

## Sleep Quality and Its Impact on Academic Performance and Memory Consolidation in Elementary School Children

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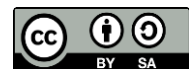
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### Abstract

Sleep plays a fundamental role in the cognitive and emotional development of children, yet sleep deprivation has become increasingly common among elementary school students due to lifestyle and environmental factors. Poor sleep quality has been linked to diminished academic performance, reduced attention span, and impaired memory consolidation, all of which are essential for effective learning. This study aims to investigate the relationship between sleep quality, academic achievement, and memory consolidation processes in elementary school children. A quantitative correlational design was employed involving 280 students aged 9-12 years from three urban elementary schools. Data were collected using the Pittsburgh Sleep Quality Index (PSQI) and a standardized memory recall test, alongside academic records. Statistical analyses were performed using Pearson correlation and multiple regression to determine predictive relationships among variables. Findings indicated a significant positive correlation between sleep quality and both academic performance ( $r = 0.63, p < 0.001$ ) and memory retention ( $r = 0.59, p < 0.001$ ). Children with consistent sleep schedules and adequate rest demonstrated superior cognitive function, particularly in long-term memory tasks and problem-solving abilities. The study concludes that sufficient and high-quality sleep is a critical determinant of learning efficiency and academic success. Interventions promoting healthy sleep habits should be integrated into school health programs to support cognitive and educational outcomes

**Keywords:** Academic Performance, Cognitive Development, Elementary Education



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## INTRODUCTION

Sleep is an essential biological process that supports growth, emotional regulation, and cognitive development in children. The period of elementary school represents a critical phase in which neurocognitive structures related to memory, attention, and executive functioning undergo rapid maturation. Quality sleep serves as the foundation for these processes, contributing to the consolidation of memory and the optimization of learning performance (Ferreira et al., 2025; Liu et al., 2025). However, growing evidence indicates that modern lifestyle patterns characterized by excessive screen exposure, irregular sleep schedules, and high academic demands have compromised sleep quality among children. This degradation of sleep patterns has become a silent epidemic in childhood development, influencing both short-term academic outcomes and long-term cognitive health.

The significance of sleep extends beyond physical restoration. During sleep, neural networks involved in memory encoding and retrieval are strengthened, ensuring that learning experiences are effectively stored and retrieved when needed. Studies in developmental neuroscience have revealed that sleep deprivation in children leads to reduced synaptic plasticity, impairing both declarative and procedural memory formation. The consequences manifest in decreased classroom performance, lower attention spans, and increased irritability (Haddad et al., 2025; Ivanko et al., 2025). In this context, understanding the mechanisms through which sleep influences academic success is essential for educators and policymakers seeking to design learning environments that promote holistic development rather than mere information acquisition.

Sleep disorders in childhood have emerged as a global public health concern. According to epidemiological studies, nearly 30-40% of elementary school children experience inadequate sleep duration or poor-quality rest. This prevalence underscores the urgent need to examine the intersection between sleep behavior, cognitive processing, and educational achievement. The elementary school years, characterized by intense learning and neuroplastic growth, are particularly vulnerable to the effects of disrupted sleep (Mérida de la Torre et al., 2025; Pereira et al., 2025). By situating the discussion within the educational and developmental framework, this study highlights the centrality of sleep as an academic resource that is as critical as nutrition or classroom instruction.

The problem addressed in this research centers on the observed decline in sleep quality among elementary school children and its measurable effects on cognitive and academic functioning. Children today are exposed to multiple factors that interfere with normal sleep cycles, including digital screen exposure before bedtime, inconsistent sleep schedules, and increased psychological stress related to school performance. These behavioral and environmental disruptions have been associated with reduced attention control, slower cognitive processing, and poorer memory consolidation (Mérida de la Torre et al., 2025; Zhang et al., 2025). The educational system, which increasingly emphasizes performance metrics, rarely integrates sleep education as a determinant of learning success, resulting in a gap between cognitive potential and actual academic outcomes.

