes. Initial theories revolved around the passive role of sleep in enhancing memory, wherein sleep was thought to "protect" against forgetting by reducing the susceptibility to interference from retroactive stimuli [6]. More recently, the focus has shifted to the role played by sleep in memory consolidation [8], and the processes by which this happens are intricate [8, 9]. In the last few decades, a much better understanding has been gained of the underlying neurobiological, electrophysiological, and genetic mechanisms involved [10, 11].

Increasing age is accompanied by considerable changes in sleep patterns, such as decreased sleep duration, increased nighttime awakenings, altered circadian rhythm, decreased slow-wave sleep, and reduced sleep quality [12]. However, the nature and

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intensity of these changes are not uniform across all individuals [13]. Also, which of these sleep changes predispose aging individuals to cognitive disorders is unclear. The majority of previous studies have focused on sleep duration, revealing that changes in sleep duration could result in adverse changes in cognition [14–16]. Disturbed sleep is another dimension that has been related to cognitive impairment and increased dementia risk in several studies [17, 18]. The effects of other sleep characteristics, such as sleep latency, efficiency, and daytime dysfunction, have also been investigated [16]. Therefore, understanding which kind of sleep abnormalities play a key role in making the aging brain more vulnerable to developing dementia is crucial to developing appropriate preventive and management strategies for dementia.

Furthermore, at what stage during the aging process do sleep abnormalities confer maximal risk for cognitive impairment is essential to understand. There is considerable evidence available on the relationship between sleep problems and cognitive performance among those who have already developed some degree of clinical cognitive impairment (individuals with MCI and dementia). However, there is minimal evidence on the potential influence of sleep problems among cognitively healthy middle-aged and older adults.

Finally, the impact of sleep problems on the aging brain could be variable across different ethnic groups. Further, there is some evidence that cognitive impairment may manifest early in rural inhabitants, and there might be clinically significant changes in the development, course, and prognosis of cognitive impairment depending on where a person lives [19]. Hence, population-specific studies investigating the influence of sleep abnormalities on cognitive functioning are needed.

Additionally, the impact of sleep problems on cognitive functioning is likely to be varied across cognitive domains. As mentioned above, its influence on the memory domain has probably garnered the maximum focus since evidence from numerous molecular, animal, and human research has pointed to sleep's vital role in memory encoding and consolidation [6]. Furthermore, memory is the most commonly involved cognitive domain in most cognitive disorders, including dementia. However, the memory domain is also the most complex among all the cognitive domains. Assessment of memory functions is not straightforward and involves individual testing of multiple sub-domains. Prior studies investigating the impact of sleep on cognitive functioning have mainly used short screening tools to assess global cognition. In contrast, the association of multiple sleep characteristics with distinct sub-domains of memory has not been adequately explored.

In the above scenario, this study aims to examine the cross-sectional association between specific dimensions of sleep and different sub-domains of memory in a large sample of middle-aged and older adults from rural India, a population that has been, thus far, grossly underrepresented in this area of research. We have used a self-reported questionnaire, namely the Pittsburgh Sleep Quality Index (PSQI), to assess sleep quality across seven dimensions. Though the use of wearable biosensors has become common in recent research and can provide more accurate sleep measurements, since our rural cohort has limited access to modern technology such as smartphones and the internet, we have used a self-reported questionnaire to assess sleep quality.

Methods

Study design

The present study employed a cross-sectional design, using the baseline clinical assessment data from the SANSCOG cohort.

Study setting

This study was conducted in a rural community settled in the villages of Srinivaspura "taluk" (subdistrict) of Kolar district in Karnataka, India.

Recruitment

The parent study, SANSCOG, follows an area sampling strategy for recruiting participants from the above rural study site. The SANSCOG study has a dedicated recruitment team comprising trained social workers—field data collectors (FDCs), with a field data supervisor. This team is recruited locally so that they are well-versed in the local culture and language. They liaise with the relevant stakeholders in the public-funded rural healthcare system to build connections with the community. In particular, the team leverages the experience of the local community health activists, called ASHAs (accredited social health activists), who are an integral part of the rural public health system in India. Awareness about the study is given to the community, taking into confidence the leaders of the village administrative bodies. The field team then conducts home visits to register eligible and consenting participants. Further details on the SANSCOG study's protocol and recruitment strategies have been published separately [20, 21].

