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Research Article

Impact of Sleep Duration on Cognitive Performance and Emotional State Changes in High School Students

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Abstract

Background/Aim

Adolescents' sleep is essential for cognitive performance, emotional regulation, and academic success. This study aimed to assess the impact of sleep duration on cognitive abilities and mood among high school students.

Materials and Methods

Fifty 11th-12th grade students (ages 17-18) from northern Israel participated. Each student completed cognitive and mood assessments under two conditions: after 8-10 hours of sleep (optimal sleep) and after 4-6 hours of sleep (sleep deprivation). Tests included memory evaluation (computerized card game), concentration assessment (feature deduction game), and a chemistry test derived from national exams. Mood states were evaluated using the Profile of Mood States (POMS) questionnaire. Paired t-tests and Wilcoxon Signed-Rank Tests were used to analyze differences.

Results

Sleep deprivation significantly reduced memory by 20.39% and concentration by 22.72%. Chemistry scores declined by 35%, while mood disturbances included increases in tension (64.92%), depression (63.39%), anger (46.8%), and fatigue (64.9%). Vigor decreased by 57.8%.

Conclusion

Sleep deprivation adversely affects cognitive performance and emotional well-being, emphasizing the importance of promoting healthy sleep practices among adolescents to enhance academic performance and mental health.

Keywords: sleep duration; cognitive performance; emotional state; high school students; memory; concentration; mood

1.Introduction

Sleep is a fundamental biological process essential for maintaining cognitive performance, emotional regulation, and overall well-being, particularly during adolescence. Adolescence is a critical developmental stage characterized by biological, social, and academic challenges, which contribute to sleep disturbances. Research highlights that adequate sleep enhances attention, memory, and cognitive function, while insufficient sleep leads to deficits in these areas and impairs emotional health [1, 2, 3, 4]. In light of increasing academic pressures, irregular sleep schedules, and biological changes in circadian rhythms, adolescents are particularly vulnerable to sleep deprivation [12, 18, 19, 29].

The relationship between sleep and cognitive processes has been well-documented. During sleep, memory consolidation occurs through distinct neural mechanisms, particularly during slow-wave sleep (SWS) and REM sleep. These phases facilitate the transfer of information from short-term to long-term memory through hippocampal-neocortical processes, which are critical for learning and problem-solving [3, 4, 5, 6]. When sleep is restricted, these processes are disrupted, leading to impaired memory encoding, retention, and retrieval [10, 15, 16, 23]. Moreover, studies confirm that sleep deprivation slows reaction time, reduces alertness, and impairs higher-order cognitive functions, including attention and executive functioning [17, 18, 20, 22]. For instance, partial sleep

deprivation of even two to three hours can significantly reduce performance on tasks requiring sustained attention [13, 21, 23, 25].

Adolescents are particularly susceptible to the cognitive consequences of insufficient sleep. Research indicates that students experiencing reduced sleep duration report significant declines in academic performance, particularly in subjects requiring abstract thinking and problem-solving, such as mathematics and science [14, 16, 31]. These deficits are exacerbated by societal factors such as early school start times, excessive use of digital devices, and increased academic expectations [29, 35, 39, 46]. For example, studies show that students who sleep fewer than six hours per night achieve lower scores in standardized exams compared to peers who sleep for eight or more hours [12, 17, 18].

In addition to cognitive performance, sleep plays a pivotal role in regulating emotional well-being. Sleep deprivation increases activity in the amygdala, the brain region responsible for processing emotions, leading to heightened emotional reactivity and reduced emotional regulation [31, 34, 36, 39]. This imbalance manifests in mood disturbances such as increased levels of anger, anxiety, and depression [33, 39, 40, 41]. A meta-analysis of adolescent sleep studies demonstrated a 55% increase in mood-related risks among students with shorter sleep durations [36, 39, 45]. Furthermore, chronic sleep deprivation exacerbates fatigue and irritability, creating a negative feedback loop in which emotional distress further disrupts sleep quality [39, 42, 43].

The interaction between sleep and emotional regulation has profound implications for adolescent mental health. Insufficient sleep has been linked to the development of psychiatric disorders such as depression and anxiety, particularly in adolescents experiencing high levels of academic stress [36, 38, 40]. The combination of emotional dysregulation and cognitive deficits due to sleep loss creates significant challenges for students, reducing their ability to meet academic demands and manage social relationships effectively [15, 17, 35].

