NHSRC

SIR GANGA RAM HOSPITAL
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REPORT ON PREVALENCE OF SLEEP DEPRIVATION AND ITS ASSOCIATION WITH COGNITIVE FUNCTIONS IN SCHOOL GOING ADOLESCENTS (12-18 YEARS) IN DELHI

ACKNOWLEDGEMENT

We gratefully acknowledge the invaluable support and encouragement received throughout the course of this study.

Our heartfelt thanks to Dr. D. S. Rana, Chairman Sir Ganga Ram Trust Society for his motivation and constant inspiration to pursue high-quality research. We sincerely thank Dr. Ajay Swarup, Chairman Board of Management, Sir Ganga Ram Hospital for his instrumental role in facilitating the collaboration by signing the Memorandum of Understanding (MoU) with National Health Systems Resource Centre (NHSRC), which laid the foundation for this study. We are deeply grateful to Maj. Gen. (Prof.) Dr. Atul Kotwal, Executive Director, NHSRC, for his expert scientific insights, constant guidance, and unwavering support throughout the study.

We also express our sincere thanks to Dr. V. K. Khanna, Head of the Department of Pediatrics, for his continuous support and encouragement.

Our special thanks to Dr. Seema Patrikar for her support in data analysis, and to Dr. Col Arun K. Yadav for his valuable inputs during the proposal development phase.

We acknowledge the dedicated efforts of the teams at Sir Ganga Ram Hospital (SGRH) and the NHSRC for their support in data collection, coordination, and report writing.

Lastly, we are grateful to the participating schools and students, whose involvement was central to the successful conduct of this study.

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EXECUTIVE SUMMARY

Objectives of the study

Primary objectives:

1. To estimate the prevalence of sleep deprivation among the school-going adolescent population in the age group of 12-18 years.
2. To assess the association between sleep deprivation and cognitive functions.

Secondary Objectives:

1 To understand the various factors influencing sleep deprivation.

2. To assess the association between sleep deprivation and depression.
3. To assess the influence of sleep deprivation on school absenteeism and academic performance among school-going adolescents.
4. To understand sleep hygiene practices followed by school-going adolescents, their sleeping patterns and daytime sleepiness.

Research Design and Methodology

An analytical cross-sectional study was conducted across government, government-aided, and private schools in Central Delhi. In-depth interviews (IDIs), using pre-determined questionnaires with school-going children belonging to the 12-18 years age group, were conducted to evaluate the prevalence of sleep deprivation, and the associated factors affecting sleep.

(a) Central Delhi district was selected purposively for the study. Based on the list of Government, Government-aided and Private Schools in the selected district, a systematic random sampling approach was used to select schools such that one each of the different types of schools was included in the sampling frame. Data was collected from schools after acquiring necessary permissions from the respective school authorities.

(b) Respondents were chosen based on probability proportionate to the size sampling method. Thus, larger schools contributed more students to the final sample. The study sample included students in the age group of 12-18 years who gave assent, had parental consent, and fulfilled the pre-screening criteria. A total of 1,521 school-going adolescents were interviewed.

(c) The data collection was done using pre-determined questionnaires such as the Montreal Cognitive Assessment (MoCA), Pittsburgh Sleep Quality Index (PSQI), Patient Health Questionnaire (PHQ-9), Adolescent Sleep Hygiene Scale (ASHS), Modified Kuppuswamy Scale, and other information on socio-demographic variables. Information related to physical, recreational activities and other sleep-related factors were collected separately. All the tools were translated into Hindi and validated.

(d) Data collection was done using the Epicollect5 software by a trained team of medical professionals.

Key Findings

I. The prevalence of sleep deprivation among adolescents in the study was found to be 22.5% (CI-95%, 20-25%). The overall PSQI scores for the sample ranged from 0 to 13, and mean score was 3.91, indicating good sleep quality within the surveyed population.

II. The study found a mean MoCA score of 23.8 among the population, with 65.7% of adolescents demonstrating poor cognitive function. The study did not find any significant correlation between sleep quality and poor cognitive functioning.

III. Sleep deprivation was found to significantly impact academic performance, with sleep-deprived adolescents achieving a lower mean academic grade (64%) compared to their non-sleep-deprived peers (67%). However, no significant association was observed between sleep deprivation and school attendance ($p = 0.42$), suggesting that while adolescents may physically attend school, the quality of their academic engagement could be compromised due to insufficient sleep. Another issue observed was daytime dysfunction, where 48.3% of adolescents reported having issues staying awake during daily activities at least once a week.