Study participants

The sample for the present study included 1195 SANSCOG cohort participants (females: 568; males: 627), who had undergone their baseline study assessments between January 2018 and October 2022. These participants mainly belong to a low socioeconomic status; they have minimal formal education and are primarily farmers.

Inclusion and Exclusion Criteria

Participants had to be 45 years and above, be residents of the SANSCOG study site (rural Srinivaspura) for at least five years, have finished their baseline study visit, and have complete data on social networking, memory assessments, and the covariates included in this analysis.

Individuals with dementia were excluded by active screening done pre-recruitment at the community level by the FDCs. Furthermore, any participants with a clinical diagnosis of dementia during the detailed clinical assessments were excluded. Similarly, those with severe medical illness or psychiatric disorders that could limit their study participation and those with significant hearing or vision impairment or locomotor disability that could interfere with their study evaluations were excluded.

Ethics and privacy

The SANSCOG study has obtained ethical clearance from the Institutional Human Ethics Committee of the Center for Brain Research, Indian Institute of Science. All participants provided voluntary, written informed consent for participation in the study, including specific consent for undergoing clinical and cognitive assessments.

Study assessments

The following assessment data were collected as part of this study.

(i) Sociodemographic details.

The following information was collected: age, sex, education (no. of formal years of education), occupation (categorized as

elementary occupations; clerks/skilled agricultural, crafts or service workers; technicians/associate professionals; professionals; and administrators/managers).

(iii) Sleep assessment.

The PSQI was administered by trained clinicians in the participants' local language. PSQI is a validated, self-report questionnaire that takes 5 to 10 minutes to complete and rates sleep quality over the last month [22]. It comprises 19 questions that are divided into seven dimensions, namely [1] subjective sleep quality [2], sleep latency [3], sleep duration [4], sleep efficiency [5], sleep disturbance [6], use of sleep medication, and [7] daytime dysfunction. Each sleep component is scored on a scale of 0 to 3: 0 for "not problematic," 1 for "somewhat problematic," 2 for "moderately problematic," and 3 for "highly problematic," as follows:

- The subjective sleep quality component is scored 0 (not problematic) if the participant answers "very good," 1 (somewhat problematic) for "fairly good," 2 (moderately problematic) for "fairly bad," and 3 (highly problematic) for "very bad."
- The sleep latency score is based on the time taken to fall asleep and the trouble falling asleep. The time taken to fall asleep is scored 0 if the duration is 15 minutes, 1 for 16–30 minutes, 2 for 31–60 minutes, and 3 for more than 60 minutes. The trouble falling asleep is scored 0 for "not during the past month," 1 for "less than once a week," 2 for "once or twice a week," and 3 for "three or more times a week." After that, the sum of the above two criteria is scored 0 (not problematic) if the sum is 0, 1 (somewhat problematic) if the sum is 1–2, 2 (moderately problematic) if the sum is 3–4, and 3 (highly problematic) if the sum is 5-6.
- In the sleep duration component, a duration of more than 7 hours is scored 0 (not problematic), 6–7 hours as 1 (somewhat problematic), 5–6 hours as 2 (moderately problematic), and less than 5 hours as 3 (highly problematic).
- The sleep efficiency score is calculated based on the proportion of hours of actual sleep to the number of hours spent in bed. The score is 0 (not problematic) if the efficiency is more than 85%, 1 (somewhat problematic) for 75%–84%, 2 (moderately problematic) for 65%–74%, and 3 (highly problematic) for less than 65%.
- For the sleep disturbance component, there are nine sub-questions related to the trouble sleeping, each of which is scored depending on the frequency of occurrence as 0 for "not during the past month," 1 for "less than once a week," 2 for "once or twice a week," and 3 for "three or more times a week." The final component score is calculated as 0 (not problematic) if the sum is 0, 1 (somewhat problematic) if the sum is 1–9, 2 (moderately problematic) if the sum is 10–18, and 3 (highly problematic) if the sum is 19–27.
- For the sleep medication component, the frequency of taking sleep medication is scored 0 (not problematic) for "not during the past month," 1 (somewhat problematic) for "less than once a week," 2 (moderately problematic) for "once or twice a week," and 3 (highly problematic) for "three or more times a week."
- In the daytime dysfunction component, the scoring is based on the severity of the problem in staying awake and the duration of the problem. For the severity, the scoring is 0 for "no problem at all," 1 for "only a very slight problem," 2 for "somewhat of a problem," and 3 for "a very big problem." For the duration, the scoring is 0 for "not during the past month," 1 for "less than once a week," 2 for "once or twice a week," and 3 for "three or more times a week." After that, the sum of the above two criteria is scored 0 (not problematic) if the sum is 0, 1 (somewhat problematic) if the sum is 1–2, 2 (moderately problematic) if the sum is 3–4, and 3 (highly problematic) if the sum is 5–6.