Efforts to mitigate the effects of sleep deprivation have focused on systemic interventions and behavioral strategies. Delaying school start times has been shown to improve sleep duration, academic performance, and mood outcomes in adolescents [29, 46, 47, 48]. Additionally, promoting sleep hygiene education among students, parents, and educators can play a key role in addressing sleep-related challenges [39, 44, 50]. Behavioral strategies such as limiting screen time before bed, maintaining consistent sleep schedules, and creating a conducive sleep environment have been identified as effective approaches for improving sleep quality [23, 33, 34].

Despite the wealth of evidence linking sleep to cognitive and emotional outcomes, there remains a need for further research focusing on the adolescent population. Many existing studies have examined the effects of extreme sleep deprivation; however, more research is needed to understand the impact of moderate sleep restriction, which is more common among adolescents [18, 21, 22, 31]. Additionally, while previous studies have focused on isolated cognitive or emotional outcomes, few have comprehensively examined the combined impact of sleep deprivation on both domains within the same cohort.

The current study aims to address these gaps by investigating the effects of sleep duration on cognitive performance and emotional states among high school students. Specifically, the study compares performance on memory, concentration, and academic tasks under two sleep conditions: optimal sleep (8-10 hours) and sleep deprivation (4-6 hours). Emotional states, including mood disturbances such as tension, depression, anger, fatigue, and vigor, are also assessed. By using a within-subject design and validated assessment tools, this study provides a comprehensive analysis of the relationship between sleep and cognitive-emotional functioning. The findings will contribute to the growing body of literature highlighting the importance of sleep for adolescent well-being and offer practical implications for education and public health policies.

2. Materials and Methods

2.1 Participants

The study involved 50 of whom 62% were female and 38% were male in the 11th and 12th grades (ages 17-18) from a school in northern Israel. After obtaining informed consent from their parents, the students voluntarily participated in the study. They completed a series of tests on their free days, outside of the regular school schedule.

All the students belonged to the Arab communities, representing a normal distribution of socioeconomic status.

2.2 Procedure

This study was conducted over two weeks with two groups of participants. During the first week, Group 1 completed the tests after 8-10 hours of sleep, while Group 2 did so after 4-6 hours. In the second week, the groups switched conditions. Each participant completed the assessments after a night of adequate sleep (8-10 hours) and after a night of sleep deprivation (4-6 hours). The assessments included:

1. A 10-minute computerized card game evaluating memory, with final scores recorded after 10 minutes [51].
2. A 10-minute feature deduction game to assess concentration, with scores recorded after 10 minutes.
3. A 10-minute chemistry test featuring knowledge, understanding, application, and analysis questions from national high school exam materials [51].
4. The Profile of Mood States (POMS) questionnaire [52], translated into Hebrew and shortened to 28 items [53], with verification [54]. Each of the 28 statements is rated on a 5-point scale from 0 ("Not at all") to 4 ("To a very great extent"), grouped into five factors.

The statements are grouped into five factors, with each question categorized as follows:

- **Vigor**: Questions 5, 7, 9, 17, 24, 26, 27
- **Fatigue**: Questions 3, 12, 18, 23, 28
- **Tension**: Questions 1, 10, 19
- **Depression**: Questions 4, 8, 11, 15, 16, 21, 22
- **Anger**: Questions 2, 6, 13, 14, 20

A higher score in the "Vigor" factor indicates a more positive mood, while higher scores in the other factors correspond to a more negative mood.

2.4 Statistical analysis

The statistical analyses conducted in this study were meticulously designed to address the research objectives while accounting for the specific characteristics of the data. A combination of parametric and non-parametric methods was employed to ensure robustness and accuracy in the results. Paired t-tests were used for comparing means and percentage changes between the two sleep duration groups (8-10 hours vs. 4-6 hours) across variables such as memory, concentration, and emotional state, where normality assumptions were met. For the chemistry test, the Wilcoxon Signed-Rank Test was applied as the primary analysis, given the confirmed non-normal distribution of the data ($p < 0.05$), ensuring appropriate handling of the data's distributional properties. Spearman's correlation was selected to assess relationships between variables, providing flexibility for both continuous and ordinal data while

maintaining consistency in the analysis of non-normally distributed data. Furthermore, MANCOVA was employed to explore the influence of sleep duration on cognitive and academic performance, with univariate analyses complementing this multivariate approach. This comprehensive statistical strategy ensured the reliability and validity of the findings, aligning with best practices in the field of scientific research.