IV. One of the major concerns highlighted was the PHQ-9 scores of the study sample. Nearly 60% of the adolescent population were reported to have symptoms of depression, and among them, 32.9% experienced mild depression, while 27% fell into the moderate to severe categories. Moderate positive correlation was also seen between PSQI and PHQ-9 scores, indicating that higher levels of sleep deprivation were associated with increased depressive symptoms. Depression status was also a significant predictor of sleep deprivation, with adolescents experiencing depression being 3.5 times more likely to report sleep deprivation.

V. Using ASHS score, sleep hygiene practices were reported, and the mean score for the study population was 4.79, indicating average sleep hygiene practices in the surveyed individuals. Adolescents with better sleep hygiene demonstrated significantly lower levels of sleep deprivation, as evidenced by a negative correlation between ASHS and PSQI scores. ASHS and PHQ-9 scores were also negatively corelated, implying that better sleep hygiene practices are associated with lower levels of depression. Sleep hygiene also emerged as a critical factor in the logistic regression, suggesting that better sleep hygiene substantially reduced the odds of sleep deprivation.

Policy Implications

1. There is need to leverage existing platforms such as Rashtriya Bal Swasthya Karyakram (RBSK) and Rashtriya Kishor Swasthya Karyakram (RKSK) to generate awareness on importance of sleep. RKSK tool may be modified to include basic questions on sleep health assessment towards the targeted interventions. Counselors at AFHCs to be trained to address sleep hygiene as part of adolescent health interventions. There should be direct linkages with Tele MANAS and AFHCs to identify the adolescents and ensure timely intervention and guidance.

2. TeleMANAS toll free number may be displayed at the school premises to utilize the counselling services. Awareness campaigns in schools can encourage students to seek mental health support through Tele MANAS helplines, if required.

3. Ministry of Education (MoE) may explore the possibility of revising the school curriculum to also include sessions on sleep health and its importance to improve overall health outcomes. Existing counsellors/Teachers in schools may be trained on the implications of excess screen usage among adolescents and how it may impact sleep and improve their overall health and lifestyle behavior.

4. Existing Ayushman Bharat-School Health Program can be utilized to create awareness and educate adolescents through School Health Ambassadors on good sleep hygiene practices and importance of sleep in cognitive and physical development.

5. Primary healthcare team at Ayushman Arogya Mandir may be trained to counsel adolescents on good sleep practices.

6. Existing community-based campaigns/ platforms may be utilized for promoting the significance of sleep hygiene among parents, educators, and healthcare providers to ensure a supportive home and school environment for adolescents.

7. IEC campaigns under Poshan Abhiyaan may be utilized to spread awareness among families about the role of sleep in cognitive and physical development.

8. Digital Detox Awareness Campaigns, educating students on the impact of blue light exposure and encouraging regulated screen time habits can be promoted at school level.

9. The Khelo India Programme can be leveraged to encourage participation in physical activities, reducing academic stress and indirectly improving sleep patterns among adolescents.

CHAPTER 1

INTRODUCTION

Humans spend almost a third of their lifetime sleeping (1). Sleep can be defined as an active, repetitive and reversible state of perceptual disengagement from and unresponsiveness to the environment (2). Sleep is essential for learning, physical, psychological, and cognitive development in both children and adolescents (1,2,3,4). Broadly adolescence refers to the period marking the transition from childhood to adulthood. Historically, this typically spans from 12 to 18 years of age, which roughly corresponds to the time from pubertal onset (i.e., specific hormonal changes) to guardian independence (i.e., the legal definition of "adulthood" in many countries) (5). Sleep is a biological necessity for regeneration of body systems, and mind (6). Numerous changes occur during sleep in biological and physiological bodily functions such as regulation of blood pressure, heart rate, hormonal secretion, and immune defence functions, cellular repair, temperature control, restoration of memory capacity, and cognition (7,8). Healthy sleep patterns are a combination of adequate sleep duration, good sleep quality, and regular sleep timing (9). Sleep deprivation (SLD) or sleep insufficiency is defined "as the state of not obtaining enough sleep" or getting less than the required amount of sleep or a total loss of sleep (10,11,12). Sleep insufficiency is when there is not enough sleep to maintain optimal levels of alertness, performance, and health. This condition can result from either decreased total sleep duration (decreased quantity) or fragmented sleep from frequent short awakenings (6, 13).

