

Chronic Sleep Deprivation and Its Effects on Executive Functioning in School Students

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ABSTRACT

Sleep is a primary biological need crucial for the cognitive development of adolescents. Prolonged sleep deprivation among school-going students has precipitated considerable concerns over its effects on EF, which includes cognitive flexibility, planning, working memory, or control. Assessing its impact of chronic sleep deprivation on school student's EF is one of the main objectives of current research.

The research utilized a quantitative cross-sectional research method, in which the total sample size consisted of 200 students who were sampled via the use of the stratified random sampling method. Pittsburgh Sleep Quality Index (PSQI) was the tool employed in the study to assess sleep quality, while another tool used in the study to assess the aspects of memory and other functions of the brain attributed to the executive functioning of the brain was the Behaviour Rating Inventory of Executive Function (BRIEF), whose domains included shifting, emotional control, inhibition, working memory, planning, etc. Descriptive statistics were used to analyse the data. For that purpose, measures such as mean, median, standard deviation, range, and frequency distribution of both sleep patterns and scores of executive functioning were applied. The findings have been displayed in tables and graphs to give an in-depth understanding of the subjects' executive functioning and sleeping patterns.

Findings will be significant for school counsellors, educators, and policymakers to design and implement strategies focused on improving cognitive abilities through sleep health interventions.

Keywords: Chronic Sleep Deprivation, Executive Functioning, School Students, PSQI, BRIEF, Descriptive Statistics, Stratified Random Sampling,

INTRODUCTION

Sleep is an essential physiological activity that plays a significant role in the development of brain, emotions, or cognitive ability, and this starts from adolescence. As per the National Sleep Foundation, teenagers among the ages of 13-18 years need to sleep between eight and ten hours per day. However, with the study demands, usage of too much media, and inconsistent sleep schedules, sleep deprivation has become a major problem with school-going children all over the world.

Chronic sleep deprivation describes a condition characterized by a prolonged period of insufficient sleep. Cognitive domains that are generally most susceptible to sleep deprivation include executive functions. Executive functions are cognitive functions that are of a high mental order. Working memory, inhibitory control, cognitive flexibility, decision making, and cognitive planning are all aspects of executive function. These are of critical importance to the academic performance, social skills, as well as the functional capability of adolescents.

Based on research lack of sleep has adverse effects on the prefrontal cortex. This area of the brain controls the various functions of the body. Research shows that sleep-deprived teenagers lack attention span, Various research studies have clearly pointed out that a lack of sleep affects the functioning of the prefrontal cortex. The prefrontal cortex, as is commonly known, is responsible for the entire process of "executive functioning." Numerous research studies clearly establish the fact that adolescents who do not get adequate sleep suffer from a short attention span, poor impulse control, poor memory consolidation, and difficulty in solving problems. There is a lack of substantial research pertaining specifically to the association between "Sleep Deprivation" and "executive functioning" among students.

Behaviour Rating Inventory of Executive Function (BRIEF) and the Pittsburgh Sleep Quality Index (PSQI) are two very popular and validated tests for evaluating the quality of sleep and executive function, respectively. By using these tests for an entire sample of 200 students, who will be randomly chosen through stratified sampling, the entire dimension of the link between the two would be comprehensively evaluated.

Accordingly, the current study proposes to fill the above-mentioned gap by assessing the impact of chronic sleep deprivation on the executive function skills of school-going students belonging to the age group of 13-18 years. It is anticipated that the current study will make substantial contributions to the existing literature, with its implications for practice for various key stakeholders.

Background and context

Sleep is considered an important modality for cognitive development, memory consolidation, and neural restoration. During adolescence, significant maturation of the brain occurs between the ages of 13 and 18, especially in the prefrontal cortex, which is the seat of executive functioning. Executive functioning is a critical cognitive capacity that underlies working memory, planning, inhibitory control, cognitive flexibility, and decision-making-all essential for academic success and daily adjustment.

Chronic sleep deprivation severely compromises the functioning of the prefrontal cortex and disrupts executive functioning, particularly during adolescence, which is a stage when both systems are developing concomitantly.