3.Results

3.1. Concentration and Memory

The comparative effects of Sleep Duration on concentration and memory are presented in Table No. 1.

The statistical analysis was performed using paired t-tests to assess differences in cognitive skills (memory and concentration) in the same students under two sleep conditions (8–10 hours vs. 4–6 hours). Prior to the analysis, the assumptions of normality of differences were tested and confirmed [55,56].

	Sleeping 8-10 hr N=50	Sleeping 4-6 hr N= 50			
Cognitive skills	Average±SE	Average ±SE	t-test	P	% of decrease
Memory	202.29±10.82	161.04±9.6	-6.05	P<0.0001	-20.39%
concentration	98.33±7.31	76.0±5.81	-3.52	P<0.001	-22.72%

Table No. 1- Effects of Sleep Duration on High School Students' Concentration and Memory (Maximum Score Achieved in 10 Minutes).

Note: In addition to the statistical significance, the effect size was calculated using Cohen's d for both memory and concentration performance. For memory, Cohen's d was 3.81, and for concentration, Cohen's d was 3.37, both indicating very large effect sizes. These results highlight the substantial impact of sleep duration on cognitive abilities, emphasizing its critical role in supporting high-level cognitive functioning in high school students [55,56].

Impact of Sleep Duration on Memory Performance

The paired samples t-test, selected as the primary analysis due to its reliability under confirmed normality (Shapiro-Wilk W = 0.979, p = 0.527), demonstrated a significant improvement in memory performance with extended sleep ($t = 6.049$, $p < 0.001$). The mean difference of 41.25 ± 0.768 points between the two sleep conditions underscores the substantial positive impact of 8-10 hours of sleep on memory.

These findings highlight the critical role of adequate sleep in optimizing memory and support integrating sleep hygiene into educational and public health policies for improved cognitive outcomes.

Impact of Sleep Duration on Concentration Performance

The paired samples t-test revealed a significant improvement in concentration performance with extended sleep ($t = 3.52$, $p < 0.001$), demonstrating a mean increase of 22.35 points between 4-6 hours (Mean = 75.98) and 8-10 hours of sleep (Mean = 98.33). Normality was confirmed (Shapiro-Wilk W = 0.980, p = 0.560), supporting the validity of the t-test for this analysis. These results underscore the critical role of extended sleep in enhancing concentration, with practical implications for improved productivity, academic success, and cognitive optimization. The findings advocate for prioritizing sleep hygiene in public health and education strategies to maximize cognitive outcomes.

3.2. Academic Performance in Chemistry

The comparative effects of Sleep Duration on Academic Performance in Chemistry are presented in Table No. 2.

Paired Samples Wilcoxon Signed-Rank Test

		statistic	p	Mean difference	SE difference	
8-10 sleep hours	4-6 sleep hours	*Wilcoxon W*	771[a]	<.001	7.50	0.76

Note. H_a μ Measure 1 - Measure 2 = 0

Note. [a] 9 pair(s) of values were tied

Table 2: Effects of Sleep Duration on High School Academic Performance in Chemistry

Descriptive	N	Mean	Median	SD	SE
8-10 sleep hours	48	19.2	20.0	2.15	0.310
4-6 sleep hours	48	12.3	10.0	4.94	0.713

Wilcoxon Signed-Rank Test For Paired Sample- primary method

Paired Samples T-Test						
Statistic	**df**	**p**	**Mean difference**	**SE difference**		
8-10 sleep hours 4-6 sleep hours	Student's t	8.95	47.0	<.001	6.88	0.768
Note. H_a μ Measure 1 - Measure 2 > 0						

Normality Test (Shapiro-Wilk)		
	W	**P**
8-10 sleep hours - 4-6 sleep hours	0.925	0.004
Note. A low p-value suggests a violation of the assumption of normality		

T-Test: Paired Two Sample for Means

The Academic Performance in Chemistry level associated with 8-10 hours of sleep was 19.2±2.15. This decreased significantly by 35.88% when sleep duration was reduced to 4-6 hours.