(iv) Memory assessment.

Memory functions were examined using immediate recall, delayed recall, name-face association, and semantic association subtests from a culturally validated, computerized, neurocognitive test battery, COGNITO (Computerized assessment of adult information processing) [23]. In the immediate recall test, the participant is shown a list of names, each displayed for 3 seconds, and immediately asked to recall the names. Subsequently, for the delayed recall test, the participant must recall those names learned previously after a specified period. The name-face association test starts with a face recall trial (no result is recorded for this trial), where nine names given in the previous test are presented with nine corresponding faces, and the participant is asked to remember the face and the name associated with it. Later, the participant is shown a series of 18 faces, of which nine were previously associated with names (in the face recall trial). Then, the participant has to decide whether the face appeared before or not. The number of correctly recognized faces is the score for the name-face association test (faces subtest), whereas the number of correctly recognized names is the score for the name-face association (names subtest). In the semantic association test, the participant has to name an object that appears on the screen; subsequently, four other objects are shown, and the participant has to choose the one that is related to the first presented object. For all the above tests, the number of correct responses is considered for scoring. Since COGNITO has been specifically adapted to the Indian sociocultural milieu and local language, this made it feasible for use in our rural participants with low literacy levels [24].

Covariates

In addition to age, sex, and education, the following covariates were considered.

Cognitive status

The Clinical Dementia Rating (CDR) instrument was used to classify individuals into two groups based on their cognitive status: 1) cognitively normal and 2) mild cognitive impairment (MCI). CDR is an extensively validated scale that assesses a person in six cognitive and functional domains: memory, orientation, judgment and problem-solving, community affairs, home and hobbies, and personal care. The overall CDR score is calculated using a predetermined algorithm, and an overall score of "0" is interpreted as cognitively normal, while a score of "0.5" is categorized as MCI [25].

Depression

Depression was diagnosed using the 30-item Geriatric Depression Scale (GDS-30). This is a well-validated self-report questionnaire that was specifically developed to screen for depression among older adults [26]. It comprises thirty questions that must answered as "yes" or "no," and the maximum score that can be obtained is 30. A score of 10 or more indicates a diagnosis of depression.

Statistical analyses

Descriptive analyses were used for the sociodemographic variables. Categorical and continuous variables were expressed as frequencies (%) and means with standard deviations (SD), respectively. Linear regression models were used to analyze the effect of the seven sleep dimensions on each of the memory subtests. Model 1 was unadjusted, whereas model 2 was adjusted for cognitive status. Models 3, 4, and 5 were further adjusted for age, sex, and depression, respectively. All statistical analyses were conducted using the IBM SPSS Version 25 [27].

Results

The sociodemographic and clinical characteristics of the study sample are displayed in Table 1. The mean age of the sample was 57.10 ± 8.87 years, and the sex distribution was 52.5% males and 47.5% females. The relative frequencies of responses ("not problematic," "somewhat problematic," "moderately problematic," and "highly problematic") to each of the seven dimensions of sleep quality are shown in Figure 1.

Association between sleep dimensions and memory

Out of the seven sleep dimensions in the PSQI, only two dimensions, namely sleep duration and sleep efficiency, were significantly associated with memory functions.

Sleep duration.

In the unadjusted model 1, shorter sleep duration was significantly associated with poorer performance in delayed recall (β = –0.271, p = .001) and name-face association-names(β = –0.181, p = .017). In model 2 (after adjusting for cognitive status), the significance persisted for delayed recall (β = –0.270, p = .001) and name-face association-names (β = –0.175, p = .020). However, in model 3 (after adjusting for cognitive status and age), shorter sleep duration was significantly associated with poorer performance only for delayed recall (β = –0.218, p = .002). In model 4 (after adding sex as a covariate), the above association remained significant for delayed recall (β = –0.218, p = .002). Finally, in the fully adjusted model 5 (model 4 + depression), shorter sleep duration was still significantly associated with poorer performance in delayed recall (β = –0.214, p = .003).

