Relationship Between Sleep and Cognitive Ability

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Abstract

Sleep has been recognized as a factor that plays a crucial role in cognitive ability. However, nowadays, sleep is often sacrificed for other work in society. To prove or observe the real relationship between sleep and cognitive ability, this study examines the relationship between sleep duration and cognitive ability among adolescents or high school student body. Thirty-five students aged from 14 to 19 reported their sleep from the previous night and answered 11 cognitive questions. A scatterplot, regression line, and t-test were used to analyze the data. The regression line and scatterplot showed no significant relationship between sleep and cognitive ability. Due to an unexpected number of participants who did not follow the instructions, an additional t-test was done to examine the difference between the group that followed instructions and the group that did not. However, the t-test showed that the data are not statistically significant, indicating that there was no correlation between the immediate amount of sleep and cognitive ability.

Introduction

Sleep is one of the most essential human needs, as it supports human survival and health. In addition to simply resting the body, sleep restores energy, boosts self-recovery, and prepares the brain for learning the next day (Cleveland Clinic). Despite this, sleep's value is often underestimated in modern society, especially in fast-paced environments where productivity and deadlines are prioritized. Many people are aware of the benefits of sleep, yet they still choose to sacrifice rest in order to spend more time and effort on work and academics. In fact, according to the Centers of Disease Control and Prevention (CDC), national health statistics show that about one-third of adults in the United States regularly do not get enough sleep (Adjaye-Gbewonyo; Ng; Black). Additionally, the younger generation, especially high school students, are particularly vulnerable to reduced sleep patterns.. Students frequently stay up late to finish homework and prepare for exams, often believing that working longer will lead to better performances (Singer). Specifically, about 36% of fifteen-year-olds in England reported that they do not get enough sleep to concentrate on school work (Bruce). However, what is overlooked is that giving up rest may actually harm the very cognitive abilities that are necessary for academic success, including disrupting attention span and incomplete memory consolidation (Singer). According to the National Sleep Foundation, teenagers are recommended to get about 8 to 10 hours of sleep nightly, while 75% of 12th graders get less than 8 hours of sleep a day (Singer; National Sleep Foundation). Most 12th-grade students fail to meet this recommendation due to academic burden and extracurricular commitments (Bruce). In addition, one study revealed that the sleeping problems from the age of 16 are likely to continue in the later stages of life: one third of them will continue until 23 years old, emphasizing the severity of lack of sleep in the early stage of life (Bruce).

Scientific research has consistently demonstrated the role sleep plays in brain function. Studies in neuroscience and psychology reveal that adequate sleep strengthens memory consolidation, stabilizes attention, and improves decision-making (Rasch; Born). Experiments comparing well-rested and sleep-deprived individuals show a clear discrepancy: those who sleep enough tend to perform better on focus-based tasks, while those who lack sleep often

experience worse performance, such as slower reaction times and reduced learning efficiency (Sen; Tai). This evidence suggests that sleep is not only helpful but essential for peak cognitive performance. Nevertheless, although there is research and experiments done on adolescents, the majority of this evidence comes from laboratory-based research or from studies conducted on adults. As a result, there is less certainty about how these patterns apply directly to students who must balance school and extracurriculars, all while changing their sleep cycles during adolescence.

Building on this gap in the field, this experiment aims to investigate how variations in sleep affect the efficiency of cognitive ability among an adolescent population in the real academic environment. By focusing on the student body of a private high school in Pebble Beach, this experiment examines the connection between students' self-reported sleep levels and their performance on a short cognitive survey, including logic, math, language, and pattern recognition. The experiment will both contribute to a more closely investigated understanding of how sleep impacts cognitive ability in adolescents and highlight the importance of maintaining a sufficient amount of sleep. By directly comparing sleep levels and cognitive outcomes, this study offers insight into the importance of adequate sleep.

Method

To gather information about the relationship between cognitive ability and sleep, a survey was conducted in the student body of a private high school in Pebble Beach. The survey contains a group of questions related to cognitive ability in various categories, including math, language, and pattern finding, created by the experimenter himself and brought from a cognitive test websites including IQ test. All data were collected through a Google Forms survey distributed via schoolwide email so that all students at the school could participate if they wished to. Participants were instructed to report the number of hours they slept the night before and then complete a short cognitive task, including eleven questions in math, language, logic, and pattern recognition. The quiz was intentionally designed at a difficulty level that any high school student should be able to complete successfully, and participants were instructed to repeatedly solve the questions until they reached a full score. This requirement was meant to ensure consistent accuracy across responses and to make completion time the indicator of cognitive performance. The data collected included each participant's sleep duration, test score, and test completion time, which were later analyzed through scatterplots and linear regression to determine whether sleep showed any measurable relationship to cognitive ability.

