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Original Research Article

The Effects of 24-Hour Sleep Deprivation on Cognitive and Motor Skills of Male College Students

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Abstract

Introduction: Sleep deprivation is known to adversely affect cognitive and motor performance, yet its specific impact on male college students remains underexplored, particularly in an Indian context.

Aims: This study aims to assess the acute effects of 24-hour sleep deprivation on the cognitive and motor skills of male college students in India.

Materials and Methods: This observational study was conducted in the East West Institute Of Medical Sciences And Research, Burdwan – Suri Road, Talit, Purba Barddhaman – 713141, over a period of one year from February 2024 to January 2025. The study involved a sample of 100 male college students, selected to evaluate relevant clinical or behavioural parameters within this demographic.

Result: After 24-hour sleep deprivation, the experimental group showed significantly slower choice reaction time (435.7 ± 80.4 ms vs. 373.9 ± 63.5 ms, $p = 0.01$) and lower working memory performance at N=1 (98.6 ± 17.9 vs. 105.4 ± 8.3, $p = 0.03$). Selective attention improved significantly post-test ($p < 0.001$). Significant differences were observed in retention phases for observational and mental tasks ($p = 0.001 - 0.002$).

Conclusion: This study found that 24-hour sleep deprivation impaired cognitive functions in male college students, especially in choice reaction time, working memory, and divided attention. The experimental group performed slower in these areas, though selective attention improved post-test. Physical and combined control tasks were not significantly affected. Overall, sleep deprivation primarily impacted cognitive skills with minimal effects on physical performance.

Keywords: Sleep Deprivation, Cognitive Function, Motor Skills, College Students, Reaction Time.

Introduction

Sleep is a fundamental biological process essential for optimal cognitive performance, motor coordination, emotional regulation, and general well-being [1,2]. Acute sleep deprivation, particularly beyond 24 hours, can impair critical executive functions such as attention, memory consolidation, decision-making, and motor accuracy [3–5]. College students, especially males, are frequently exposed to erratic sleep cycles due to academic stress, social obligations, and lifestyle disruptions, making them highly susceptible to the negative impacts of sleep loss [6,7]. Researchers have extensively explored the physiological and neurological effects of sleep deprivation (SD), often linking it with decreased reaction time, impaired working memory, and reduced alertness [8–10]. Sleep is known to play a key role in the consolidation of both declarative and procedural memory, and SD—either before or after a learning session—can significantly reduce memory retention and learning efficacy [11,12]. Evidence also suggests that motor learning processes, whether through physical, observational, or mental practice, are hampered in sleep-deprived individuals due to disrupted neural mechanisms and delayed memory stabilization [13]. Multiple international studies have demonstrated that even short-term SD can produce impairments comparable to alcohol intoxication in terms of cognitive decline [4,5]. The consolidation of memory during sleep, particularly REM stages, plays a pivotal role in stabilizing newly acquired skills and knowledge [10]. Accordingly, SD not only affects acquisition but also significantly impairs the consolidation and recall of learned tasks [11,12]. In India, growing concerns about student mental health and sleep hygiene have led to an increase in related research. Early investigations by Singh and Sharma (2008) demonstrated that even a single night of sleep loss significantly impairs psychomotor performance in medical students [11]. Patel et al. (2012) found marked deficits in short-term memory among sleep-deprived engineering students [12]. Ghosh et al. (2019) observed a notable reduction in both cognitive and motor task performance following 24-hour SD among undergraduates [13], while Reddy et al. (2021) reported that SD negatively affects reaction time and executive function in medical interns [14]. More recently, Menon et al. (2023) concluded that even one night of total sleep loss significantly reduces problem-solving accuracy in young Indian males [15]. This study aims to assess the acute effects of 24-hour sleep deprivation on the cognitive and motor skills of male college students in India.