When we plotted the mean score of each of the memory domains against five categories of sleep duration: <5, 5 to <6, 6 to <7, 7 to <8, 8 to <9, ≥9 hours, we observed an inverted U-shaped pattern for delayed recall, immediate recall, semantic association, and name-face association (names and faces), as depicted in Figure 2.

Table 1. Sociodemographic Characteristics of the Study Participants

Characteristics	Mean
Age (years)	57.10 ± 8.87
Sex	
Female	568 (47.5%)
Male	627 (52.5%)
Education	5.68 ± 4.82
Occupation	
Elementary occupations	252
Clerks/skilled agricultural, crafts, or service workers	867
Technicians and associate professionals	41
Professionals	33
Administrators/Managers	2
PSQI	
Total	7.58 ± 2.48
Female	7.65 ± 2.53
Male	7.51 ± 2.43
Cognitive status	
Cognitively Normal	1110
MCI	85
Depression	
Normal	1021
Depressed	174

Sleep efficiency.

In model 1, lower sleep efficiency was significantly associated with poorer performance in delayed recall (β = –0.238, p = 0.003), name-face association-names (β = –0.161, p = 0.039), and semantic association (β = –0.214, p = 0.003). In model 2, the significance persisted for the above three memory subtests: delayed recall (β = –0.248, p = .001), name-face association-names (β = –0.163, p = .035), and semantic association (β = –0.178, p = .025). In model 3, the significance persisted only for delayed recall (β = –0.201, p = .002) and semantic association (β=–0.152, p = .001). In model 4, the significance remained for delayed recall (β = –0.20, p = .006) and semantic association (β = –0.132, p = .002). Finally, in the fully adjusted model 5, lower sleep efficiency was still significantly associated with poorer performance in delayed recall (β = –0.197, p = .008) and semantic association (β = –0.128, p = .004) (Table 2 and Figure 3).

Discussion

This study aimed to understand the impact of sleep quality on memory functions in a large sample of non-demented, middle-aged and older rural-dwelling Indians. Our findings revealed that after accounting for potential confounders, shorter sleep duration and lesser sleep efficiency were associated with poorer performance in distinct memory subtests.

Our findings align with previous population-based studies among aging individuals, which show that only certain aspects of sleep are associated with poorer cognitive performance. A study among healthy older adults, which used the PSQI, found that only sleep latency and sleep efficiency were correlated with cognitive performance; the other components, including sleep duration, did not show any significant associations [28]. Cross-sectional analysis of data from a sizeable aging cohort study on Chinese adults aged 55 years and above (Guangzhou Biobank Cohort Study) showed that participants with poorer sleep efficiency had poorer memory performance, though this relationship was not observed with the global PSQI score [29]. Findings from the Singapore Longitudinal Aging Study showed that early morning awakening was associated with decreased performance in distinct cognitive domains [30]. However, the other dimensions of sleep assessed in the above study, namely difficulty initiating sleep and difficulty maintaining sleep, did not show significant associations with any cognitive domain. Another study on non-demented older individuals