SLD occurs when inadequate sleep leads to decreased performance, inadequate alertness, and deterioration in health. Inadequate sleep is either due to decreased quantity or impaired quality of sleep, this decrease in quantity occurs over multiple nights whereas quality is determined by the number of awakenings from sleep during the night (14). Although sleep requirement varies for different age groups according to the level of physical and mental activities. On an average 7- 8 hours sleep per night is needed to function without impairment and with poor sleep quality, sleep deprivation may still occur, and five or more arousals during the night lead to daytime sleepiness (9,14,15). As per the recommendation of the Centre for Disease Control and Prevention (CDC) school children require 9-11 hours of sleep, and adolescents require about 8-10 hours of sleep (16).

Adolescence is defined as the period of gradual transition between childhood and adulthood. These transitions are overlapping yet conceptually distinct from the physical changes marking puberty and physical maturation and is characterized by drastic changes in hormonal and somatic status accompanied by substantial nonlinear changes in brain structural and functional organization and behaviour (13). The somatic, neuronal, behavioural, and psychological signatures of adolescence are associated with prominent maturational changes in sleep–wake cycle, and sleep timing, duration, and architecture. These sleep changes are suggested to reflect neurobiological sleep regulatory mechanisms that undergo maturation during adolescence, global synaptic reorganization hallmarking this period, or rapid adaptation of the sleep–wake schedule in response to changes in environmental requirements (13).

The onset of adolescence is also a time of both social and physiological changes that affect sleep (17). As children grow into adolescents there is a gradual decline in sleep time although the need for sleep among adolescents does not decrease (4). Factors such as a decreased biological depth of sleep and various circadian changes at puberty, combined with modern cultural elements like artificial lighting and access to stimulating activities, contribute to heightened arousal levels. Additionally, adolescents experience an increase in cognitive abilities, which can lead to worries and perceived threats, further pushing the balance away from sleep and towards high arousal (17). According to the National Sleep Foundation, most of today's adolescents are sleep-deprived. This condition of sleep deprivation (SLD) and poor sleep quality in adolescence has been linked to several adverse health outcomes and behavioural and emotional problems (7).

Some of the common causes of SLD are poor sleeping habits, disturbances in circadian rhythms, sleep disorders (such as insomnia, narcolepsy, restless leg syndrome, sleep apnea) and use of medications or drugs. Additionally, the onset of puberty, breathing problems during sleep (large adenoids and tonsils), the physiological shift in sleep onset to later times in the night during adolescence and Attention Deficit Hyperactivity Disorder or Autism Spectrum Disorder may be the reasons for SLD in children and adolescents (18). The prevalence of sleep disorders ranges between 12-15% in primary school children as seen in a community survey and around 45.3% in a hospital-based study (17,19). Studies have highlighted poor academic performance, school absenteeism and emotional regulation difficulties because of insufficient and inconsistent sleep in developing adolescents (19). Subjective sleep quality, bedtime routine, sleep latency, midnight waking frequency, and total sleep hours are some of the factors to determine the overall sleep and sleeping habits.

Numerous studies have documented the effects of SLD in adolescents, and it is imperative to explore SLD, address sleep issues and comorbid disorders and their impact on health, and the various sleep education programs. The country has a low understanding of sleep problems, which further influences treatment-seeking behaviour. Awareness about the prevalence of sleep deprivation in adolescents can help health professionals and parents to take remedial measures to avoid the adverse physical and psychological consequences of sleep deprivation.

REVIEW OF LITERATURE

Sleep has a significant impact on both physical and mental health. Studies on sleep deprivation demonstrate an impact on mood, executive function, and cognitive performance. It has also been shown to disrupt hippocampal function, particularly memory consolidation (12).

SLD can be partial (sleeping less than 5 hours in one 24-hour period), short-term (no sleep for 24-48 hrs., long-term total SLD (no sleep for more than 48 hours) or Acute and Chronic SLD. Acute results from a lack of sleep for a few days while chronic is persistent sleep insufficiency for more than 3 months. A study highlighted evidence from previous research, showing that both acute and chronic sleep deprivation result in induced anxiety states and deficits in attention and memory as sleep deprivation can influence neurobehavioral outcomes by altering the inflammatory response and neuroendocrine stress system (20) Chronic sleep deprivation predisposes the child to a higher

risk of both physical and mental health concerns. Long-term or chronic SLD can seriously impede the academic performance of individuals and since adolescents are chronically sleep deprived due to several causes like studying, excessive use of gadgets, and hormonal changes they are more vulnerable to adverse mental health issues. A meta-analysis showed that the adverse effects of SLD in some individuals may be after a single night's deprivation or after several nights (21). Total sleep deprivation for more than 24 hours decreases performance on a variety of tasks and activities, such as response speed (reaction time), memory, verbal comprehension, as well as the efficiency of performing mathematical operations. Performance on all these tasks and activities may be compromised by the alteration of three basic cognitive processes: attention, working memory, and executive functions (22).