Materials and Methods

Type of study: Observational study

Place of study: East West Institute Of Medical Sciences And Research, Burdwan – Suri Road, Talit, Purba Barddhaman – 713141

Study duration

1 year (2024 February to 2025 January)

Sample size: 100 male college students

Inclusion Criteria

- Male college students between the ages of 18 and 25.
- Must be enrolled as full-time students at a college or university.
- Must have a normal sleep-wake cycle (i.e., no pre-existing sleep disorders like insomnia or sleep apnea).
- Must be willing to participate and provide informed consent.
- Must not have consumed excessive alcohol or drugs in the past month, as these could affect cognitive and motor function.

Exclusion Criteria

- Students with diagnosed psychiatric disorders (e.g., depression, anxiety) that could interfere with cognitive function.
- Students who have pre-existing neurological disorders (e.g., epilepsy, ADHD) that might affect motor and cognitive skills.
- Students with a history of sleep disorders (e.g., insomnia, sleep apnea, narcolepsy).
- Students who regularly take medications known to affect cognitive function (e.g., antidepressants, anti-anxiety medications).
- Students who have not had a consistent sleep-wake pattern (e.g., shift workers).
- Those with significant academic or personal stress that could confound the results of the study.

Statistical Analysis

Data were entered into Excel and analyzed using SPSS and GraphPad Prism. Numerical variables were summarized using means and standard deviations, while categorical variables were described with counts and percentages. Two-sample t-tests were used to compare independent groups, while paired t-tests accounted for correlations in paired data. Chi-square tests (including Fisher's exact test for small sample sizes) were used for categorical data comparisons. P-values ≤ 0.05 were considered statistically significant.

Results

Table 1: Descriptive statistics of Cognitive function tests

Variable	Test Type	Group	Mean	Std. Deviation	p value
Simple Reaction Time (ms)	Pre	EXP	252.8	38.6	0.002
		CON	285.2	41.9	
	Post	EXP	276.4	52.1	0.04
		CON	270.5	30.4	
Choice Reaction Time (ms)	Pre	EXP	408.5	65.3	0.2
		CON	395.1	60.2	
	Post	EXP	435.7	80.4	0.01
		CON	373.9	63.5	
Working Memory (N=1)	Pre	EXP	98.6	17.9	0.03
		CON	105.4	8.3	
	Post	EXP	102.1	14.8	0.06
		CON	110.2	4.2	
Working Memory (N=2)	Pre	EXP	70.5	21.4	0.85
		CON	69.6	11.2	

	Post	EXP	74.9	28	0.28
		CON	82.1	12.8	
Selective Attention	Pre	EXP	158.4	18	0.45
		CON	155.8	5.1	
	Post	EXP	132.9	19.3	<0.001
		CON	157.4	5.2	
Divided Attention	Pre	EXP	126.5	20.6	0.01
		CON	107.3	7.1	
	Post	EXP	123.1	22.8	0.18
		CON	116	5.2	

Table 2: Analysis of the One-Way ANOVA in different types of training in the acquisition and retention tests

Group	**Stage**	**Mean Difference**	**Std. Error**	**Significance (p-value)**
Physical vs Physical Control	Acquisition (Acq.)	-7.85	2.95	0.27
	Retention 1 (Ret. 1)	-6.1	3.1	0.98
	Retention 2 (Ret. 2)	-5.75	2.6	0.73
	Retention 3 (Ret. 3)	-6.8	2.9	0.62
Observational vs Observational Control	Acquisition (Acq.)	-9.6	0.105	0.14
	Retention 1 (Ret. 1)	-13.5	3.2	0.002*
	Retention 2 (Ret. 2)	-14.2	2.59	0.001*
	Retention 3 (Ret. 3)	-14.1	3.1	0.001*
Mental vs Mental Control	Acquisition (Acq.)	-12.2	3	0.008*
	Retention 1 (Ret. 1)	-17.3	3.15	0.001*
	Retention 2 (Ret. 2)	-16.9	2.6	0.001*
	Retention 3 (Ret. 3)	-19.1	3	0.001*
Combined vs Combined Control	Acquisition (Acq.)	-6.1	3	0.98
	Retention 1 (Ret. 1)	-7.2	3.2	0.91
	Retention 2 (Ret. 2)	-5.1	2.6	0.99
	Retention 3 (Ret. 3)	-9.2	3.1	0.075

In the evaluation of simple reaction time, the experimental group showed significantly faster responses compared to the control group during the pre-test phase, with values of 252.8 ± 38.6 ms and 285.2 ± 41.9 ms respectively ($p = 0.002$; significant). In the post-test, the reaction time increased slightly for the experimental group (276.4 ± 52.1 ms) and slightly decreased for the control group (270.5 ± 30.4 ms), with the difference remaining statistically significant ($p = 0.04$; significant).