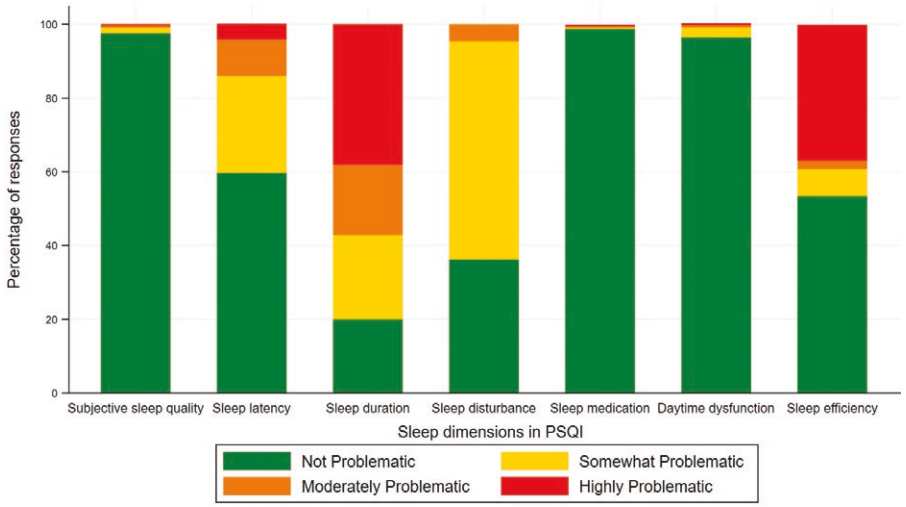

Figure 1. This figure displays the relative frequencies of responses to each of the seven dimensions of sleep in the Pittsburgh Sleep Quality Questionnaire (PSQI). The responses are categorized as (1) Not problematic, (2) Somewhat problematic, (3) Moderately problematic, and (4) Highly problematic.