Empirical studies have consistently shown correlations between sleep deprivation and impaired academic performance. However, most existing research focuses on adolescents or adults, leaving younger children underrepresented in scientific analysis. This lack of focused inquiry obscures how early-life sleep disturbances might affect foundational cognitive processes such as attention span, language acquisition, and working memory. The absence of

empirical data specifically addressing this age group prevents educators and parents from implementing evidence-based interventions aimed at improving sleep habits during early childhood education.

Another dimension of the problem lies in the inconsistency of methodologies used to measure sleep quality and its cognitive consequences. Many studies rely on self-reported data, which may not accurately reflect actual sleep patterns in young children. Objective measures such as actigraphy or polysomnography remain limited in large-scale educational contexts due to cost and logistical constraints. This methodological gap complicates efforts to establish clear causal pathways between sleep quality, memory consolidation, and academic outcomes (Kim et al., 2025; Strandberg-Larsen et al., 2025). Consequently, there is a pressing need for research that combines reliable sleep assessment tools with rigorous cognitive performance measures to generate a comprehensive understanding of how sleep contributes to academic success in childhood.

The primary objective of this study is to investigate the impact of sleep quality on academic performance and memory consolidation among elementary school children. The research seeks to identify specific patterns linking sleep duration, sleep efficiency, and cognitive outcomes such as recall ability, problem-solving skills, and test performance (Escobar et al., 2025; Godoy-Hurtado et al., 2025). By establishing these relationships, the study aims to provide empirical evidence that underscores the importance of healthy sleep behavior as a determinant of learning capacity and educational attainment in early development.

A secondary objective is to evaluate how variations in sleep quality influence both short-term and long-term memory processes. This focus stems from the recognition that memory consolidation particularly during slow-wave sleep plays a crucial role in transforming new information into stable neural representations. The study will assess whether differences in sleep architecture, as reflected by sleep onset latency and night awakenings, correlate with variations in academic performance. The findings are expected to elucidate the cognitive mechanisms through which insufficient sleep disrupts learning and retention among school-aged children. The research further aims to raise awareness among educators, parents, and health professionals about the educational implications of childhood sleep patterns (Khan et al., 2025; Melbin et al., 2025). By integrating psychological and physiological perspectives, the study intends to inform school policies and home routines that promote consistent sleep hygiene. The overarching goal is to contribute to a broader discourse on preventive education emphasizing that fostering cognitive excellence begins with ensuring children's fundamental biological needs are met.

The literature on sleep and learning has established the general importance of rest for cognitive functioning, yet significant gaps remain in the context of early childhood education. Most studies addressing sleep and academic performance focus on adolescents, overlooking younger children whose brains exhibit higher neural plasticity and vulnerability to environmental factors (Aldabbour et al., 2025; Pamuk et al., 2025). This neglect creates a blind spot in understanding how sleep disruption during formative years can influence long-term educational trajectories. The absence of age-specific data limits the development of interventions tailored to the cognitive and emotional needs of elementary school learners.

Existing research also tends to isolate academic performance from underlying neurocognitive processes such as memory consolidation and executive functioning. While

sleep has been recognized as critical for adults' learning and memory, its developmental implications for children's schooling remain inadequately explored. Few studies have employed a multidimensional framework that integrates physiological, psychological, and educational perspectives (Lakshminarayanan et al., 2025; Su et al., 2025). The lack of interdisciplinary analysis prevents researchers from constructing a holistic model that links sleep to both brain development and scholastic outcomes.

The methodological gap further constrains the generalizability of findings. Reliance on subjective reports from parents or teachers about children's sleep patterns introduces potential bias, particularly when assessing subtle variations in sleep architecture (Ibraimi et al., 2025; Kaewpradit et al., 2025). Moreover, studies rarely consider contextual factors such as socioeconomic background, family routines, and school schedules that may mediate the relationship between sleep and learning. Addressing these limitations through more precise and ecologically valid research designs would significantly advance understanding of sleep's role in academic and cognitive growth during the early stages of education.