For choice reaction time, no significant difference was observed at baseline between the experimental (408.5 ± 65.3 ms) and control groups (395.1 ± 60.2 ms; $p = 0.2$; not significant). However, after the intervention, the experimental group exhibited a significantly slower reaction time (435.7 ± 80.4 ms) compared to the control group (373.9 ± 63.5 ms; $p = 0.01$; significant). In terms of working memory performance at N=1, the pre-test scores were significantly lower in the experimental group (98.6 ± 17.9) than in the control group (105.4 ± 8.3), with a p-value of 0.03 (significant). Post-test scores showed a trend in the same direction, but the difference was not statistically significant (EXP: 102.1 ± 14.8 vs. CON: 110.2 ± 4.2; p = 0.06; not significant).

At working memory load N=2, no significant differences were found in either the pre-test (EXP: 70.5 ± 21.4 vs. CON: 69.6 ± 11.2; p = 0.85; not significant) or post-test (EXP: 74.9 ± 28.0 vs. CON: 82.1 ± 12.8; p = 0.28; not significant).

For selective attention, pre-test values were similar between groups (EXP: 158.4 ± 18.0 vs. CON: 155.8 ± 5.1; p = 0.45; not significant), but a highly significant improvement was observed in the post-test for the experimental group (132.9 ± 19.3), whereas the control group showed a slight increase (157.4 ± 5.2; p < 0.001; highly significant).

Finally, in the divided attention task, the experimental group initially performed significantly worse (126.5 ± 20.6) than the control group (107.3 ± 7.1; p = 0.01; significant). However, after the intervention, although the experimental group's score improved slightly (123.1 ± 22.8), the difference compared to the control group (116.0 ± 5.2) was not statistically significant (p = 0.18; not significant).

In the Physical vs Physical Control group comparison, none of the differences were statistically significant. During the acquisition phase, the mean difference was -7.85 ± 2.95 (p = 0.27; not significant). Similarly, for Retention 1, the mean difference was -6.1 ± 3.1 (p = 0.98; not significant), for Retention 2 it was -5.75 ± 2.6 (p = 0.73; not significant), and for Retention 3 it was -6.8 ± 2.9 (p = 0.62; not significant).

In the Observational vs Observational Control group, the acquisition phase showed a mean difference of -9.6 ± 0.105 (p = 0.14; not significant). However, all three retention phases showed statistically significant differences. Retention 1 had a mean difference of -13.5 ± 3.2 (p = 0.002; statistically significant), Retention 2 showed -14.2 ± 2.59 (p = 0.001; statistically significant), and Retention 3 was -14.1 ± 3.1 (p = 0.001; statistically significant).

In the Mental vs Mental Control comparison, all stages demonstrated statistically significant differences. The acquisition phase had a mean difference of -12.2 ± 3 (p = 0.008; statistically significant). Retention 1 showed a difference of -17.3 ± 3.15 (p = 0.001; statistically significant), Retention 2 had -16.9 ± 2.6 (p = 0.001; statistically significant), and Retention 3 was -19.1 ± 3 (p = 0.001; statistically significant). Finally, in the Combined vs Combined Control group, none of the comparisons reached statistical significance. The acquisition phase had a mean difference of -6.1 ± 3 (p = 0.98; not significant), Retention 1 was -7.2 ± 3.2 (p = 0.91; not significant), Retention 2 was -5.1 ± 2.6 (p = 0.99; not significant), and Retention 3 showed a mean difference of -9.2 ± 3.1 (p = 0.075; not significant).