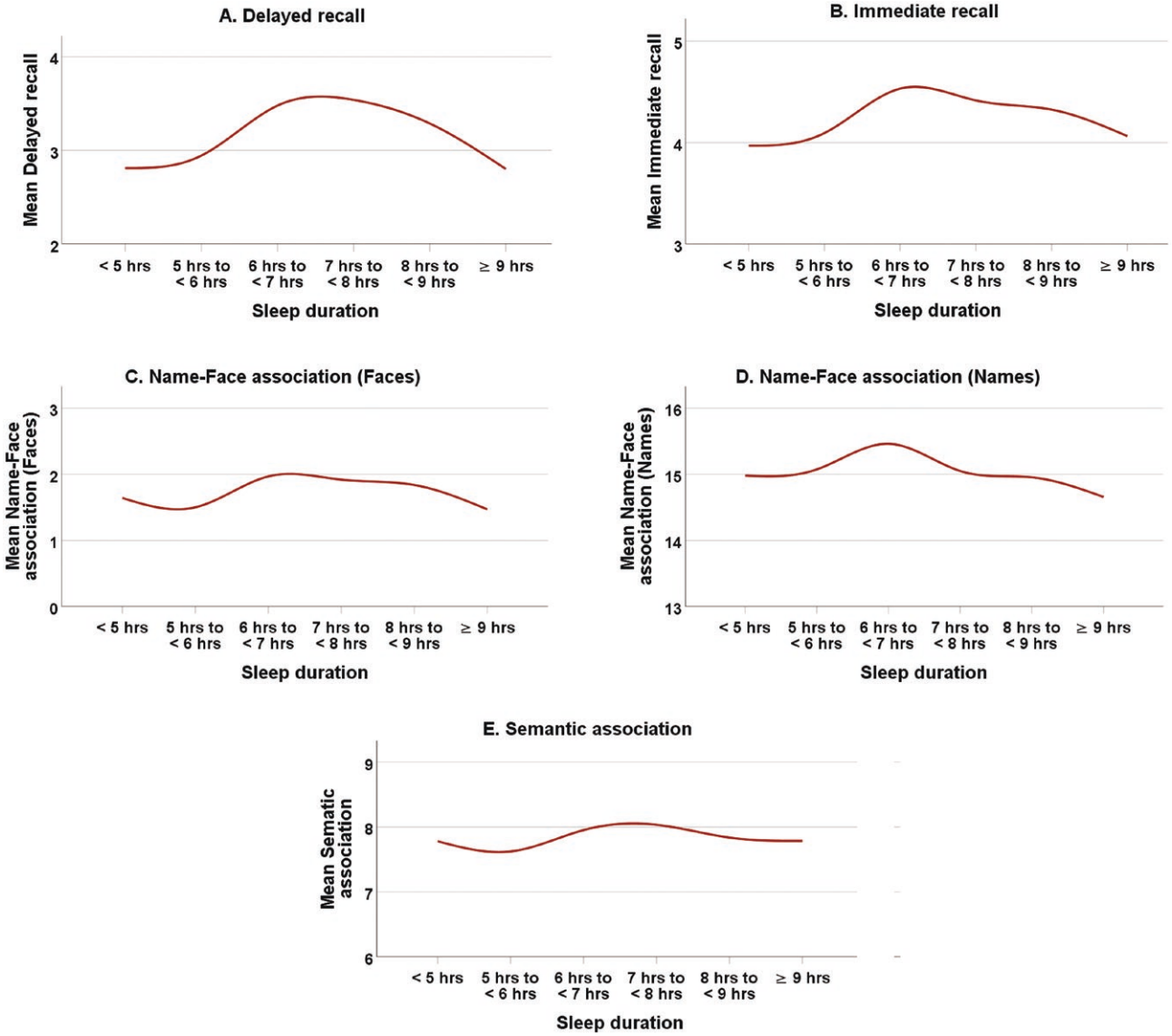

Figure 2. This figure depicts the relationship between sleep duration and the mean scores in the memory subtests, namely (A) Immediate recall, (B) Delayed recall, (C) Name-Face association-Names, (D) Name-Face association-Faces, and (E) Semantic Association.

Table 2. Association between sleep dimensions on the Pittsburgh Sleep Quality Index (PSQI) and memory tests adjusted for cognitive status, age, sex, and depression (shown as standardized β Values)

	Immediate recall	Delayed recall	Name-face association- names	Name- face association-faces	Semantic association
Model 1: Unadjusted model					
Subjective sleep quality	0.011	0.049	0.004	0.054	−0.031
Sleep latency	−0.047	−0.039	−0.026	−0.015	−0.02
Sleep duration	−0.148	−0.271*	−0.181*	−0.056	−0.142
Sleep disturbance	0.005	−0.002	−0.041	−0.046	−0.045
Sleep medication	0.012	−0.025	−0.009	−0.007	−0.033
Daytime dysfunction	−0.093	−0.017	−0.032	−0.017	−0.003
Sleep efficiency	−0.142	−0.238*	−0.161*	−0.036	−0.17*
Model 2: Adjusted for cognitive status					
Subjective sleep quality	0.013	0.04	−0.002	0.050	−0.046
Sleep latency	−0.041	−0.032	−0.022	−0.012	−0.017
Sleep duration	−0.143	−0.270*	−0.175*	−0.052	−0.14
Sleep disturbance	0.031	0.021	−0.023	−0.034	−0.023
Sleep medication	0.006	−0.031	−0.013	−0.010	−0.038
Daytime dysfunction	−0.065	0.009	−0.014	−0.004	0.024
Sleep efficiency	−0.15	−0.248*	−0.163*	−0.038	−0.178*
Model 3: Adjusted for age and cognitive status					
Subjective sleep quality	0.013	0.052	0.007	0.060	−0.049
Sleep latency	−0.027	−0.013	−0.008	0.004	−0.004
Sleep duration	−0.102	−0.218*	−0.136	−0.0008	−0.111
Sleep disturbance	0.036	0.024	−0.019	−0.029	−0.018
Sleep Medication	0.011	−0.025	−0.009	−0.005	−0.034
Daytime dysfunction	−0.078	−0.006	−0.026	−0.018	0.02
Sleep efficiency	−0.112	−0.201*	−0.127	0.002	−0.152*
Model 4: Adjusted for sex, age, and cognitive status					
Subjective sleep quality	0.014	0.052	0.009	0.061	−0.041
Sleep latency	−0.024	−0.012	−0.002	0.007	0.021
Sleep duration	−0.101	−0.218*	−0.135	−0.008	−0.105
Sleep disturbance	0.037	0.024	−0.015	−0.027	−0.003
Sleep medication	0.011	−0.025	−0.009	−0.005	−0.034
Daytime dysfunction	−0.079	−0.007	−0.029	−0.019	0.008
Sleep efficiency	−0.11	−0.2*	−0.123	0. 004	−0.132*
Model 5: Adjusted for depression, sex, age, and cognitive status					
Subjective sleep quality	0.015	0.052	0.010	0.062	−0.041
Sleep latency	−0.014	−0.01	0.008	0.017	0.023
Sleep duration	−0.078	−0.214*	−0.111	0.016	−0.10
Sleep disturbance	0.045	0.025	−0.007	−0.019	−0.001
Sleep medication	0.012	−0.025	−0.008	−0.004	−0.033
Daytime dysfunction	−0.079	−0.007	−0.029	−0.019	0.008
Sleep efficiency	−0.091	−0.197*	−0.103	0.024	−0.128*

*$p < .05$.

examining the association of sleep parameters measured using wrist actigraphy and cognitive performance revealed that lower sleep efficiency, higher sleep latency, and higher wake after sleep onset were associated with cognitive impairment. However, such an association was not observed with sleep duration [31]. Some prior studies have reported an inverted U-shaped association between sleep duration and cognitive outcomes [15]. In our research, when we categorized sleep duration into <5, 5 to <6, 6 to <7, 7 to <8, 8 to <9, and ≥9 hours, we also observed the inverted U-shaped pattern for some of the memory subtests.