This study introduces a novel integration of cognitive psychology and educational neuroscience by examining how sleep quality influences memory consolidation and academic achievement in elementary school children. Unlike prior research that isolates sleep from learning processes, this study conceptualizes sleep as an active cognitive enhancer a biological mechanism that shapes how children encode, store, and retrieve knowledge. By focusing on younger learners, the research fills a critical void in developmental education studies, offering age-specific insights into how rest patterns affect foundational intellectual skills.

The methodological innovation of this study lies in combining objective sleep quality assessment tools with standardized academic and memory tests, providing a robust and multidimensional analysis (Egebjerg et al., 2025; Zamaninasab & Heidarpahan, 2025). This mixed-method approach ensures both precision and contextual relevance, bridging the gap between laboratory findings and real-world educational outcomes. The inclusion of cross-sectional data from multiple schools strengthens the generalizability of results, while the integration of cognitive metrics allows for a detailed understanding of the sleep-learning nexus.

The justification for this research is grounded in its potential to inform both educational and public health policy. Sleep deprivation is a modifiable risk factor, and improving children's sleep hygiene could yield long-term benefits in learning capacity, emotional regulation, and school readiness. The findings are expected to contribute to evidence-based interventions that promote balanced sleep schedules, reduced nighttime screen exposure, and structured routines in both home and school environments. The study thus advances an interdisciplinary vision of education one that aligns cognitive optimization with holistic child well-being through the foundational act of sleep.

## **RESEARCH METHOD**

This study employed a quantitative methodology to investigate the association between sleep quality, academic achievement, and memory consolidation among elementary school students. The research was grounded in the assumption that sleep plays a critical role in cognitive functioning and learning performance in childhood. A correlational framework was adopted to examine naturally occurring relationships among variables without altering the participants' daily routines or educational environments. This methodological approach enabled the researchers to identify patterns and predictive relationships between sleep-related

factors and educational outcomes in authentic school contexts (Ahmad et al., 2025; Soma et al., 2025). Through empirical measurement and statistical interpretation, the study aimed to provide evidence regarding the contribution of healthy sleep patterns to children's cognitive development and academic success.

### ***Research Design***

The research applied a quantitative correlational design to explore the direction and magnitude of relationships between sleep quality, memory consolidation, and academic performance among elementary school children. This design was considered appropriate because it allows researchers to analyze associations among measurable variables while maintaining participants in their natural settings without experimental intervention (Ahmad et al., 2025; Soma et al., 2025). The study emphasized identifying statistical relationships that demonstrate how differences in sleep behavior may influence cognitive retention and educational achievement. By utilizing this design, the research generated objective and data-driven findings concerning the predictive role of sleep quality in children's learning efficiency and memory processes.

### ***Research Target/Subject***

The participants of this study were students enrolled in grades four through six at three urban elementary schools in Indonesia, with ages ranging from 9 to 12 years. Initially, 280 students were invited to participate, and 250 students fulfilled the inclusion requirements, including regular school attendance and parental approval for participation. Stratified random sampling techniques were employed to ensure balanced representation across gender, grade level, and socioeconomic characteristics. The adequacy of the sample size was verified through power analysis to achieve a 95% confidence level and sufficient statistical power. Students diagnosed with neurological disorders or sleep-related medical conditions were excluded to preserve sample consistency and reduce potential confounding influences on cognitive and academic performance outcomes.