The Wilcoxon Signed-Rank Test, selected as the **primary analysis** due to its robustness in handling non-normal distributions, revealed a significant improvement in performance with longer sleep ($W = 771$, $p < 0.001$), with a mean difference of 7.50 ± 0.768 points. Supplementary analysis using a paired t-test ($t = 8.95$, $p < 0.001$) aligned with the Wilcoxon results, leveraging the Central Limit Theorem (sample size = 50) to validate the findings despite non-normality. Variance analysis further supported these results, showing greater consistency in performance under 8-10 hours of sleep (variance = 4.61) compared to 4-6 hours (variance = 24.42). These findings underscore the importance of sufficient sleep for enhancing cognitive performance and academic outcomes, reinforcing the need to integrate sleep hygiene into public health and educational strategies.

Multivariate Analysis of Covariance – MANCOVA

MANCOVA						
Multivariate Tests						
	value	**F**	**df1**	**df2**	**p**	
sleep hours Pillai's Trace	0.792	2.54	36	255	<.001	
Wilks' Lambda	0.351	2.90	36	246	<.001	
Hotelling's Trace	1.46	3.30	36	245	<.001	
Roy's Largest Root	1.15	8.15	12	85	<.001	
Univariate Tests						
	Dependent Variable	**Sum of Squares**	**df**	**Mean Square**	**F**	**p**
sleep hours	memory (2)	105224	12	8768.6	1.70	0.082
	concentration	46015	12	3834.6	1.60	0.106
	test results	1384	12	115.3	7.27	<.001
Residuals	memory (2)	439096	85	5165.8		
	concentration	203283	85	2391.6		
	test results	1348	85	15.9		

Note: All assumptions of MANCOVA, including multivariate normality, linearity, and homogeneity of covariance matrices, were tested and met. Any deviations from these assumptions are noted [55,56].

Table 3. Impact of Sleep Duration on Cognitive and Academic Outcomes

Extended sleep duration (8-10 hours) has a statistically significant multivariate impact on cognitive and academic outcomes, as confirmed by MANCOVA tests (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, Roy's Largest Root; all $p < 0.001$). Univariate analysis reveals a significant improvement in academic performance ($F = 7.27$, $p < 0.001$), with positive but non-significant trends for memory ($F = 1.70$, $p = 0.082$) and concentration ($F = 1.60$, $p = 0.106$). These findings highlight the critical role of sufficient sleep in optimizing cognitive function and academic success, supporting the integration of sleep hygiene into public health and educational strategies.

This analysis examines the correlations of the same measure (e.g., academic results, memory, etc.) across two sleep conditions (1 refer to 4-6 hours and 2- refer to 8-10 hours) using Spearman's rho.

Variable Pair	Spearman rho	p-value	Interpretation
Academic Results (1) vs. Academic Results (2)	0.034	0.819	No significant correlation between academic results in both sleep conditions.
Memory (1) vs. Memory (2)	0.736	<.001	**Strong positive correlation**; memory is consistently better with extended sleep.
Concentration (1) vs. Concentration (2)	0.525	<.001	Moderate **positive correlation**; concentration improves with longer sleep.
Tension (1) vs. Tension (2)	0.201	0.157	No significant correlation in tension levels across conditions.
Anger (1) vs. Anger (2)	0.311	0.027	Weak **positive correlation**; anger levels slightly related between sleep groups.
Fatigue (1) vs. Fatigue (2)	0.433	<.001	Moderate **positive correlation**; fatigue shows consistency across sleep durations.
Depression (1) vs. Depression (2)	0.632	<.001	**Strong positive correlation**; depression levels are similar across conditions.
Vigor (1) vs. Vigor (2)	-0.246*	0.082	Weak negative correlation; no significant pattern for vigor across sleep groups.

Table 4: Analysis of Spearman Correlation Matrix: Within-Variable Correlation

Note 1. Significant Results ($p < 0.05$): Memory, concentration, fatigue, and depression exhibit statistically significant positive correlations between the two sleep durations, with memory and depression showing particularly strong consistency.

Note 2. Non-Significant Results ($p > 0.05$): Academic results, tension, and vigor do not show significant correlations, suggesting that these measures might be influenced by other factors beyond sleep duration.

Note 3.(*) -The weak negative correlation for vigor, though not statistically significant, could suggest a slight variation in energy levels between conditions.