Sleep Deprivation Prevalence

Adolescents should aim for 8-10hr of sleep every night; however, most don't meet this recommendation. In the United States, on school nights, more than 69% of high school students sleep for less than 8 hours (Keyes et al., 2015). The CDC characterizes this as a public health epidemic. In India, competitive academics, coaching classes, and smartphone usage contribute to similar patterns, with many students sleeping under 7 hours nightly.

Need for the Study

In spite of the increased awareness about the need for adequate sleep, the rate of chronic sleep deprivation, particularly among adolescents, continues to rise at an alarming rate, mainly due to increased academic demands, proliferation of digital gadgets, and early school starting hours. This is a worrying trend, considering that this is an important period of development for the prefrontal cortex of the brain.

The existing body of literature was characterized by three major drawbacks. Firstly, the literature mostly used adult populations while ignoring adolescent school populations. Secondly, it mainly used laboratory cognitive tasks instead of ecologically oriented behavioral tests to measure natural executive functioning.

Thirdly, few studies have incorporated standardized measures like the PSQI and BRIEF in sample populations. The need for this study arises from the following compelling reasons:

1. Sleep and Adolescent Development

Sleep is a factor that forms physical, emotional, and cognitive development in adolescents. Walker (2017) demonstrated that sleep is a neurological process, not a passive state that is important for memory consolidation, emotional regulation, and brain restoration. Teenagers between the ages of 13 and 18 should get eight to ten hours of sleep every night to function properly and healthily, as per the American Academy of Sleep Medicine. On the other hand, Numerous studies frequently show that academic pressures cause many schools students fail in this recommendation, social media usage, and irregular schedules.

Carskadon (2011) pointed out that during adolescence, a biological shift in circadian rhythm takes place, making it natural for sleep-onset delay to conflict with early school start times. This misfit between the biological sleep need and school schedules accounts for much chronic sleep deprivation experienced during adolescence. Owens et al. (2014) have additionally demonstrated that early school start times are highly correlated with adolescents having decreased sleep duration and increased daytime sleepiness.

2. Chronic Sleep Deprivation

Chronic sleep deprivation is defined as the consistent method of acquiring fewer hours of sleep than the body needs for optimum efficiency over a long period of time. In comparison to acute sleep deprivation or chronic sleep deprivation causes deterioration that develops gradually; thus, the individual experiencing it does not fully comprehend the effects of chronic sleep deprivation on cognition. In one experiment carried out by Van Dongen et al. (2003), it was proven that chronic sleep deprivation can bring about cognitive deterioration similar to total sleep deprivation; however, the individual does not comprehend this.

A study by Baum et al. (2014) concluded that teenagers who did not obtain more than eight hours of sleep nightly presented with greater emotional dysregulation, academic performance issues, and behavioural problems compared to those receiving the recommended amount of sleep. The PSQI is the standard assessment of sleep quality, as mentioned by Buysse et al. (1989), measuring seven characteristics of the subject's sleep over the previous month. If the subject presents with a global rating of over five, the sleep is considered of poor quality.

3. Executive Functioning

Executive functioning comprises a grouping of cognitive control processes that are mediated primarily by the prefrontal cortex. Miyake et al. (2000) provided a very popular model of the basics of executive functioning. Executive functioning involves inhibition, shifting, and updating or working memory, according to Miyake et al. Executive functioning processes are considered to be acutely important to academic learning, social interactions, emotional functioning, and adaptive behaviour.

Diamond (2013) emphasized the fact that the development of executive function skills is pronounced in adolescence; therefore, adolescence is the stage that is particularly vulnerable to effects of the environment, including sleep. Behaviour rating inventories of executive function developed by Gioia et al. (2000) are having most comprehensive measures of executive function skills in children or adolescents. The domains assessed include inhibition, shifting, working memory, emotional control, initiation, planning, organization, or monitoring.