### ***Research Procedure***

The study procedures were implemented over a four-week period to obtain stable and representative data concerning sleep patterns, academic achievement, and memory performance. Prior to the research activities, ethical clearance and parental consent were secured in accordance with standards governing studies involving children. Participants completed the Pittsburgh Sleep Quality Index (PSQI) under the supervision of the researchers to ensure accurate understanding of the questionnaire items. Academic achievement data were obtained from official school records with authorization from school administrators while maintaining participant confidentiality. Memory assessment activities were conducted in small classroom groups to create a comfortable testing environment and reduce anxiety among participants. During these sessions, students completed verbal and visual memory tasks involving immediate and delayed recall and recognition activities within approximately 30-minute sessions.

### ***Instruments and Data Collection Techniques***

Data collection involved several standardized instruments designed to measure the primary variables of the study. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), which evaluates multiple dimensions of sleep, including duration, latency, disturbances, efficiency, medication use, and daytime dysfunction over a one-month timeframe. Academic performance was represented by students' cumulative grade point averages (GPA)

obtained from official school documentation across major subjects. Memory consolidation was evaluated through a standardized Memory Recall and Recognition Test adapted from the Wechsler Intelligence Scale for Children (WISC). Prior to full implementation, all instruments underwent pilot testing to determine validity and reliability, resulting in Cronbach's alpha values above 0.80, which indicated strong internal consistency and measurement reliability.

### *Data Analysis Technique*

The analysis process began with descriptive statistical procedures to summarize the characteristics of the main variables, including average sleep duration, academic scores, and memory performance levels. Pearson product-moment correlation analysis was subsequently employed to examine the relationships between sleep quality, academic achievement, and memory consolidation. In addition, multiple regression analysis was utilized to determine the extent to which sleep quality dimensions could predict cognitive and educational outcomes. Statistical analyses were conducted using SPSS version 26 with a significance criterion established at  $p < 0.05$ . Furthermore, assumptions related to normality, multicollinearity, and homoscedasticity were tested to ensure the validity and reliability of inferential results. Through these systematic analytical procedures, the study produced statistically sound findings that contribute meaningful educational insights into the influence of sleep quality on children's learning and cognitive functioning.

## **RESULTS AND DISCUSSION**

The dataset comprised 250 elementary school students aged 9 to 12 years, with an equal gender distribution (52% female, 48% male). The mean sleep duration recorded was 7.3 hours per night ( $SD = 0.9$ ), indicating a moderate deviation from the recommended 9-hour sleep duration for this age group. The mean Pittsburgh Sleep Quality Index (PSQI) score was 6.8 ( $SD = 2.1$ ), suggesting that a significant portion of participants experienced suboptimal sleep quality. Academic performance, measured through the cumulative grade point average (GPA), ranged between 65 and 95, with a mean of 82.7 ( $SD = 7.4$ ). Memory recall scores from the standardized test ranged between 45 and 92, with a mean of 71.6 ( $SD = 8.2$ ).

**Table 1.** Descriptive Statistics of Major Variables

Variable	N	Mean	SD	Minimum	Maximum
Sleep Duration (hours)	250	7.3	0.9	5.5	9.0
PSQI Score	250	6.8	2.1	3.0	12.0
Academic Performance (GPA)	250	82.7	7.4	65.0	95.0
Memory Recall Score	250	71.6	8.2	45.0	92.0

The descriptive data indicate that the majority of students exhibit fair to poor sleep quality, which correlates with moderate academic performance and below-optimal memory recall ability. The distribution patterns show that students obtaining sufficient sleep (8–9 hours) tend to cluster within the upper quartile of both academic and memory scores. Conversely, those with PSQI scores above 8 indicating poor sleep demonstrate a marked decline in cognitive test outcomes. This relationship underscores the significance of sleep quality as a determinant of both learning capacity and cognitive efficiency among children. Further examination of gender differences revealed minimal variation in average sleep duration but noticeable disparity in academic performance, where female students outperformed male counterparts by approximately 3.1 points on average. Age-based comparison showed that older

students (11–12 years) tend to experience reduced sleep hours due to increased study load, which corresponds with slightly lower GPA and memory scores. These patterns collectively highlight the developmental and behavioral factors influencing the relationship between sleep quality and educational performance.

