The Consequential Effects of Sleep Quality on the Academic Performance of University Students

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Abstract

Sleep is a vital biological process essential for proper physiological and cognitive functioning. While its true purpose remains largely theoretical, sleep deprivation has been proven to impair numerous brain functions, particularly in college students who are increasingly susceptible to irregular sleep patterns. Drawing on evolutionary and neurological theories, such as the restorative, synaptic homeostasis, and brain plasticity theories, the article examines the impact of sleep deprivation on cognitive processes, memory retention, attention span, and overall brain connectivity. Through recent studies utilizing tools such as MRI and attention network tests, a consistent decline in brain activity and memory function was observed in sleep-deprived individuals. These effects are especially prevalent in university settings, where academic pressures, lifestyle changes, and increased substance intake contribute to deteriorating sleep quality. The findings highlight that inadequate sleep not only diminishes students' ability to retain and process information but also places them at higher risk for academic failure and long-term health consequences. Ultimately, the article emphasizes that sleep is not only necessary for survival but also fundamental to academic success and cognitive resilience.

Introduction

While sleep is understood as a state of unconsciousness for rest and several dynamic neuroligical processes, the purpose behind its true nature has not been fully discovered. Many correlative theories and evolutionary explanations exist to uncover the true purpose of sleep. Scientifically reasonable theories include inactivity, energy conservation, restoration, synaptic homeostasis, and brain plasticity theory (Division of Sleep Medicine at Harvard Medical School, 2021). The inactivity theory–also described as the evolutionary or adaptive theory–suggests that sleep was an evolutionarily advantageous quality, particularly for survival. The energy conservation theory theorizes another evolutionary explanation for sleep: when sources of food were scarce, conserving energy by sleeping would be an efficient method to maximize the utility of energy. More recent research has led to the other three theories: restorative, synaptic homeostasis, and brain plasticity, all of which refer to the function of the brain and its necessity to reset in terms of necessary chemicals, neural connections, and memory along with developmental aspects. Much like the human body–which cannot sustain exertive physical activity and requires recovery through sustenance, reconnection of muscle fibers, and rest–the brain can function ordinarily through mandatory rest. Regardless of the true physiological objective of sleep, sleep is an essential, life-sustaining activity necessary for function.

Figure 1. Research has indicated multiple phases in one sleep cycle, each with varying characteristics and roles. The main phases include N1, N2, N3, and REM, which describe the physical stages of sleep one experiences throughout their sleep (Suni, 2025).

The detrimental effects of sleep deprivation are evident. Sleep quality is subjective for every person; varying durations of overall sleep, along with duration within each stage of the sleep cycle, can differ. However, a general deviation from quality sleep has demonstrated harmful effects. While the issue of sleep deprivation has been on the

rise for the general American population, the greatest contributors to this statistic are college students.

As the number of sleep-deprived college students rises, the importance of exploring possible causes of sleep deprivation grows. Many students find college to be their first experience away from home, which can be an unfamiliar and uncomfortable environment. Aspects of this new environment, such as dining hall food and roommates, can negatively affect sleep quality. In addition, the potential increase in workload for students can affect the quality and duration of sleep due to factors such as lack of sufficient time and stress. College also presents easier access to alcohol and other substances, which may cause passing out, and although the duration of unconsciousness may be long, the quality of sleep is poor (Gaultney 2010). Furthermore, unregulated intake of caffeine severely affects sleep as the substance indirectly inhibits melatonin synthesis and secretion by preventing the binding of adenosine triphosphate to the active site of the receptor, leading to prolonged time without sleep. With these facets for decreased sleep quality, the potential development of sleep and mental health disorders increases, which can further affect a student's sleep. With the specific analysis of university students and their decreased sleep quality, the correlation between sleep deprivation and academic performance can be explored. This article argues that sleep deprivation significantly impairs the academic performance of university students by reducing cognitive function as well as diminishing memory retention and attention span, ultimately hindering their ability to succeed academically and maintain overall well-being.