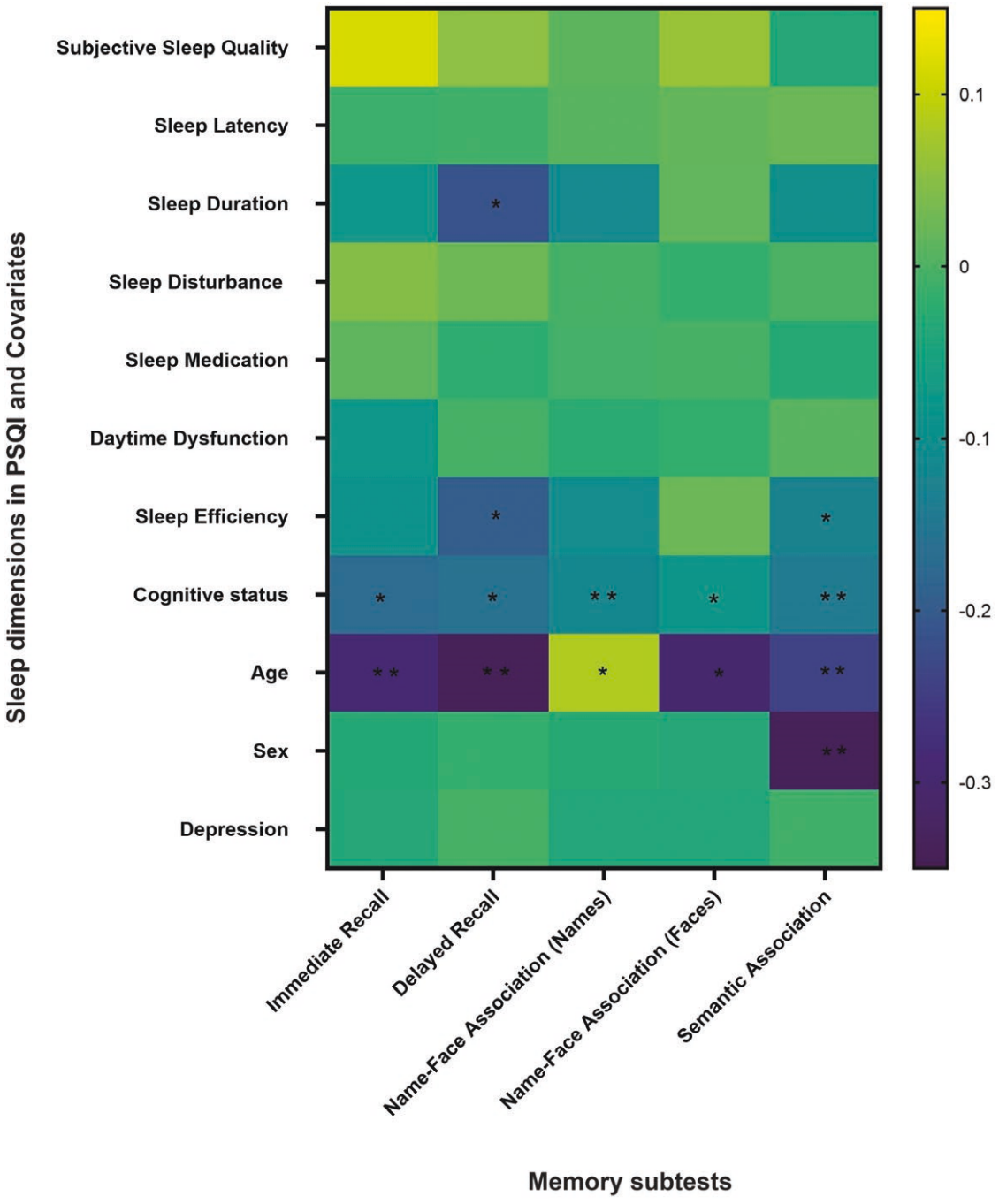

Figure 3. This figure is a heat map of the coefficients of regression between the seven dimensions of sleep assessed in the Pittsburgh Sleep Quality Index (PSQI) and the memory subtests, adjusted for cognitive status, age, sex, and depression $^{*}p < .05$, $^{**}p < .001$.