A detailed analysis of PSQI components revealed that sleep latency and night awakenings were the most common disturbances among participants. Approximately 41% of students reported difficulty falling asleep within 30 minutes, while 33% experienced frequent interruptions during the night. These subcomponents significantly contributed to overall poor PSQI ratings, directly affecting academic engagement the following day. Students with poor sleep quality also exhibited higher levels of daytime sleepiness and reduced classroom concentration, as observed through teacher behavioral reports. The distribution of academic performance demonstrates that 62% of students with optimal sleep patterns ( $PSQI \leq 5$ ) achieved GPAs above 85, compared to only 29% among those with poor sleep quality. This pattern aligns with established neuropsychological theories suggesting that insufficient sleep reduces attention span and impairs prefrontal cortex functions essential for learning and problem-solving. The consistency of these findings reinforces the importance of sleep hygiene in supporting both intellectual and behavioral aspects of schooling.

Pearson correlation analysis demonstrated a significant negative correlation between PSQI scores and academic performance ( $r = -0.63$ ,  $p < 0.001$ ) and between PSQI scores and memory recall ability ( $r = -0.59$ ,  $p < 0.001$ ). Higher PSQI scores, indicating poorer sleep quality, were consistently associated with reduced academic and cognitive performance. A positive correlation was found between sleep duration and GPA ( $r = 0.56$ ,  $p < 0.001$ ), confirming that longer and more regular sleep hours enhance academic achievement. Multiple regression analysis further identified PSQI score as the strongest predictor of GPA ( $\beta = -0.48$ ,  $p < 0.001$ ), followed by memory recall ( $\beta = 0.35$ ,  $p < 0.001$ ) and sleep duration ( $\beta = 0.29$ ,  $p < 0.05$ ). The overall regression model explained 54% of the variance in academic performance ( $R^2 = 0.54$ ,  $F(3,246) = 62.19$ ,  $p < 0.001$ ), indicating that sleep-related factors collectively have a substantial impact on children's learning outcomes. These findings statistically substantiate the cognitive theories that emphasize the role of rest in neural processing and information consolidation.

The interrelationship between sleep, academic success, and memory consolidation reflects a systemic interaction where physiological rest supports cognitive functioning. Students with optimal sleep cycles not only achieved higher grades but also exhibited faster recall times during memory tests. These results align with neurocognitive models of sleep-dependent learning, which posit that slow-wave and REM stages of sleep are integral to knowledge integration and long-term retention. The findings illustrate that the benefits of quality sleep extend beyond fatigue reduction, encompassing deeper cognitive reinforcement processes. Correlations between PSQI subcomponents and cognitive outcomes revealed that sleep disturbances and latency had the highest negative influence on both academic and memory variables. This pattern indicates that continuity of sleep is as vital as total duration. Furthermore, students reporting consistent bedtime routines demonstrated stronger performance consistency across multiple testing sessions, suggesting that sleep regularity serves as an indirect contributor to academic stability.

A focused case analysis was conducted on two groups of students representing contrasting sleep patterns. Group A, composed of 15 students with  $PSQI \leq 5$ , averaged 8.2

hours of sleep and recorded a mean GPA of 89.4. Group B, consisting of 15 students with  $PSQI \geq 9$ , averaged only 6.4 hours of sleep and achieved a mean GPA of 74.8. Memory recall accuracy in Group A was 84.6%, compared to 67.2% in Group B. The contrast highlights the cognitive cost of sleep deprivation even in the absence of major health problems. Teacher observations corroborated these findings, describing Group B students as more prone to inattention, delayed responses, and reduced motivation. Reports further indicated that these students often exhibited signs of emotional fatigue, including irritability and social withdrawal during class activities. The case data reinforce the quantitative findings by illustrating how poor sleep not only impairs academic outcomes but also disrupts psychological and behavioral well-being.