The reasons for student's sleep deprivation may include a wide range of social, cultural, environmental and biological factors and a range of lifestyle and physiological factors can also interfere with sleep (17). The main correlates of poor academic performance are self-reported erratic sleep-wake schedule, short total sleep time, phase delay, and poor-quality sleep (23). Sleep deprivation in adolescents can have negative outcomes like poor academic performance, mood and behaviour changes, substance abuse and accidents (24,25). It may also lead to a variety of health problems such as cardiovascular, obesity, anxiety, and depression (1). SLD in adolescents may result in the development of attention deficit and behavioural difficulties (25). Hence, it becomes important to study sleep in adolescents.

Sleep deprivation (SLD) among adolescents

In a study from England, it was found that around 30% of boys and 49% of girls had sleeping disruptions, and around 36% of them acknowledged not having enough sleep and being unable to concentrate on their studies resulting in poor academic performance (26). Numerous Studies conducted in countries like Kuwait (27) China (28), Saudi Arabia (29), USA (30), Japan (31) reported a high prevalence of sleep deprivation among adolescents. It was also found in some of these studies that females were prone to sleep deprivation compared to males (29,31). Sleep deprivation in children is strongly linked to internalizing behaviors like anxiety, depression, and social withdrawal. Sleep loss impairs emotional regulation, increasing the risk of mood disturbances (32). Environmental factors, such as poor living conditions, often worsen sleep deprivation in children from low socioeconomic backgrounds (33). Reduced verbal intelligence, caused by chronic sleep loss, further impacts social interactions and self-esteem, leading to isolation and heightened risks of internalizing behaviors (34).

SLD among adolescents is becoming a significant concern in our country as well. A study in Delhi on sleep patterns in school-going adolescents shows a higher incidence of daytime sleepiness and sleep deprivation and its effect on their academic performance and self-esteem (35). Among school-going children, 47.5% were observed to have some form of sleep disorder. The prevalence of SLD in adolescents increased with age, from 83.7% to 87.1% in 11 to 12 years to 90.5% to 92.5% in 13 to 15 years (36). Prevalence of sleep deprivation (SLD) among adolescents aged 13 to 18 years was found to be 76.07% in a recent cohort study (37). In another study nearly 60% of the adolescents were sleep-derived (38).

Causes of sleep deprivation among adolescents

The causes identified in this population include internal biological processes such as the normal shift (delay) in circadian rhythm that occurs in association with puberty and a developmentally based slowing of the "sleep drive" (during adolescence, there is a natural shift in the body's internal clock, leading to a preference for later bedtimes and wake-up times) and external factors including stress and anxiety, systemic illnesses (sleep apnea, insomnia), extracurricular activities, excessive homework load, evening use of electronic media, caffeine- intake and early school start times (39-41). The circadian rhythm is the body's natural sleep-wake cycle and a 24-hour internal clock that regulates various physiological processes, including sleep. Hypersomnia, narcolepsy, and sleepwalking can disrupt the body's circadian rhythm and can lead to sleep cycle disturbance and ultimately sleep deprivation in adolescents (40,42,43). During adolescence SLD can have a serious negative impact on physical and mental health that can last in adulthood. A cross-sectional study showed the impact on sleep quality in adolescents due to the number of hours spent on electronic devices (44).

Cognitive function, scholastic performance and Sleep deprivation

Sleep plays critical roles in the optimal execution of learning, memory, executive functions, sustained attention, emotional regulation, and mood regulation (45-50), all of which are essential for academic success, adjustment, and mental health (51). The neural areas that govern emotional regulation and executive functions are sensitive to sleep deficiency (52-58). “It is crucial to maintain cognitive performance during wakefulness while performing daily activities such as studying and working” (59).