The Spearman correlation analysis reveals significant relationships for key cognitive and emotional measures across two sleep conditions (4-6 hours vs. 8-10 hours). Strong correlations were observed for memory ($r = 0.736$, $p < 0.001$), concentration ($r = 0.525$, $p < 0.001$), depression ($r = 0.632$, $p < 0.001$), and fatigue ($r = 0.433$, $p < 0.001$), suggesting consistency in these measures, with likely improvements under extended sleep durations. Moderate correlations for anger ($r = 0.311$, $p = 0.027$) highlight partial stability influenced by sleep. However, academic results, tension, and vigor displayed weaker or non-significant correlations, indicating higher variability and sensitivity to other factors. These findings underscore the stabilizing role of adequate sleep on cognitive and emotional performance, with practical implications for promoting sleep hygiene to enhance outcomes in academic and personal domains.

Variable Pair	Spearman rho	p-value	Interpretation
Memory (1) vs. Memory (2)	0.736	<.001	Strong positive correlation (**p < 0.001**)
Memory (1) vs. Concentration (1)	0.302	0.037	Moderate positive correlation (**p < 0.05**)
Memory (2) vs. Concentration (2)	0.525	<.001	Strong positive correlation (**p < 0.001**)
Fatigue (1) vs. Depression (1)	0.676	<.001	Strong positive correlation (**p < 0.001**)
Fatigue (1) vs. Anger (1)	0.636	<.001	Strong positive correlation (**p < 0.001**)
Vigor (1) vs. Academic Results (1)	0.324	0.026	Weak positive correlation (**p < 0.05**)
Vigor (1) vs. Anger (1)	-0.427	0.002	Moderate negative correlation (**p < 0.01**)
Depression (1) vs. Academic Results (1)	-0.295	0.044	Weak negative correlation (**p < 0.05**)
Academic Results (1) vs. Fatigue (1)	-0.599	<.001	Strong negative correlation (**p < 0.001**)

Table 5 : Analysis of Spearman Correlation Matrix: Cross-Variable Correlation

Table and Analysis of Statistically Significant Findings Only.

The Spearman correlation analysis reveals significant interrelationships between cognitive, emotional, and academic measures under varying sleep conditions. Strong positive correlations, such as between memory and concentration ($r = 0.525$, $p < 0.001$), underscore the consistency and alignment of cognitive functions, particularly under longer sleep durations. Negative correlations, including the strong inverse relationship between fatigue and academic performance ($r = -0.599$, $p < 0.001$), highlight the detrimental effects of fatigue and emotional strain on cognitive outcomes. These findings emphasize the interconnected nature of cognitive and emotional factors, reinforcing the critical role of adequate sleep in enhancing academic success and mental well-being.

3.3 Emotional State

Five **Wilcoxon Signed-Rank Tests** were conducted to assess the comparative effects of sleep duration on emotional states based on the five categories of the POMS questionnaire: Vigor, Fatigue, Tension, Depression, and Anger. The results of these tests, which compare

emotional state levels following 8-10 hours versus 4-6 hours of sleep, are presented in Table No. 6.

Note. Given the nature of the data, which involved dependent samples, the Wilcoxon Signed-Rank Test was chosen as the appropriate non-parametric method for analysing the paired differences in emotional states between the two sleep conditions. (Table No. 7.)

Wilcoxon Signed-Rank Test

	Sleeping 8-10 hr N=50	**Sleeping 4-6 hr N=50**	**% of change**	**Wilcoxon W**	**P**	**Effect Size**
Mood	**Average±SD**	**Average ±SD**				
Tension	0.536±0.312	1.420±0.927	64.92%	804.0[a]	P<0.0001	0.961
Depression	0.1124±0.1951	1.0794±0.8288	63.39%	1736.0[b]	P<0.0001	0.962
Anger	0.1080±0.2350	1.1306±1.1647	46.85%	835.0[d]	P<0.0001	0.849
Fatigue	0.536±0.312	1.420±0.927	64.92%	1120.5[e]	P<0.0001	0.987
Vigor	1.9641±0.7994	0.8288±0.5785	-57.80%	36.5[f]	P<0.0001	-0.94

Note. H_a $\mu_{Measure\ 1 - Measure\ 2} \neq 0$

[a] 11 pair(s) of values were tied

[b] 20 pair(s) of values were tied

[d] 8 pair(s) of values were tied

[e] 4 pair(s) of values were tied

[f] 2 pair(s) of values were tied

Table 6: Effects of Sleep Duration on High School Students' Emotional State (Assessed on a Scale of 0-4)