Existing literature also reveals that the impact of poor sleep on cognitive performance is heterogeneous with respect to which cognitive domains are involved [4], but several studies have shown that the memory domain is one of the key domains that is impacted [5, 29, 32, 33]. However, there have also been contradictory findings from a few other studies. A cross-sectional analysis of the UK Biobank data demonstrated that after adjustment for potential confounding variables, participants with frequent insomnia symptoms had significantly better cognitive performance than participants without these symptoms; the authors commented that the statistical significance was small and may not be clinically meaningful [34].

The strengths of our study include a large, community-based sample of rural Indians, on whom this topic has been grossly understudied. We have also used a well-validated, widely used sleep assessment questionnaire and multiple subtests to assess the memory domain. Limitations of our study include the cross-sectional design, in which causal effects cannot be established. Another major limitation of our study was that we used a single self-report questionnaire to assess sleep quality. In an era where objective sleep measurements with wearable devices such as wrist actigraphs, smart rings, or ambulatory EEG headbands are used widely, questionnaire-based assessments carry the drawbacks of multiple biases. Prior studies utilizing self-report

measures for sleep have used a set of questionnaires to improve reliability, but we have used a single questionnaire, implying that our findings need to be interpreted with caution.

The translational implications of our study are that sleep abnormalities among aging individuals must be checked explicitly and diagnosed promptly. Specifically, our study demonstrates that sleep problems are related to memory impairments in aging Indians well before the onset of dementia. Furthermore, our findings in the relationship between individuals' sleep components and memory subtests remained significant after adjusting for age, sex, education, depression, and cognitive status as covariates. Thus, improving sleep quality with respect to duration and efficiency may improve memory functions, regardless of the above factors. Prior evidence from longitudinal studies has revealed that sleep abnormalities occurring in midlife are associated with a greater risk of incident dementia in later life [35, 36]. Worsening of self-reported sleep quality has been found to be correlated with increased levels of cerebrospinal fluid biomarkers for Alzheimer's disease pathology [37]. In the backdrop of the non-availability of a definitive treatment for dementia, promptly identifying and targeting potentially modifiable lifestyle-related risk factors, such as sleep problems, could be an effective, community-level strategy for preventing dementia.

A recent meta-analysis suggested that sleep problems could account for 15% of the population's attributable risk for dementia. Our study findings add strength to such emerging evidence that poor sleep could be an important modifiable risk factor for dementia. We propose to follow up our study participants periodically over the coming years to determine if those with abnormal sleep parameters develop faster memory decline than those without. We also highlight the need for interventional studies among older adults with sleep problems to check if prompt interventions to enhance sleep health could improve cognitive performance or prevent cognitive decline.

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Disclosure Statement

All authors declare no conflict of interest.

Author Contributions

Pooja Rai (Conceptualization [equal], Data curation [equal], Formal analysis [equal], Methodology [equal], Visualization [equal], Writing—original draft [equal]), and Jonas Sundarakumar (Conceptualization [equal], Project administration [equal], Resources [equal], Software [equal], Supervision [equal], Validation [equal], Writing—review & editing [equal]).

Data Availability

The data supporting the findings of this study can be made available upon reasonable request to the corresponding author, in accordance with the Centre for Brain Research's data sharing policy and the statutory requirements of the Government of India.

Ethics Approval

The Institutional Human Ethics Committee of the Centre for Brain Research, Indian Insitute of Science has approved the study. Voluntary informed consent was obtained in writing from each participant before enrollment in the study. All investigators and research staff adhered to the guidelines laid down by the Declaration of Helsinki.

Informed Consent

Consent for publication (Authors): All authors approved and consented to the final version of the manuscript for publication. All authors had full access to the study's data and take responsibility for data integrity and accuracy of data analysis. *Consent for publication (Participants):* not applicable.

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