The survey had a total of 34 participants who were current students with an agreement to take part of their own choice. Although this approach does not ensure randomization, it is the most feasible within a school setting. Ethical approval was obtained from an Institutional Review Board composed of a medical professor, an educator, and a school administrator. The study presented minimal risk, as it only collected anonymous, observational data without personal identifiers. Participation was voluntary, and informed consent was gathered through a checkbox on the survey's opening page.

All responses across the 11 cognitive questions were summed, culminating in a total score ranging from 3 to 11, where higher scores reflect better cognitive performance. Each student's cognitive performance score was plotted on the y-axis, and their sleep was plotted on the x-axis on a dot distribution graph. A linear regression line was calculated to identify the general relationship between sleep and cognitive ability. To measure the strength and accuracy of this relationship, a correlation coefficient (r^2) was calculated. Using these methods, the analysis helped determine whether there is a statistically significant relationship between sleep duration and cognitive performance among adolescents in a real educational setting. T-tests were also conducted to compare the sleep patterns of two groups: those who completed the cognitive task correctly and those who did not. The purpose of the t-test was an unexpected number of participants who did not finish the survey properly, raising a question about whether there is any difference between these groups, and there was a difference between the two groups, which could be meaningful, creating a necessity to check whether the difference happened due to chance.

Results

A total of thirty-five students between the ages of fourteen and nineteen participated in the study, representing about seven percent of the Stevenson School student body. Reported sleep ranged from three to twelve hours, with an average of around 7.5 hours, which is slightly lower than the recommended sleep hours for adolescents. The cognitive task scores ranged from three to eleven, with noticeable variation in completion times for all eleven questions. While 9 students completed the test properly, 25 participants finished it differently from the way that they were instructed, as they were told to retry the test until they got the full points. This uneven data quality affected the precision of later analysis but still offered useful insight into general trends within the sample.

The relationship between sleep and cognitive ability was examined through a scatterplot between hours of sleep and completion time with the 9 participants who did the survey right (Figure 1). The regression line calculated from these data was nearly flat, indicating almost no visible pattern between the two variables. The correlation coefficient (r^2) was -0.0073, which is close to zero, showing that there was no strong linear relationship between the amount of sleep and cognitive ability. Additionally, with the p-value of 0.964, which highly exceeds the standard metric of $p < 0.05$, the data shows that the result is not statistically significant and could happen by chance. In other words, students who reported sleeping more did not consistently finish faster or perform better than those who slept less.

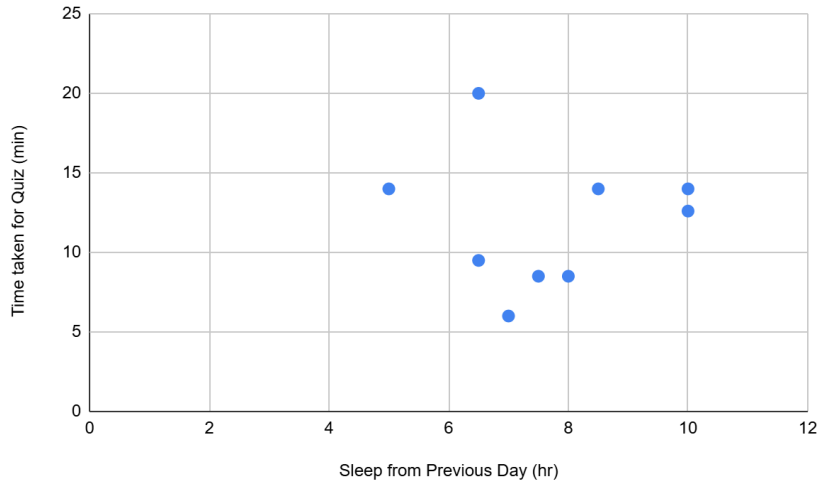

Fig 1: Scatterplot of Sleep and Time taken for Quiz

With the unexpected results of a lot of participants who did not properly finish the survey, additional analysis between a group who properly participated and the other group who did not seemed meaningful. Participants were divided into two categories: the *complete group*, consisting of students who answered all eleven questions correctly, and the *incomplete group*, which included students who did not. The average sleep time for the proper group was 7.96 hours, which was slightly higher than that of the incomplete group with 7.56 hours, implying that well-rested students may have been somewhat more likely to complete the test carefully (Figure 2). However, when a t-test was performed to compare these averages, the difference was not statistically significant ($t(32) = 0.792$, $p = 0.434$). This means that the result could have occurred by chance and does not provide strong evidence that sleep duration directly affected accuracy or cognitive ability. Together, these findings indicate that although students' sleep patterns varied, there was no significant correlation between a single night of sleep and cognitive ability within this randomized high school sample.

