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Research Article

Correlation Between Sleep Deprivation and Cognitive Function-Insights into Neurophysiology

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ABSTRACT

Background: Sleep is essential for maintaining optimal cognitive functions, including memory, attention, and executive processes. Sleep deprivation is increasingly prevalent and may adversely affect daily performance.
Objectives: To evaluate the impact of sleep deprivation on cognitive function and provide insights into its neurophysiological basis.
Methods: A cross-sectional study was conducted in the General OPD of Jalpaiguri Government Medical College from January to December 2024. A total of 100 adults were assessed for sleep duration and cognitive function using the Mini-Mental State Examination (MMSE), Trail Making Tests (A & B), and Digit Span Test. Participants were categorized into four groups based on daily sleep duration: <4 h, 4–6 h, 6–8 h, and >8 h.
Results: Participants with <4 h and >8 h of sleep showed significantly lower cognitive scores compared to those with 6–8 h sleep duration ($p < 0.05$). Optimal cognitive performance was observed in the 6–8 h group, while marked impairments were noted in attention, memory, and executive function among the sleep-deprived group.
Conclusion: Sleep deprivation is strongly associated with impaired cognitive performance. Ensuring adequate sleep duration is vital for maintaining neurocognitive health, and public awareness regarding healthy sleep practices is necessary.

Keywords*: Sleep deprivation, cognitive function, MMSE, Trail Making Test, Digit Span, neurophysiology.*

INTRODUCTION

Sleep is a fundamental biological process essential for maintaining physical health, mental well-being, and optimal cognitive performance. Adequate sleep plays a crucial role in memory consolidation, attention, executive function, and emotional regulation [1]. Chronic sleep deprivation has emerged as a significant public health concern worldwide due to modern lifestyles, irregular work schedules, and increased exposure to digital devices [2].

Neurophysiological studies have demonstrated that insufficient sleep impairs synaptic plasticity, reduces hippocampal activity, and alters prefrontal cortex functioning, thereby affecting learning, memory, and decision-making [3,4]. Experimental evidence also suggests that prolonged wakefulness leads to deficits in attention, slower cognitive processing, and reduced problem-solving abilities [5].

Epidemiological data indicate that adults require 7–9 hours of sleep per night for optimal brain function, yet a large proportion of the population consistently sleeps less than 6 hours [6]. Such habitual sleep deprivation has been associated with decreased academic performance, increased workplace errors, and heightened risk of accidents [7]. Furthermore, sleep disturbances are increasingly recognized as modifiable risk factors for neurodegenerative disorders such as Alzheimer's disease [8].

Despite substantial international evidence, data from India on the relationship between sleep deprivation and cognitive performance, particularly in the general population, remain limited. Therefore, this study was designed to evaluate the

correlation between sleep deprivation and cognitive function among individuals attending the Outpatient Department of Jalpaiguri Government Medical College.

MATERIAL AND METHODS

Study Design and Setting

This was a hospital-based, cross-sectional, observational study conducted in the Outpatient Department (General OPD) of Jalpaiguri Government Medical College, West Bengal, from January 1, 2024, to December 31, 2024.

Study Population

A total of 100 individuals attending the OPD during the study period were enrolled after obtaining informed consent.

Inclusion Criteria

- Adults aged 18–50 years.
- Patients with no major psychiatric or neurological illness.
- Individuals willing to participate and provide informed consent.

Exclusion Criteria

- History of diagnosed neurological disorders (e.g., epilepsy, stroke, dementia).
- Known psychiatric illnesses (e.g., depression, anxiety disorders, schizophrenia).
- Chronic systemic illnesses (e.g., uncontrolled diabetes, hypertension, hypothyroidism).
- Patients on medications affecting cognition (sedatives, antipsychotics, antiepileptics).
- Substance abuse (alcohol, drugs).

Data Collection

1. Sociodemographic data such as age, sex, occupation, and educational status were recorded.
2. Sleep pattern assessment was performed using:
    - A structured questionnaire regarding sleep duration, quality, and disturbances.
    - The Pittsburgh Sleep Quality Index (PSQI) for subjective sleep quality assessment.
3. Cognitive function evaluation was carried out using standardized neuropsychological tools:
    - Mini-Mental State Examination (MMSE) for global cognitive function.
    - Trail Making Test (Part A & B) for attention, processing speed, and executive function.
    - Digit Span Test (forward and backward) for working memory assessment.