Compromise of Cognitive Activity

A study explored the characteristics of sleep deprivation imposed on eight healthy male and female subjects, with normal sleep conditions as the control. Within the study, the brain activity of subjects who received normal sleep and 24 hours of sleep deprivation was monitored. Although "normal sleep" was not specified to an exact time of unconsciousness, "good" or "normal" sleep was accepted as being subjective. Thus, the researchers utilized measurements of fitness, usage of certain substances, presence of sleep disorders, and a Pittsburgh Sleep Quality Index (<5) to filter participants and maintain their norm throughout the study. (L Wang, Y Chen, Y Yao, Y Pan, Y Sun, 2016). With every participant having a Fitbit monitoring their sleep status, subjects were randomly assigned to sessions of an attention network test, followed by an MRI test that measured the amplitude of low-frequency fluctuations (ALFF). The data gathered described higher ALFF areas in the right cuneus and lower ALFF areas in the right lentiform nucleus, right claustrum, left middle frontal gyrus, left dorsolateral prefrontal cortex, and left inferior parietal cortex within the sleep-deprived subjects. The research team associated the lower ALFF in the left dorsolateral prefrontal cortex with a reduction in gray an essential tissue in the brain and spinal cord for many cognitive and motor-control functions, as well as a reduction in regional homogeneity (Wang, Chen, Yao, Pan, Sun, 2016). With the brain scans that demonstrated lower ALFF levels, the cognitive function and the connectivity between the inferior parietal cortex and the medial prefrontal cortex were compromised, thus, detrimentally affecting memory recall, consolidation, and retrieval along with crucial cognitive functions.

The left inferior parietal cortex is involved in memory recall, consolidation, and retrieval, as well as cognitive functions like bodily awareness, responsibility, and moral decision-making (L Wang, Y Chen, Y Yao, Y Pan, Y Sun, 2016). One particular finding demonstrated that "sleep deprivation reduced the left inferior prefrontal cortex deactivation during a visual short-term memory task" (A. Krause, E. Simon, B. Mander, S. Greer, J. Saletin, A. Goldstein-Piekarski, M. Walker, 2017). With crucial cognitive functions within the responsibilities of the left inferior prefrontal cortex and the left inferior parietal cortex, sleep deprivation that contributes to the declining function of both leaves an overall underperforming brain. This research demonstrates the significant effect that sleep deprivation contributes to the rapid degeneration of several crucial areas of the brain and their respective functions.

Within the brain, two primary networks—the default mode network (DMN) and its anticorrelated network (ACN)—exist to establish connections between neural networks to fulfill applicative tasks. Typically, the ACN corresponds to the frontoparietal network (FPN), which shows a negative correlation with DMN activity (L Wang, Y Chen, Y Yao, Y Pan, Y Sun, 2016). "In the sleep-deprived state, there is unstable reciprocal inhibition between task-related FPN activity and DMN activity, and erratic ascending arousal activity influencing thalamic activity" (Krause, Simon, Mander, Greer, Saletin, Goldstein-Piekarski, Walker, 2017). The lower ALFF in these regions describes a weakening of the neurological connections within the brain, ultimately demonstrating detrimental effects on attention, working memory, and overall cognitive function. The consequence of sleep deprivation and the associated reduced function of areas within the brain stimulated compensatory activity from non-orthodox regions such as the lentiform nucleus and claustrum. Although the compensatory activity of these regions of the brain allows for extended cognitive function, the quality of such functions is compromised, with results demonstrating inconsistent cognitive abilities.

Diminishing Memory Retention and Attention Span

Memory is one of the main functions of the brain, and sleep deprivation has significant effects on memory. The tired hippocampus: The molecular impact of sleep deprivation on hippocampal function, published by Curr Opin Neurobiol, states that "Sleep deprivation has the biggest impact on hippocampal memory consolidation in the first few hours

following training when it overlaps with the second wave of cAMP signaling, transcription, and protein synthesis critical for increasing synaptic efficacy and memory storage."

Sleep deprivation results in the attenuation of cAMP-PKA-LIMK pathways (Chua, E. C., Fang, E., & Gooley, J. J., 2017), which is the direct cause of the detrimental effects on hippocampal function. Furthermore, this study discovered that sleep deprivation also reduces the translational and transcriptional processes through the inhibition of the mTORC1 pathway. In their study Effects of Total Sleep Deprivation on Divided Attention Performance, Chua, Fang, and Gooley (2017) reported that "divided attention performance was impaired during exposure to total sleep deprivation, as demonstrated by a significant interaction between task load (single, dual, and triple tasks) and time since wake on aGNG response times and errors." The auditory Go/No-Go (aGNG) task, which measures attention and response control, was used to assess participants' performance under varying cognitive loads. Results showed that participants performed worse on the aGNG task when required to divide attention across multiple tasks, compared to when completing the aGNG task alone. This decline in performance was further exacerbated by sleep deprivation, highlighting its significant negative impact on multitasking and overall cognitive functioning.

In addition to impaired memory, distractibility, which is the difficulty in maintaining performance and effort, is increased (Chua, E. C., Fang, E., & Gooley, J. J., 2017). Just like food and water, sleep is a necessity for life, and the homeostatic pressure of sleep and the given task conflict, ultimately resulting in the reduction of attention span and an increase in distractibility.