Research on the effects of SLD on performance has been centered on two basic cognitive processes: attention and executive functions, some studies propose that SLD primarily affects attention, while executive functions remain preserved and therefore, people can respond to demanding situations but have trouble responding efficiently to monotonous tasks, due to attentional deficiencies (60). While few other studies highlight that sleep-deprived people can perform simple tasks, they have difficulties accomplishing complex tasks, in which executive functions are implicated. A study has shown that sleep is essential for synaptic plasticity and brain connection consolidation. Sleep deprivation can interfere with these processes, potentially resulting in decreased neuronal plasticity and poorer brain connections in adolescents which mainly affects two domains of cognitive functions i.e., memory consolidation and attention (61). Furthermore, high-density EEG studies in youth detecting electrical activity of the brain suggested that insufficient sleep might alter neural function, connecting to impairments in memory formation and learning, executive functioning, and emotional well-being (61). Studies have also shown that sleep-deprived adolescents have reduced activity in the prefrontal cortex, leading to deficits in these cognitive functions (62-64). Systematic reviews on sleep and functioning in adolescents provide evidence that low sleep duration is associated with lower school performance and increases in risk-taking behaviour, such as substance use (2).

Other studies highlight the negative impact of SLD on attention, memory consolidation, information processing, and problem-solving abilities in studies (66-68). In one such study, a week

of intermittent SLD affects a variety of cognitive processes, perceived alertness, and mood (68). Lack of sleep is associated both with increased negative mood and heightened emotional reactivity to visual scenes and faces, as well as altered emotional memory processing (69). Preliminary evidence suggests that sleep loss also negatively affects mood and emotional regulation in adolescents, both following chronic and acute doses of sleep restriction (70). Less sleep is associated with more depressive symptoms, feelings of hopelessness, and greater anxiety (34).

A healthy amount of sleep is necessary to replenish each day and aid in learning and memory processing (71,72). Sleep is essential for both memory and learning and the shortening of sleep and subsequent sleepiness may impair an adolescent's opportunity to perform to the best of their ability in class (73). Longer habitual sleep duration has been associated with improved performance on tests of perceptual reasoning and total IQ in healthy school-age subjects (74). Another study based on sleep deprivation and scholastic performance has suggested that as adolescents advanced in age and school, their sleep time reduced (75). Another study reported similar findings among urban adolescents about sleep disruptions and deprivation with growing age and grade levels (76,77). In another study, students' learning ability and academic performance are directly correlated with sleep quantity and quality. Sleep deprivation has a strong correlation with poor logical and procedural learning in adolescents (78). Sleep deprivation causes poor school performance, heightened risk of drug and alcohol use, increased irritability, and aggressive behaviour, and these can interfere with relationships with peers, parents, and teachers (79).

NEED FOR THE STUDY

Sleep disruption is a major problem today and is a concern among both school-going children and adolescents. The adolescent brain undergoes rapid changes and connections between brain cells and brain pathways become more effective including structural and functional reorganization. Sleep is essential for sustaining these activities, which include memory consolidation, emotional regulation, and executive functioning. While there has been a lot of attention paid to sleep health in Western countries, there has not been much focus on Indian children and adolescents particularly on sleep deprivation, its quality and its impact on cognitive functions and associated academic performance.

Understanding how sleep deprivation affects cognitive development during this critical developmental age is important for maximizing their learning capacity and mental well-being. Exploring/ Examining the relationship between sleep deprivation and cognitive abilities can be helpful for educators and parents in implementing strategies to improve academic outcomes. Many studies have been conducted on these components individually (sleep deprivation and cognition), but insufficient research has been conducted in India to determine the association between sleep deprivation and cognition in the adolescent population. As a result, this study is being conducted to investigate the association between sleep deprivation and cognitive function in adolescents and to assess whether sleep deprivation relates to impaired cognitive performance.

Overall, this knowledge may be used to guide the development of treatment modalities and policies to promote good sleep habits and optimum cognitive and emotional development in adolescents.

OBJECTIVES

Primary objectives:

1. To estimate the prevalence of sleep deprivation among the school-going adolescent population in the age group of 12-18 years.
2. To assess the association between sleep deprivation and cognitive functions.

Secondary Objective:

1. To understand the various factors influencing sleep deprivation.
2. To assess the association between sleep deprivation and depression.
3. To assess the influence of sleep deprivation on school absenteeism and academic performance among school-going adolescents.
4. To understand sleep hygiene practices followed by school-going adolescents, their sleeping patterns and daytime sleepiness.

CHAPER 2

METHODOLOGY

Study Design – Analytical Cross-Sectional Study

Study Setting - Community-based with the study setting in Government, Government-aided and Private schools in Central Delhi.

Study Population - Students belonging to the age group of 12 to 18 years from Government, Government-aided and Private Schools in Central Delhi.