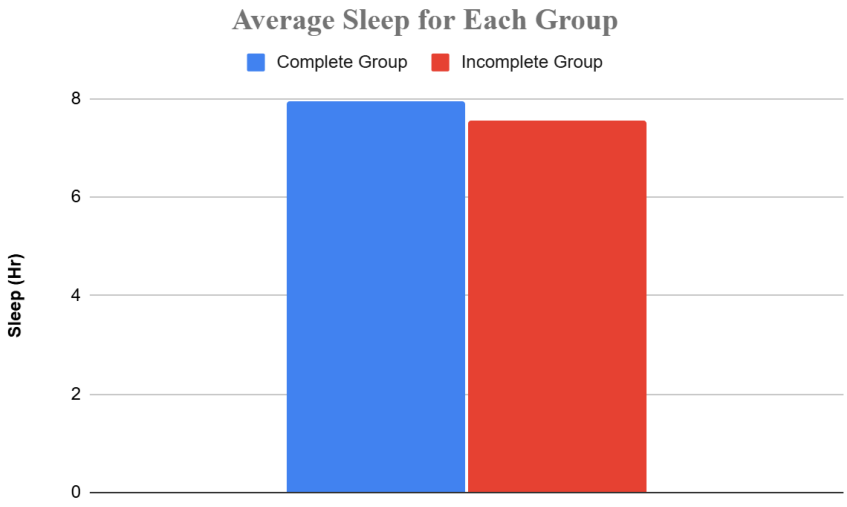

Fig 2: Sleep duration between Complete Group and Incomplete Group (p-value: 0.792)

Discussion

The analysis showed no significant relationship between hours of sleep and cognitive performance, with a nearly flat regression line and no meaningful difference in sleep between students who completed the task properly and those who did not. Overall, a single night's sleep did not appear to affect short-term cognitive ability in the student population. Additionally, looking at only the number of hours of sleep, not the quality of it, could have influenced the results of the survey. The results show that short-term sleep variation did not significantly affect cognitive ability among the student body. While scientific research often shows that lack of sleep damages attention and cognitive ability, this experiment's nearly flat regression line and low correlation coefficient imply that a single night's sleep difference may not be enough to create measurable and significant effects in overall cognitive performance, at least in the current sample, who on average, slept close the recommended nightly amount. This emphasizes the complexity of sleep's effects in real life (Balsamo; Berretta; Meneo; Baglioni; Gelfo). Potentially, students' performance is likely influenced by many other factors that were not considered in the experiment, including genetics, environmental distractions, and fatigue, which take tremendous effort to control in an observational survey. For example, some people require genetically less sleep than others with various mutations in genes related to hormones (PBS NewsHour). The absence of a clear correlation does not mean one night of sleep has no impact on cognitive function, but it may indicate that sleep may only disrupt cognition when lower amounts of sleep are acquired. It may also be possible that the relationship between sleep and cognition is more subtle or cumulative over time.

Additionally, another observation from the data was the difference between the complete and incomplete groups. Students who completed all eleven questions correctly showed slightly more sleep on average, though the result was not statistically significant. Still, this pattern indicates that students with better sleep habits might also be more focused and consistent when performing cognitive tasks. The lack of significance likely came from the limited sample size and inconsistent data quality. Further experiments could control these variables with tasks under supervision, ensuring that all participants understand and complete the same test conditions.

The study's limitations were clear, but it was meaningful. Because participation was voluntary and conducted online, students participated in uncontrolled environments that could have affected their concentration and timing accuracy. In future versions of the study, the experiment could be repeated under careful supervision. The duration can also be expanded to over several days, to track long-term sleep patterns instead of just one night's sleep. Lastly, expanding the sample size and including additional measures would provide a more complete view of how sleep affects different aspects of cognitive ability while considering other factors that may influence this relationship, such as social relationships and health conditions. Despite its imperfections, this project highlights how even a student-led experiment can reveal meaningful

patterns and help students understand the challenges of designing reliable research in real-life settings.

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