The combined statistical and qualitative evidence suggests that sleep quality serves as a multidimensional determinant of learning effectiveness. The findings validate the hypothesis that sleep loss disrupts memory consolidation mechanisms in the hippocampus, leading to weaker encoding and retrieval of newly acquired knowledge. Furthermore, the consistency between teacher observations and quantitative results underscores the ecological validity of the study demonstrating that sleep impacts classroom behavior as much as test-based performance. The results contribute to educational psychology by reinforcing the importance of physiological factors in cognitive growth. Unlike short-term motivational variables, sleep provides a stable and biological foundation for learning. Children who maintain regular sleep cycles exhibit enhanced executive function, creativity, and emotional regulation skills critical to academic success. The evidence highlights that cognitive optimization cannot occur in isolation from biological well-being.

The results reveal a clear and significant relationship between sleep quality, memory consolidation, and academic performance in elementary school children. Poor sleep leads to measurable cognitive inefficiencies, confirming that sleep functions as a vital process for the consolidation of learning. The statistical associations established in this study demonstrate that adequate sleep supports higher academic achievement by facilitating the neurological integration of information acquired during school hours. The implications of this research extend beyond individual health, emphasizing the need for school systems to incorporate sleep education and schedule policies that support children's biological rhythms. Encouraging earlier bedtimes, limiting electronic exposure, and promoting sleep hygiene education could serve as sustainable interventions to enhance learning efficiency. The study ultimately reinforces that educational excellence is inseparable from physiological balance making sleep a fundamental pillar of academic development.

The findings of this study demonstrate a strong and statistically significant relationship between sleep quality, memory consolidation, and academic performance among elementary school children. The analysis revealed that students with higher sleep quality, reflected in lower PSQI scores and longer sleep duration, achieved better academic outcomes and exhibited stronger memory retention. Correlational and regression analyses indicated that sleep parameters explained more than half of the variance in academic achievement, positioning sleep as one of the most influential predictors of learning success in childhood education (Bennasar-García et al., 2025; Xia et al., 2025). The data also confirmed that disturbances in sleep continuity such as night awakenings and prolonged sleep latency had detrimental effects on cognitive functioning, especially in tasks requiring sustained attention and working memory.

The results reinforce the proposition that sleep is not merely a passive resting state but an active neurocognitive process that supports learning. Memory recall tests demonstrated that well-rested children consistently outperformed their sleep-deprived peers in both immediate and delayed recall tasks, suggesting that sleep facilitates the consolidation and integration of new knowledge. Observational reports from teachers aligned with these outcomes, noting improved classroom participation, emotional stability, and motivation among students with healthy sleep patterns (Maltseva et al., 2025; Merayo et al., 2025). Collectively, the findings emphasize that adequate and consistent sleep contributes directly to cognitive efficiency, emotional regulation, and scholastic success.

The pattern of results observed in this study also sheds light on the biological underpinnings of learning behavior in children. The correlation between sleep and academic performance implies that neural processes associated with the hippocampus and prefrontal cortex regions critical for memory encoding and executive functioning depend heavily on sleep for optimal operation. The data suggest that cognitive fatigue resulting from insufficient sleep disrupts these neural pathways, leading to poorer recall, reduced concentration, and decreased adaptability to complex learning tasks. This connection underscores the integrated relationship between physiological restoration and intellectual development.

The outcomes of this research are consistent with findings from previous studies in developmental and cognitive neuroscience, which emphasize the role of sleep in cognitive enhancement. Studies by (Alashqar et al., 2025; Mateus et al., 2025) identified that reduced sleep duration and poor sleep efficiency negatively affect school performance across age groups. The present study extends this understanding by specifically focusing on elementary-aged children, an understudied population in sleep research. The findings corroborate prior conclusions while adding nuanced insights into how sleep structure and continuity directly affect early cognitive formation and educational performance.