The results of the Wilcoxon Signed-Rank Test reveal significant changes in mood levels following reduced sleep duration. Specifically, the **Tension** mood level, initially at 0.536 ± 0.312 after 8-10 hours of sleep, increased by 64.92% to 1.420 ± 0.927 after 4-6 hours of sleep ($p < 0.0001$). Similarly, **Depression** levels increased by 63.39%, from 0.1124 ± 0.1951 with 8-10 hours of sleep to 1.0794 ± 0.8288 with 4-6 hours ($p < 0.0001$). **Anger** also showed a significant increase, with a 46.85% rise in mood levels (from 0.1080 ± 0.2350 to 1.1306 ± 1.1647, $p < 0.0001$). In addition, **Fatigue** levels increased by 64.92% after sleep was reduced from 8-10 hours (0.536 ± 0.312) to 4-6 hours (1.420 ± 0.927, $p < 0.0001$). In contrast, **Vigor** exhibited a 57.80% decrease, from 1.9641 ± 0.7994 after 8-10 hours of sleep to 0.8288 ± 0.5785 following 4-6 hours of sleep ($p < 0.0001$). These findings highlight the significant impact of sleep duration on emotional states, with reduced sleep leading to increased negative emotions such as tension, depression, anger, and fatigue, while longer sleep durations (8-10 hours) were associated with higher vigor and a reduction in these negative mood states. Notably, the analysis also identified a number of tied pairs in each emotional state, indicating instances where individual participants reported no change between the two conditions. These results underscore the importance of sleep duration in regulating emotional well-being and suggest potential avenues for further research into the mechanisms by which sleep influences mood and cognitive performance.

Note.1. Effect Size: The **Rank Biserial Correlation** values indicate large to very large effect sizes across all emotional states examined. Specifically, the effect sizes for **Tension** (r = 0.961), **Anger** (r = 0.962), **Fatigue** (r = 0.849), **Depression** (r = 0.987), and **Vigor** (r = -0.940) suggest that the differences observed between the two sleep conditions are not only statistically significant, but also of substantial practical importance. Positive correlations for **Tension**, **Anger**, **Fatigue**, and **Depression** reflect strong increases in negative emotional states following reduced sleep duration, while the negative correlation for **Vigor** highlights a significant reduction in energy levels. These large effect sizes provide robust evidence of the impact of sleep duration on emotional well-being, emphasizing the importance of adequate sleep for maintaining optimal mood and energy levels.

The results of the **Shapiro-Wilk test** for normality across various emotional state measures (Tension, Anger, Fatigue, Depression, and Vigor) under two sleep conditions (4-6 hours and 8-10 hours) are summarized in the table below.

The analysis indicates that most of the emotional state measures do not follow a normal distribution.

Variable	**Condition**	**W**	**P**	**Normality Conclusion**
Tension	4-6 hr	0.919	0.002	Not Normally Distributed
	8-10 hr	0.644	>0.001	Not Normally Distributed
Anger	4-6 hr	0.816	>0.001	Not Normally Distributed
	8-10 hr	0.528	>0.001	Not Normally Distributed

	4-6 hr	0.956	0.06	**Normally Distributed**
Fatigue	8-10 hr	0.866	>0.001	Not Normally Distributed
	4-6 hr	0.89	>0.001	Not Normally Distributed
Depression	8-10 hr	0.647	>0.001	Not Normally Distributed
	4-6 hr	0.925	0.003	Not Normally Distributed
Vigor	8-10 hr	0.958	0.069	**Normally Distributed**

Table 7: Shapiro-Wilk Test for Normality of Emotional State Measures.

The findings of the **Shapiro-Wilk test** indicate that most of the emotional state measures are **not normally distributed across both sleep conditions**. *Consequently, non-parametric statistical tests, such as the Wilcoxon Signed-Rank Test, should be employed for comparing groups*. **Fatigue** showed a trend towards normality under the 4-6 hr condition ($p = 0.06$), and **Vigor** exhibited a borderline result under the 8-10 hr condition ($p = 0.069$), suggesting a possible trend towards normality in these measures. However, the overall pattern of non-normality in the other measures supports the use of non-parametric tests for these data.