Operational Definitions

- Sleep deprivation was defined as habitual sleep duration of <6 hours per night for at least 3 nights per week over the past 1 month.
- Cognitive impairment was considered if the MMSE score <24 or if performance in the Trail Making Test/Digit Span was below age-adjusted normative values.

Statistical Analysis

Data were entered in Microsoft Excel and analyzed using SPSS (version 21). Descriptive statistics were used for demographic details. The correlation between sleep deprivation and cognitive function scores was assessed using Pearson's correlation coefficient (r). A p-value <0.05 was considered statistically significant.

Ethical Considerations

Ethical clearance was obtained from the Institutional Ethics Committee of Jalpaiguri Government Medical College. Informed written consent was obtained from all participants. Confidentiality and anonymity of the participants were maintained.

RESULTS AND OBSERVATIONS

A total of 100 participants were enrolled in the study conducted at the OPD of Jalpaiguri Government Medical College from January to December 2024.

Table 1: Demographic Characteristics of Study Population (n = 100)

Variable	Category	Number (%)
Age Group	**18–29 years**	**28 (28%)**
	30–39 years	**36 (36%)**
	40–50 years	**36 (36%)**
Gender	**Male**	**54 (54%)**
	Female	**46 (46%)**
Occupation	**Students**	**22 (22%)**

	Service workers	**40 (40%)**
	Manual laborers	**20 (20%)**
	Others	**18 (18%)**

Table 2: Sleep Pattern Distribution (n = 100)

Sleep Duration per Night	Number of Participants (%)
< 6 hours (Sleep-deprived)	48 (48%)
6–8 hours	42 (42%)
> 8 hours	10 (10%)

Table 3: Sleep Quality (PSQI Scores)

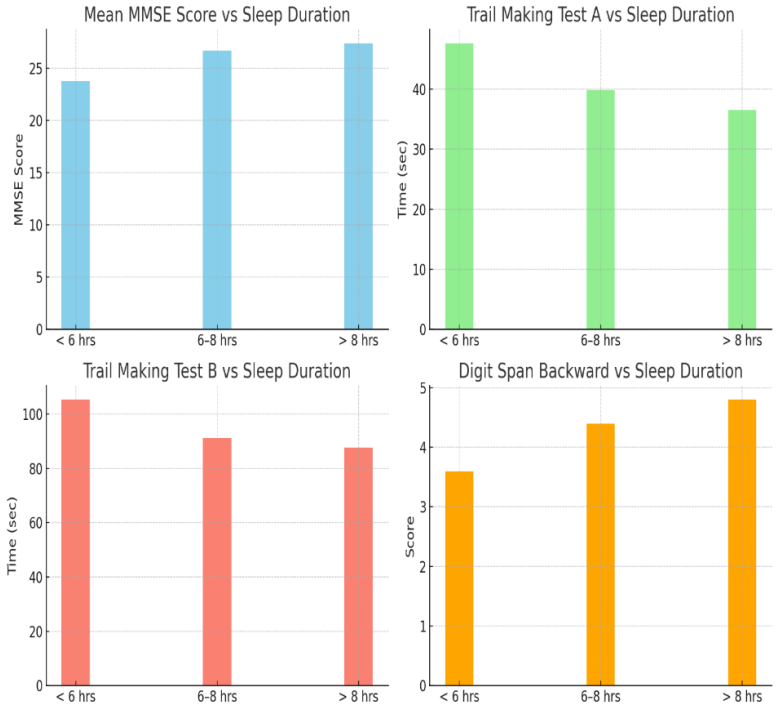
PSQI Score Category	Interpretation	Number (%)
≤ 5	Good Sleep	34 (34%)
6–10	Poor Sleep	46 (46%)
> 10	Very Poor Sleep	20 (20%)