Sample Size - The required number of participants for the study was calculated by using the formula n = z2p*(1-p)/E2 with a margin of error (E) of 2.5%, z-score of 1.96 at a 95% Confidence Interval (CI) and taking the prevalence of sleep deprivation/ disruption (p) 38.5%. The prevalence for sample size calculation was decided taking into account the type of tool that was used for assessing sleep deprivation/ disruption. After adding a 10% response rate, the final calculated sample size was 1601. However, a total of 1521 adolescents were included in the study after excluding incomplete or invalid responses during data cleaning.

Sampling Method - Out of the 11 districts in Delhi, the Central Delhi District was selected conveniently for the study purpose. Based on the list of Government, Government-aided and Private Schools in the selected district, a systematic random sampling approach was used to select. schools such that one each of the different types of schools were included in the sampling frame. The school selection was also based on the interest shown by school authorities and if the school authorities provided the necessary permission to undertake the study at their school.

Students in the 12-18 years age group who gave assent, had parental consent, and fulfilled the pre-screening criteria were included in the study. Within the selected schools, participants were chosen based on probability proportionate to the size sampling method. This ensured that larger schools contribute more students to the study, thus maintaining equal representation.

Operational Definition of Sleep Deprivation: Sleep deprivation can be defined as engaging in less than 8 hours of sleep a night (81).

The study used the following inclusion and exclusion criteria for student selection:

Inclusion Criteria

- Students and parents sign the assent and informed consent forms respectively.
- All students in the age range of 12-18 years will be taken.
- Students with no history of physical or psychological illness or any substance use/abuse or on treatment for any sleep-related concerns.
- Students who are day boarders.

Exclusion Criteria

- Students who have a diagnosis or history of psychological/ psychiatric or neurological disorders.
- Students who have a diagnosis or history of sleep-related disorders.
- Any kind of medications that may affect sleep.
- Students with chronic physical illness that may affect sleep.
- Students who are not staying with parents/guardians.

Data Collection:

The researchers contacted school authorities and explained the details of the study to the principal/head of the school and requested permission for data collection. The rationale of the study was explained to study participants and the parents/guardians. Informed consent forms were sent to students' homes to obtain parents/guardians' consent for participation. Assent was taken from student participants. Subsequently, students in the 12-18 years age group who gave assent, had parental consent, and fulfilled the pre-screening criteria were selected and various study-related questionnaires were administered. Pre-screening questions such as students with any physical and psychiatric illness, history of sleep-related concerns or who are using any medications that may influence sleep, excessive daytime sleepiness, decreased sleep or any abnormal behaviour during sleep were incorporated in the parent/guardian informed consent form.

These questions were designed to gather essential information to determine eligibility for participation and help identify participants who met the inclusion and exclusion criteria outlined in the study design.

The data collection was done using pre-determined questionnaires such as the Montreal Cognitive Assessment (MoCA), Pittsburgh Sleep Quality Index (PSQI), Patient Health Questionnaire (PHQ-9), Adolescent Sleep Hygiene Scale (ASHS) and information on socio-demographic variables such as age, gender, place of residence (rural/urban), academic grade, stream of studying, height, weight, pubertal signs as well as information related to physical, recreational activities and sleep were collected separately. All the tools were translated into Hindi and used as per the requirement. Pilot testing of the tools was done once they were translated to Hindi and were validated. The tools were digitized using Epicollect5 for ease of data collection and entry after validation.

To ensure the quality of data collection and scoring, the data collection team was trained on the administration of the tools as well as on scoring aspects given in the tools by a Clinical Psychologist at NHSRC. Doubt-clearing sessions and mock administration of tools were conducted. The data collection team then started the data collection process and administered the tools individually to each student. The total time taken for administration of study tools for each student was around 50-60 minutes.

The research team scheduled the data collection sessions between March to October 2024, considering non-exam periods to ensure that exam-related stress and anxiety did not affect the study outcome as some of the tools captured the data on the sleep of the student in the preceding one month.

Data Collection measures:

1. Socio-demographic data and variables -

The socio-demographic variables collected were age, gender, place of residence (rural/urban), academic grade, stream of studying, height, and weight to calculate Body Mass Index (BMI), type of family, type of house, sleeping before or after parents, takes any tuitions/coaching, travel time to school, time of the day spent studying, changes in weekday and weekends sleep routine, any employment, family history of sleep problems.