4. Relationship Between Sleep Deprivation and Executive Functioning

A substantial amount of literature has established that sleep deprivation is related to the loss of executive function. Beebe et al. (2010) studied the effects of sleep restriction using experimental methods with

adolescents. The study concluded that sleep restriction results in significant reductions related to working memory, inhibitory control, or cognitive flexibility. Fallone et al. (2001) study proved that mild sleep restriction results in attention and executive control deficits among school-aged children.

Sleep deprivation affects prefrontal cortex activation, according to research, thus affecting executive functioning capabilities. Harrison and Horne found that the subjects who were sleep deprived had impaired innovative thinking, flexibility, and decision-making skills, which form the basis of executive functioning. Anderson and Platten (2011) revealed that, as a consequence of restricted sleep, inhibitory control is diminished, thus promoting impulsiveness among adolescents.

5. Gender and Grade Level Differences

Research has indicated that gender and academic grade level might influence both sleep patterns and executive functioning among adolescents. Undersea et al. (2018) found that female adolescents reported poorer sleep quality and higher rates of insomnia as compared to male counterparts, which could be due to a reason related to hormonal differences and greater sensitivity to stress. On the other hand, male adolescents exhibited higher rates of excessive daytime sleepiness.

In terms of grade level, there has been a greater tendency for sleeping quality to be reported as much poorer among higher-achieving senior school students with increased academic and examination demands compared to junior students. Curcio et al. (2006) found that academic stress mediated among sleep deprivation or cognitive performance, particularly in higher-grade students.

Theoretical Background

The study is embedded within three interlinked theoretical frameworks explaining the relationship among sleep deprivation or executive functioning.

Neurodevelopmental Theory

The prefrontal cortex, responsible for executive functioning, follows a protracted developmental trajectory that extends through adolescence into the mid-twenties. This extended course of development renders the adolescent brain more susceptible to environmental perturbations that interfere with normal neural maturation. Sleep is an active process that supports synaptic pruning, myelination, and neural connectivity—all processes integral to the maturation of the prefrontal cortex. Chronic sleep deprivation during this period of vulnerability may therefore disrupt these maturational processes and give rise to executive functioning deficits.

Sleep-Dependent Memory Consolidation Theory

According to Walker and Stick gold, this theory—which was proposed in 2006—states that sleep is vital in the consolidation of learning and memory, including both procedural or declarative memories. When one sleeps, the brain replays and strengthens neural connections made during wakefulness. Working memory, which is the central component of executive functioning, relies heavily on these processes of consolidation. Sleep disruption affects memory consolidation and diminishes the cognitive resources available for complex executive functions such as planning, problem-solving, and cognitive flexibility.

Prefrontal Cortex

A study has shown that the prefrontal cortex is disproportionately impaired by sleep deprivation compared to the effects on the rest of the brain (Drummond et al., 2005). According to the hypothesis presented here, it is proposed that the high-level cognitive functions that are mediated by the prefrontal cortex, such as control mechanisms, decision-taking capacity, and emotional responses, are the first to be impaired by

insufficient sleep. The metabolic requirements of this area are thought to explain the impaired performance of what is known as executive functions.

Homeostatic Sleep Drive and Circadian Rhythm

The 2-Process Model of Sleep Regulation (Borbély, 1982) proposes that the regulation of the sleep-wake pattern is maintained through the “homeostatic sleep pressure (Process S)” or the “circadian rhythm (Process C).” Stable circadian rhythm is marked by the delay of the body's internal clock. In adolescence, the circadian rhythm delays. However, the school schedule requires an early morning wake-up time. The sleep deprivation results in a reduced amount of sleep. The prefrontal cortex regulation is impaired with sleep deprivation. It is marked by impaired executive function.

Conceptual Framework

The conceptual framework demonstrates the hypothesized relationship between chronic sleep deprivation and executive functioning in school students, including key variables, mediating factors, and expected outcomes.

Theoretical argument

Sleep-Dependent Consolidation of Executive Skills

Executive function is not only a learning capacity but a set of skills that, unlike some skills, must be practiced, developed, refined, and consolidated. Sleep plays a vital role in consolidating procedural learning, as it strengthens neural circuits activated during daily activities. For teens, it is essential to practice executive skills such as planning, inhibiting, and shifting, after which sleep consolidates these neural patterns to create efficiency.