4.Discussion

This study provides compelling evidence for the critical role of sleep duration in influencing both cognitive performance and emotional well-being among high school students. The findings clearly show that sleep deprivation—defined as 4-6 hours per night—results in significant declines in cognitive performance, including memory (20.39%) and concentration (22.72%), alongside a 35.88% decrease in chemistry test scores. In addition, sleep deprivation caused considerable mood disturbances, with increases of 64.92% in tension, 63.39% in depression, 46.85% in anger, and 64.92% in fatigue, while vigor decreased by 57.8%. These results align with previous studies showing that insufficient sleep impairs cognitive abilities and emotional regulation [3, 4, 13, 31].

Strengths of the Study

A key strength of this study is the within-subject design, where participants completed assessments under both optimal sleep (8-10 hours) and sleep deprivation (4-6 hours) conditions. This design minimized variability caused by individual differences, thereby strengthening the internal validity of the results. Similar methodological approaches have been successful in isolating the effects of sleep on cognitive and emotional performance [3, 12, 16].

Moreover, the study utilized validated tools to assess cognitive and emotional performance, ensuring robust and reliable measurements. For cognitive evaluations, tests for memory and concentration, as well as standardized chemistry exams, provided objective insights into the effects of sleep loss. Emotional states were evaluated using the Profile of Mood States (POMS) questionnaire, which is widely recognized for its reliability in mood assessments [52, 53].

Additionally, the use of comprehensive statistical analyses—including paired t-tests, Wilcoxon Signed-Rank Tests, and multivariate analyses—enhanced the robustness of the findings. The inclusion of both parametric and non-parametric tests ensured that the data were analyzed rigorously, accounting for distributional properties [55, 56].

This study also addresses a critical and practical issue faced by adolescents, a population particularly vulnerable to sleep deprivation due to academic demands and social pressures. These findings are consistent with prior research highlighting the role of insufficient sleep in academic decline and emotional instability [18, 19, 35, 39]. By emphasizing the relationship between sleep duration and cognitive performance, this study advocates for educational policies that prioritize sleep hygiene as a fundamental component of adolescent health and academic success [29, 46, 47].

In conclusion, the strengths of this study lie in its well-controlled design, use of validated tools, and rigorous statistical analysis, which collectively provide clear and actionable evidence for the detrimental effects of sleep deprivation on cognitive and emotional well-being. These findings reinforce the critical importance of promoting healthy sleep habits among adolescents to optimize their academic performance, emotional regulation, and overall well-being.

5.Limitations

While this study provides valuable insights into the impact of sleep duration on cognitive performance and emotional well-being in high school students, several limitations should be acknowledged.

First, the sample size was relatively small, comprising only 50 students from a single school in northern Israel. Although this provided useful data, the limited sample size may affect the generalizability of the findings to broader populations, including students from different regions or educational settings. Future studies should aim to include a larger, more diverse sample to validate the results across varying demographics, socioeconomic statuses, and cultural backgrounds.

Second, the study relied on self-reported measures of sleep and mood through the Profile of Mood States (POMS) questionnaire. While this tool is widely used and validated, self-reported data can be subject to biases such as social desirability or inaccurate recall. Incorporating more objective measures, such as actigraphy or polysomnography, to track actual sleep duration and quality would provide more reliable data and a deeper understanding of the relationship between sleep and cognitive and emotional outcomes.

Third, the study was conducted over a relatively short period of two weeks. This design allowed for a controlled examination of the immediate effects of sleep deprivation, but it did not explore the long-term consequences of chronic sleep deprivation on cognitive performance and emotional regulation. Longitudinal studies are needed to assess how prolonged sleep deprivation affects students over time and whether the observed effects persist or worsen with continued lack of sleep.

Special "Conclusion"

In summary, this study highlights the crucial role of sleep in shaping both cognitive performance and emotional well-being during adolescence. The findings provide robust evidence for the adverse effects of sleep deprivation on memory, concentration, academic performance, and emotional regulation. Addressing these challenges requires a multifaceted approach that includes educational reforms, systemic interventions, and personalized strategies to promote healthier sleep patterns. To further enhance intervention insights, we recommend incorporating blood analytes assessments to identify physiological markers that can help refine and personalize sleep-related interventions. Future research should also explore the long-term impacts of chronic sleep deprivation and evaluate how individualized interventions can optimize both cognitive and emotional health in adolescents. By integrating sleep health into

educational and public health policies, we can better support students in achieving their full potential, both academically and emotionally.

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