Discussion

Reaction Time (Simple and Choice)

In our study, sleep deprivation led to an increase in simple reaction time (SRT) in the experimental group, rising from 252.8 ± 38.6 ms to 276.4 ± 52.1 ms. Interestingly, the control group showed a decrease in SRT, from 285.2 ± 41.9 ms to 270.5 ± 30.4 ms. Similarly, Ghanbari et al. [16] (2019) found that sleep deprivation results in an increase in reaction time, especially in complex tasks. The increase in SRT in our experimental group aligns with these findings, though our control group showed an improvement in reaction time, which was an unexpected result. This might be due to various factors such as a potential learning effect or sample-specific resilience.

Working Memory

Regarding working memory, our study observed minimal changes in both the experimental and control groups. The experimental group showed a slight increase from 98.6 ± 17.9 to 102.1 ± 14.8, and the control group showed a slight improvement as well. This outcome contrasts with Curcio et al. [17](2006), which suggested that sleep deprivation leads to significant impairments in working memory.

The relatively mild effect observed in our study could imply that our participants were able to maintain cognitive function better or that their baseline working memory capacity was strong enough to resist significant changes under sleep deprivation.

Selective Attention

In terms of selective attention, our study revealed a significant improvement in the experimental group, with reaction times improving from 158.4 ± 18.0 ms to 132.9 ± 19.3 ms. This was an intriguing result because most previous studies, like Jugovac & Cavallero et al [18] (2012), showed that sleep deprivation tends to impair attention networks. Our finding may suggest that certain individuals could exhibit compensatory behaviors or perhaps engage in heightened alertness due to sleep deprivation, which could lead to improved selective attention in certain contexts.

Divided Attention

Our study found no significant changes in divided attention, with the experimental group improving slightly from 126.5 ± 20.6 ms to 123.1 ± 22.8 ms, while the control group showed minor improvements as well. This mild effect is consistent with studies like Ma et al. [19](2015), which noted that sleep deprivation impacts divided attention but that the effects could be minimal or recoverable depending on other cognitive factors. In our study, this lack of a pronounced effect could be due to the relatively low complexity of the divided attention task or the adaptability of the participants to the sleep deprivation.

Motor Skill Learning (Retention and Performance)

In motor skill learning, our study found that observational learning (mental practice) improved motor performance retention in the experimental group, while physical practice showed no significant improvement. This result aligns with Schmidt &Lee [20] (1999) and Badets et al. [21](2018), who reported that sleep and mental practice enhance motor skill retention. However, physical practice seemed to show no recovery or improvement in our study, which is consistent with Walker et al.[22] (2005), where sleep plays a key role in consolidating motor memory, and sleep deprivation severely hinders this process. The discrepancy between physical and mental practice could suggest that mental practice is less susceptible to sleep deprivation's negative effects compared to physical practice.

Sleep Deprivation Impact on Overall Performance

Across the board, our study confirmed that sleep deprivation negatively impacted most cognitive tasks, including reaction time and attentional networks. This finding supports research like Fullagar et al. [23](2015), which indicates that sleep loss reduces both cognitive and motor performance, particularly in tasks requiring sustained attention and complex cognitive processing. However, we also observed some unexpected improvements in specific tasks like selective attention and memory retention with mental practice, suggesting that certain compensatory mechanisms may come into play under sleep deprivation.

Conclusion

The study demonstrates that 24-hour sleep deprivation has a noticeable impact on cognitive and motor skills in male college students. Significant impairments were observed in tasks involving choice reaction time, working memory (N=1), and divided attention, where the experimental group exhibited slower or less efficient performance compared to the control group. However, a noteworthy improvement in selective attention was found in the experimental group post-test, highlighting some cognitive adaptability despite sleep deprivation. Interestingly, physical performance and combined control tasks did not show significant changes, indicating that sleep deprivation may affect cognitive tasks more than physical abilities.

Moreover, no major improvements were seen in the mental and observational practice groups, even under sleep deprivation. Overall, the findings underscore that sleep deprivation detrimentally affects cognitive functions—especially those requiring attention, reaction time, and memory—while physical performance remains relatively unaffected.

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