However, this consolidation of learning is impaired in cases of chronic sleep deprivation, where the final stages of consolidation and optimization of the executive function circuit never materialize. Eventually, there is a compounding effect, wherein not only do the executive functions deteriorate due to chronic sleep deprivation, but their development is stunted as well.

Theoretical Implication: It is suggested that the processes linking sleep deprivation to executive dysfunction are not strictly linear or easily reversible. While recovery sleep can alleviate partial deficits promoted by sleep loss, compounding effects of chronic sleep deprivation create deficits that build over time.

Proposed conceptual model

H1 (Direct): PSQI > 5 predicts higher BRIEF scores

H2 (Moderation): Age, gender, and SES as effect strength moderators

H3 (Domain-specific): Greatest impairment in working memory, shift, inhibition, emotional control

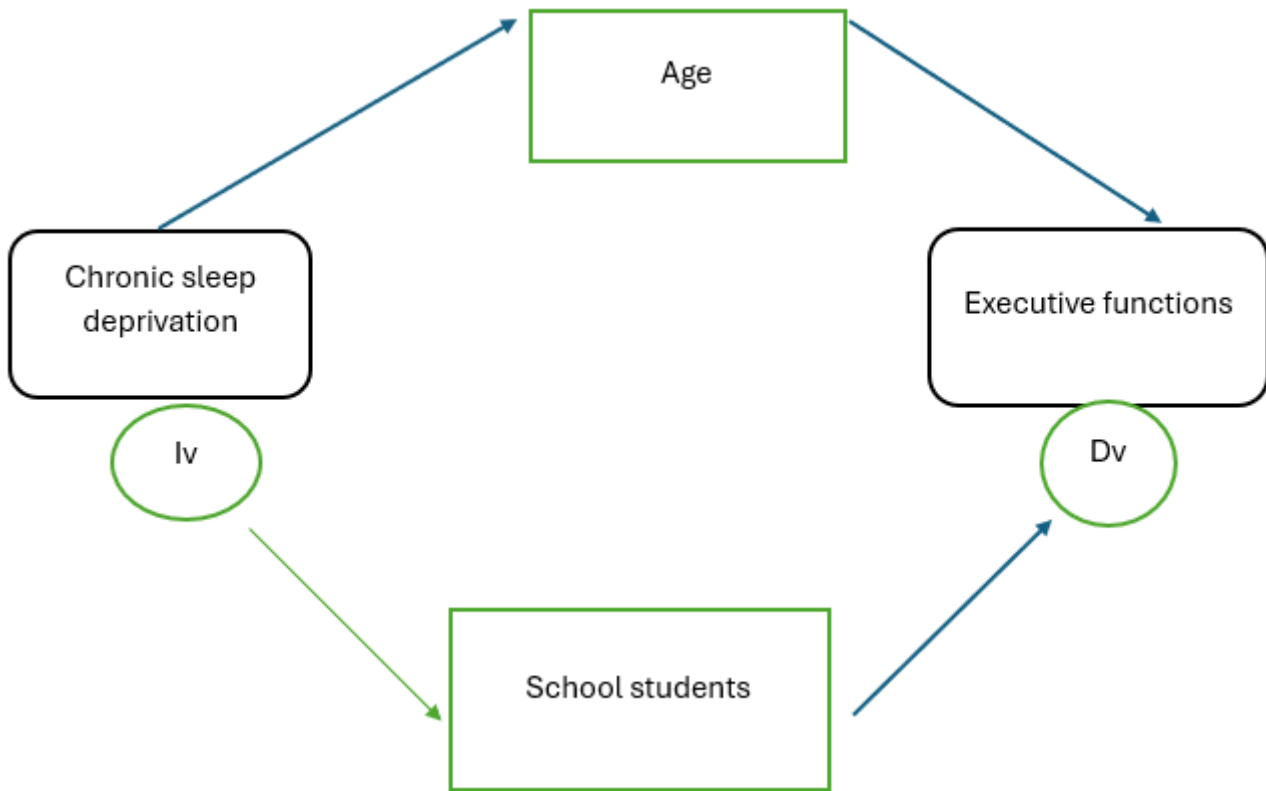


Figure-1 Visual Representation Of The Conceptual Framework

The diagram below illustrates the Mediating effect and Moderating effect proposed in this paper.