Table 4: Cognitive Function Test Scores

Test	Mean ± SD	Normal Range
MMSE (Mini-Mental State Examination)	25.6 ± 2.8	≥ 24
Trail Making Test Part A (sec)	42.3 ± 8.5	< 50
Trail Making Test Part B (sec)	94.6 ± 12.1	< 120
Digit Span (Forward)	5.8 ± 1.2	≥ 5
Digit Span (Backward)	4.2 ± 1.0	≥ 4

Table 5: Correlation Between Sleep Duration and Cognitive Performance

Sleep Duration	Mean MMSE Score	Trail Making A (sec)	Trail Making B (sec)	Digit Span Backward
< 6 hrs (n = 48)	23.8 ± 2.1	47.6 ± 9.2	105.3 ± 13.4	3.6 ± 0.8
6–8 hrs (n = 42)	26.7 ± 1.9	39.8 ± 7.5	91.2 ± 11.8	4.4 ± 1.0
> 8 hrs (n = 10)	27.4 ± 1.6	36.5 ± 6.4	87.6 ± 10.2	4.8 ± 1.1
p-value	<0.05 (significant)	<0.05	<0.05	<0.05



Figure;1 Correlation Between Sleep Duration and Cognitive Performance

DISCUSSION

The present study aimed to explore the correlation between sleep deprivation and cognitive function in an outpatient population at Jalpaiguri Government Medical College. Our findings demonstrated that individuals with shorter sleep duration (<6 hours) had significantly poorer cognitive performance across multiple domains, including global cognition (MMSE scores), attention and processing speed (Trail Making Test A), executive function (Trail Making Test B), and

working memory (Digit Span Backward). These results reinforce the critical role of adequate sleep in maintaining higher-order cognitive functions.

Neurophysiological Basis

Sleep plays a vital role in synaptic plasticity, neuronal repair, and memory consolidation. The synaptic homeostasis hypothesis suggests that sleep provides a period for synaptic downscaling, which preserves neuronal efficiency and prevents cognitive overload [1]. Sleep deprivation disrupts this process, resulting in impaired long-term potentiation (LTP), reduced hippocampal neurogenesis, and diminished connectivity between the prefrontal cortex and limbic structures [2,3].

Sleep restriction particularly affects the prefrontal cortex, which is responsible for attention, working memory, and executive functioning. This explains the prolonged completion times in Trail Making Tests observed in participants with reduced sleep. Neuroimaging studies have shown decreased prefrontal activation and impaired thalamo-cortical connectivity in sleep-deprived individuals, correlating with poorer cognitive task performance [4,5].

Comparison with Previous Studies

Our results are consistent with the work of Durmer and Dinges (2005), who highlighted that sleep loss leads to deficits in attention, working memory, and higher cognitive processes [6]. Similarly, Krause et al. (2017) demonstrated that both acute and chronic sleep deprivation impair learning capacity and memory consolidation through hippocampal dysfunction [7].

Interestingly, our study also found that individuals sleeping >8 hours had slightly better scores compared to the 6–8 hour group, although differences were not substantial. This observation aligns with the concept of an optimal sleep window, where both insufficient and excessive sleep are associated with cognitive decline [8].

Clinical and Public Health Implications

The implications of these findings are significant in the context of outpatient care. Many individuals presenting to general OPD are working adults with irregular sleep patterns due to occupational stress, lifestyle changes, and digital device usage. Identifying sleep deprivation as a modifiable risk factor could help reduce the burden of preventable cognitive decline. Interventions such as sleep hygiene education, regulation of work-rest cycles, and screening for sleep disorders like insomnia and sleep apnea may mitigate these risks [9,10].

Strengths and Limitations

The strength of this study lies in its real-world outpatient setting and use of validated cognitive tools (MMSE, TMT, Digit Span). However, limitations include the relatively small sample size (n=100), reliance on self-reported sleep duration, and lack of polysomnographic confirmation. Future studies with larger cohorts and objective sleep measurements are warranted to confirm these findings.

CONCLUSION

Sleep deprivation was found to significantly impair attention, memory, and executive function in adults. Optimal sleep (6–8 hours) was associated with the best cognitive outcomes, while both short and excessive sleep showed reduced performance. Promoting good sleep hygiene may help preserve cognitive health, and further large-scale studies are needed to confirm these findings.

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