2. Sleep Quality assessment -

2.1 Pittsburgh Sleep Quality Index Scale (PSQI)

The quality of sleep was assessed using the Pittsburg Sleep Quality Index (PSQI). PSQI has been extensively validated in different cultures and populations. It is a self-rated questionnaire which assesses sleep quality and disturbances over a 1-month interval. The questionnaire consists of 19 questions, and generates seven "component scores", each representing one of the seven components of sleep quality: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, sleep medication intake, and daytime dysfunction. Each component score is rated on a 3-point scale. This gives a combined PSQI score that ranges from 0-21, and a higher score is indicative of poorer sleep quality. PSQI scores >5 indicate poor sleep quality and ≤ 5 indicate good sleep quality.

It has high internal consistency Cronbach's alpha $= 0.83$ and high test-retest reliability of 0.85 ($p<0.001$)

3. Assessment of Cognition -

3.1 Montreal Cognitive Assessment (MoCA)

The Montreal Cognitive Assessment (MoCA) was introduced by Nasreddine and colleagues for the assessment of cognitive functions (80). It is a well-validated, reliable, and freely accessible screening tool for detecting mild cognitive impairment and has been translated and validated in 36 languages and dialects.

Cognitive functions tested include attention, working memory, short-term memory recall, visuospatial abilities, language abilities, and executive functions such as divided attention, semantic fluency, and abstraction.

MoCA is a 30-point scale, with 6 items for orientation, 5 for memory, 6 for language, 6 for mental control/attention, 3 for visuospatial, and 4 for executive abilities (including clock hands). It takes about 10 min to complete the test. The cut-off is 26 out of 30 points, i.e., scores of 26 and are considered normal.

3.2 Patient Health Questionnaire (PHQ-9)

The PHQ-9 is a multipurpose instrument for screening, diagnosing, monitoring, and measuring the severity of depression. It incorporates DSM-IV depression diagnostic criteria with major depressive symptoms in a brief self-report tool. PHQ-9 scores of 5, 10, 15, and 20 represent mild, moderate, moderately severe and severe depression (81, 82).

4. Sleep Hygiene Assessment-

4.1 Adolescent Sleep Hygiene Scale (ASHS)

The Adolescent Sleep Hygiene Scale (ASHS) is a self-reported questionnaire specifically designed to assess theoretically-based sleep hygiene domains thought to influence the sleep quality and quantity of youth aged ≥ 12 years, physiological (e.g., evening caffeine consumption); cognitive (e.g., thinking about things that need to be done at bedtime); emotional (e.g., going to bed feeling upset); sleep environment (e.g., falling asleep with the lights on); sleep stability (e.g., different bedtime/wake time pattern on weekdays and weekends); substance use (e.g., evening alcohol use); daytime sleep (e.g., napping); and having a bedtime routine.

The ASHS provides 8 subscale scores and an overall sleep hygiene score. Higher scores indicate better success in each of these dimensions of sleep hygiene. Response options are scored as Never (6 points), Once in A while (5 points), Sometimes (4 points), Quite Often (3 points), Frequently, if not Always (2 points), Always (1 point).

5. Modified Kuppuswamy Socio-economic Scale - 2023 version

The modified Kuppuswamy scale is commonly used to measure socio-economic status (SES) in urban and rural areas. It is the most popular scale for figuring out a person's SES. SES significantly influences overall human functioning, including both physical and mental well-being (83).

In the Modified Kuppuswamy scale, points are assigned to the family's total income, education level, and occupation of the family head. The cumulative points are then used to determine the SES of the family.

In this scale, total income, educational status, and employment are three of the most prevalent types of indices that are taken into consideration. On the Kuppuswamy scale, families are placed into one of five categories: upper class, upper middle class, lower middle class, upper lower class, and lower class. A family's total score can range anywhere from three to twenty-nine points, and it can only be determined by combining information about the members of the family's education level, occupation level, and income level.

Data analysis:

The statistical analysis was done using the Statistical Package for the Social Sciences software's (SPSS) version 30. Descriptive statistics such as mean, standard deviation, and range values were computed for quantitative variables. The Chi-square test was used to examine associations and

Independent Student's t-test was used to determine differences between groups. p-value of less than 0.05 was considered statistically significant. The strength of the association was estimated by reporting correlation coefficients. Multivariate logistic regression was performed for estimating effect of various factors on sleep deprivation.