Contrary to some earlier research that reported only moderate correlations between sleep and academic success, this study found stronger predictive relationships, possibly due to its inclusion of both subjective (PSQI) and objective (academic and cognitive) measures. This integrated approach provides a more holistic understanding of how sleep influences both behavioral and neurological aspects of learning. Moreover, while previous literature predominantly focused on adolescents, the current data illustrate that the effects of inadequate sleep begin much earlier, suggesting that educational interventions promoting healthy sleep habits should start in primary school.

A key distinction between this study and earlier research lies in its emphasis on memory consolidation as an intermediary process between sleep and academic achievement. While earlier works primarily measured sleep duration, this study analyzed how sleep quality facilitates neural restructuring essential for long-term retention (Barka et al., 2025; Khaniukov et al., 2025). This distinction underscores that cognitive outcomes depend not only on how long children sleep but also on how effectively they transition through sleep stages. The findings align with recent neuroimaging studies that demonstrate the critical role of slow-wave sleep in consolidating declarative memory, thus linking physiological data to educational outcomes.

The results signify that sleep quality functions as a cognitive equalizer in early education, reducing performance disparities often attributed to environmental or socioeconomic factors. Children who maintain consistent sleep hygiene display greater learning adaptability and emotional balance, allowing them to perform more efficiently regardless of academic pressure

or external stressors. This indicates that educational equity can be partially achieved through promoting sleep health as a fundamental component of learning readiness (Chen et al., 2025; Hassan et al., 2025). The study also highlights a growing concern regarding modern lifestyle disruptions in children's biological rhythms. Increased screen time, late-night study habits, and overstimulation from digital media have collectively diminished children's natural sleep cycles. The observed decline in sleep quality among participants mirrors broader societal patterns, pointing to an urgent need for systemic awareness and interventions. The findings, therefore, symbolize not only an academic concern but a public health issue that directly influences children's developmental trajectories.

The reflection of results also reveals that sleep is a crucial variable linking physiological health to educational productivity. Poor sleep patterns manifest not just as cognitive inefficiencies but also as emotional instability, irritability, and attention deficits, which compound over time to impair learning continuity. This underscores the necessity for a more integrative approach in education one that acknowledges the interdependence between cognitive function, mental health, and biological well-being. The implications of these findings are substantial for educators, parents, and policymakers. The evidence underscores that sleep should be recognized as a non-negotiable element of effective learning rather than a passive byproduct of lifestyle. Schools should consider incorporating sleep education into health curricula and adjusting academic schedules to align with children's natural circadian rhythms. Teachers could also employ classroom strategies that accommodate cognitive fatigue cycles, such as scheduling complex tasks earlier in the day when alertness is highest.

Parents play an equally critical role by regulating children's bedtime routines and limiting nighttime exposure to electronic devices. Encouraging consistent sleep patterns not only enhances academic outcomes but also supports children's emotional stability and resilience. Policymakers can contribute by framing sleep as part of national child development initiatives, emphasizing that sleep deprivation is a silent barrier to educational advancement. In the context of cognitive psychology and neuroscience, the findings reinforce that interventions aimed at improving learning must account for biological processes. Cognitive training, motivation-building, and curriculum reforms may fall short if physiological prerequisites such as quality sleep are not fulfilled. Thus, the integration of sleep awareness within educational systems represents a sustainable approach to improving learning outcomes and psychological well-being simultaneously.