General Academic Detriments

The possible theories of sleep describe reasons for the necessity of sleep. The Restorative, Synaptic Homeostasis, and Brain Plasticity Theory all propose that the necessity of sleep is correlated with the functional reset of the brain and explains a process of recovery and restoration during sleep. Deviations from quality sleep and resetting of the brain can cause insufficient recovery of the brain. Consequently, the homeostasis of the brain can be offset, and susceptibility to sleep and mental disorders can be escalated.

The poor physiological conditions, along with the deteriorating cognitive functions described previously, are direct results of sleep deprivation, demonstrating the negative consequences of sleep deprivation on academic performance.

Academic performance is critical, as college and university education are crucial steps toward future careers and further education. However, the process of learning is not so simple as going to a lecture and taking notes. The complex pathway to academic success involves a variety of aspects, one of the most important being sleep. With sleep, sufficient information encoding can take place while allowing for brain space to absorb more information. On the contrary, "Students reported insufficient sleep and a discrepancy between weekday and weekend amount of sleep. Students at risk for sleep disorders were overrepresented among students in academic jeopardy (GPA < 2.0)," said Jane F Gaultney, professor of psychology at North Carolina, Charlotte (NIH). Without such a crucial aspect of academics, simply thinking, remembering, and paying attention becomes more difficult. The beneficial aspects of quality sleep, along with the detrimental consequences of sleep deprivation, contribute directly and indirectly to the academic success of an individual, clearly demonstrating the absolute necessity of sleep, not just out of physiological necessity, but for academic success.

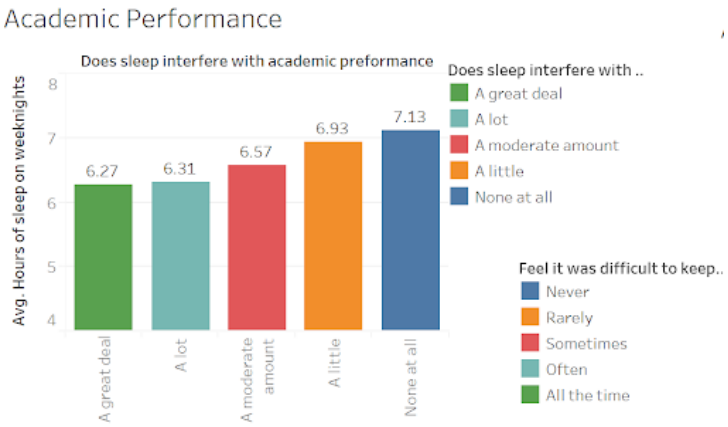

Figure 2. The barplot graph describes a negatively correlated relationship between the average hours of sleep a student gets on weeknights with how much they felt their sleep interfered with their academic performance (McGowan, Coughlin, 2017).

Extensive neurological and behavioral research demonstrates that sleep is not merely a passive state but a fundamental biological process crucial to cognitive functioning and academic performance. With evidence indicating the individual decline of each cognitive function in their effectiveness and efficiency, sleep deprivation has been demonstrated to be a significant detriment. With sleep being an absolute physiological need for humans, sleep deprivation not only harms cognitive function but also the person. With sleep deprivation demonstrating to be an incredible barrier to academic success and damaging to health, the emphasis on quality sleep is truly an imperative message to university students.

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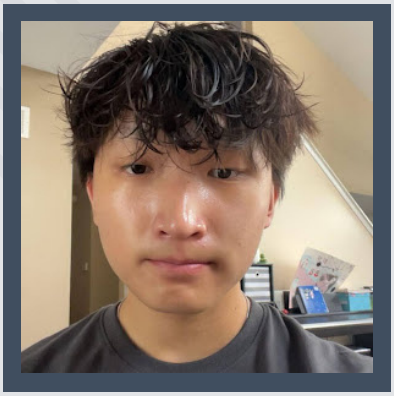

About the Author

Siwon is a pre-medical student majoring in Biochemistry at the University of Illinois Urbana-Champaign, with a strong interest in the intersection of research and clinical medicine. Passionate about understanding the molecular basis of disease and pharmacology. At UIUC, Siwon is engaged in research involving cell culture and cellular differentiation, with a focus on inducing stem cells to become muscle and neuron-like cells. Additionally, Siwon has contributed to research at the Feinberg School of Medicine, studying corneal damage and repair mechanism. Siwon plans to pursue a career in medicine that integrates both clinical practice and biomedical research. Through this dual path, he aims to help bridge laboratory discoveries with therapeutic advances that improve lives.