Research objectives and questions

R1: To examine the rate of chronic sleep deprivation among school students using Pittsburgh Sleep Quality Index (PSQI).

R2: To assess the executive functions of school students in various domains using Behaviour Rating Inventory of Executive Function (BRIEF) scale.

R3: To compare the executive functions of chronic sleep deprivation students ($PSQI > 5$) with the executive functions of students who have good sleep quality ($PSQI \leq 5$).

R4: Examine the relationship among the scores of sleep quality and scores of executive functioning using the entire sample.

R5: To determine which executive abilities are mainly impacted by chronic sleep deprivation.

Questions

RQ1: How does chronic sleep deprivation, represented by $PSQI > 5$, vary among the sample school students?

RQ2: What are the patterns of executive functioning among school students across different domains regarding BRIEF scores?

Hypothesis

H1: Chronic sleep deprivation has a significant negative impact on the executive function of school students.

H2: There is a notable difference in sleep quality between male or female school students.

Research Methodology

Research Design

The study is a correlational design as it investigated the degree, direction, and nature of the relationship among sleep deprivation (independent variable) or executive functioning (dependent variable) while controlling for any potential moderating effects of the demographic variables.

Measurement instruments

- Pittsburgh Sleep Quality Index (PSQI)
- Behavior Rating Inventory of Executive Function (BRIEF)

Data collection

Offline surveys for young adults and adult cohorts are conducted by going to schools and colleges. paper-based administration for teenagers in educational settings. It should take 25 to 35 minutes to finish. At the end of the survey, all participants will receive resources for mental health support.

Variables

Independent Variable: Chronic Sleep Deprivation: Measured as PSQI Global Score > 5, Type: Categorical (sleep deprived or adequate sleep) and Continuous (PSQI scores), Dependent Variable, Executive Functioning: Assessed using B, Eight clinical scales, Two composite indices (BRI, MI, Global Executive Composite (GEC), Type: Continuous (T-scores and percent, Moderating Variables (Explore, Age/Grade Level, Gender (Socioeconomic status).

Data collection

Using SPSS statistical software version 26, the Pearson correlation method has been utilized for the statistical analysis of 200 data samples. This approach is suitable for a correlational study to ascertain the degree of association between Pittsburgh Sleep Quality Index (PSQI), Behaviour Rating Inventory of Executive Function (BRIEF), and the variables in three study age groups. The significance of the findings will be determined by assuming a PSQI Global Score > 5.

Ethical consideration

It will guarantee that the relevant ethical clearance board approves the study. All participants must give their informed consent, and if they are younger than 18, parental consent must also be obtained. Participants are able to leave the study at any time; participation is entirely voluntary. Anonymization techniques will be used to guarantee the confidentiality of the data. There will be no deception in the research.

Research gap of this study

Although there is existing literature to support the effect of sleep deprivation on cognitive functioning to a certain level, little research has used the PSQI and BRIEF together to assess the executive functioning outcomes of school-going children by using a stratified random sampling method. This study is a descriptive study to assess the sleep quality amongst a diverse sample of 200 school children between the ages of 13 to 18 years.

Consequences

Showcasing that self-report behavioural measures like BRIEF detect cognitive impairments associated with sleep demonstrates ecologically valid measures beyond cognitive testing. Provides baseline data for conducting a study of the development of sleep-executive capacity over time.

CONCLUSION

The paper offers an objective, theoretically sound approach to investigating the relationship between executive functions and chronic sleep deprivation. Based on empirical research and well-founded psychology theory, the work outlines a potential path for a correlative study using the PSQI as the main research tool and a multi-level sampling pool of 200 participants. The proposed study is both theoretically and practically feasible, and it is both timely and justified given the growing concerns about SD and the increasing integration of executive functions into daily life. In this work, we have laid the groundwork for further investigation into that very topic.

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