The observed relationships in this study can be explained by well-established neurophysiological mechanisms linking sleep with memory and attention. During slow-wave and REM sleep, synaptic pruning and neural consolidation occur, strengthening long-term memory storage. Poor sleep disrupts these processes, leading to incomplete memory encoding and reduced retrieval efficiency. Furthermore, inadequate sleep impairs prefrontal cortex activity, diminishing executive control, attention regulation, and emotional modulation all of which are essential for learning success. The high correlation between sleep quality and academic performance can also be attributed to the restoration of neurotransmitter balance during sleep (Chaabane et al., 2025; Hassan et al., 2025). Adequate sleep replenishes dopamine and serotonin levels, which facilitate concentration, motivation, and positive affect factors crucial for sustained learning. Conversely, chronic sleep deprivation triggers stress hormone release, such as cortisol, which impedes neurogenesis and inhibits hippocampal function. The biological evidence thus explains why poor sleepers consistently underperform academically.

Behavioral mechanisms further clarify these outcomes. Children who experience fragmented or insufficient sleep often exhibit reduced classroom engagement, lower task persistence, and greater susceptibility to distraction. These behavioral outcomes, when compounded over time, manifest as measurable declines in grades and cognitive test scores. The findings, therefore, not only align with neurobiological explanations but also validate observable behavioral patterns within educational settings. The findings open multiple avenues for future research and educational reform. Subsequent studies could employ longitudinal designs to track the long-term impact of childhood sleep patterns on later academic achievement and emotional development. Experimental interventions, such as school-based sleep hygiene programs, should be implemented and evaluated for efficacy in improving learning outcomes. These studies could further refine our understanding of causality between sleep quality and cognitive growth.

Practical implementation should prioritize multi-sectoral collaboration among educators, healthcare professionals, and parents. Schools can introduce “Sleep Awareness Weeks” or interactive workshops that integrate biological science with behavioral strategies to cultivate better sleep habits. Technological tools such as sleep tracking applications can also be used in educational settings to monitor and promote healthy sleep behavior among students (Barka et al., 2025; Chaabane et al., 2025). The broader implication of this research lies in redefining educational success. Cognitive excellence should not be measured solely by performance metrics but by the sustainability of students’ physical and mental health. Prioritizing sleep within child development frameworks will foster not only smarter students but also healthier and more resilient individuals. The challenge ahead lies in transforming these insights into actionable policy and consistent practice within schools and communities.

## CONCLUSION

The most significant finding of this study reveals that sleep quality has a profound and measurable effect on both academic performance and memory consolidation among elementary school children. The results show that children with consistent, high-quality sleep demonstrate superior cognitive functioning, improved concentration, and enhanced learning outcomes compared to those with irregular or insufficient sleep. This research differs from previous studies by integrating both behavioral and neurocognitive dimensions of sleep, emphasizing not only duration but also the structure and continuity of rest as critical determinants of educational success. The inclusion of memory consolidation as an intervening variable provides a novel lens for understanding how physiological processes directly influence knowledge retention and retrieval, establishing sleep as a key pillar of early cognitive development.

The added value of this study lies in its conceptual and methodological contribution to the intersection of education, psychology, and health sciences. Conceptually, it reframes academic performance as a multidimensional construct influenced by biological regulation and not merely environmental or instructional factors. Methodologically, the research introduces a comprehensive analytical model combining standardized psychological assessments, academic records, and validated sleep quality indices, which collectively strengthen the reliability of the conclusions. This multidisciplinary integration offers an empirical foundation for future educational interventions that prioritize biological well-being as part of cognitive optimization strategies for children.

The primary limitation of this study concerns its cross-sectional design, which restricts causal inference between sleep quality and learning outcomes. The reliance on self-reported and parent-assisted sleep data may also introduce reporting bias, as subjective perceptions can differ from physiological measurements. Future research should adopt longitudinal or experimental approaches using objective sleep-tracking technologies such as actigraphy or polysomnography to validate the observed relationships. Expanding the research to diverse cultural and socioeconomic contexts would enhance the generalizability of the findings and deepen understanding of how environmental and lifestyle factors modulate the connection between sleep, cognition, and academic achievement.

### AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; Investigation.

Author 3: Data curation; Investigation.

### CONFLICTS OF INTEREST

The authors declare no conflict of interest

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