Ethical considerations:

Ethical clearance was obtained from the Institutional Ethics Committee at the National Health Systems Resource Centre, Ministry of Health and Family Welfare, Government of India and permission was sought from the Delhi Education Board and respective school authorities to conduct the study. The institute rules and regulations pertaining to confidentiality, assent, and consent were adhered to. The Parent/guardian informed consent form and assent form and all the questionnaires were translated into Hindi.

CHAPTER 3

RESULTS

Socio-demographic profile

A total of 1,521 school-going adolescents aged 12-18 years were surveyed, with a mean age of 14.18±1.61 years. The male to female ratio was 1:1. Among the surveyed individuals, the majority (73.2%) belonged to nuclear families, and lived in pucca houses (96.4%). Based on BMI classifications by WHO, the majority were classified as thin (49.66%) while 6.37% and 1.67% were categorized as overweight and obese respectively. Only around 36% of the respondents had normal BMI. The mean BMI was 18.82 ± 4.13. Socio-economic status varied between participants, with the largest proportion (46.3%) classified as lower middle class.

Table 1. Sociodemographic Characteristics of participants

Category	Subcategory	Frequency (N)	Percentage (%)
Sex	Male	761	50
	Female	760	50
Type of family	Joint	381	25
	Nuclear	1113	73.2
	Three Generation Family	27	1.8
Type of house	Kutcha	55	3.6
	Pucca	1466	96.4
BMI Category	Normal	542	36.37
	Obese	25	1.67
	Overweight	95	6.37
	Thin	740	49.66
	Underweight	88	5.91
Socioeconomic Class	Lower	15	1
	Lower Middle	704	46.3
	Upper	23	1.5
	Upper Lower	581	38.2
	Upper Middle	198	13

Pittsburgh Sleep Quality Index (PSQI)

Based on the assessment done using PSQI scale, the prevalence of sleep deprivation among adolescents in the study was found to be 22.5% (95% CI 20%-25%) (Figure 1). The global PSQI

scores for the sample ranged from 0 to 13, and mean score was 3.91 ± 2.37, indicating overall good sleep quality in the surveyed population.

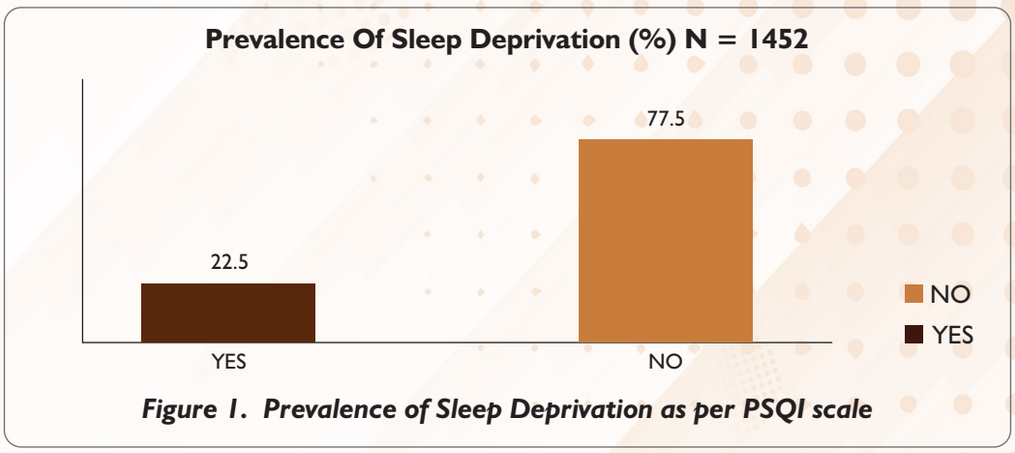

Figure 1. Prevalence of Sleep Deprivation as per PSQI scale

Sleep deprivation was also found to significantly impact academic performance, with sleep-deprived adolescents achieving a lower mean academic (percentage) grade (64%, SD = 13.53) compared to their non-sleep-deprived peers (67%, SD = 13.37; p = 0.004). However, no significant association was observed between sleep deprivation and school attendance (p = 0.42), suggesting that while adolescents may physically attend school, the quality of their academic engagement could be compromised due to insufficient sleep.

High prevalence of daytime dysfunction was observed, with 48.3% of adolescents reporting issues staying awake during daily activities at least once a week, while 6.0% experienced it three or more times a week. Enthusiasm levels were "Very Good" for 52.1%, but 4.7% rated them as "Very Bad."

Patient Health Questionnaire (PHQ-9)

Almost 60% of the adolescent population exhibited depressive symptoms (95% CI 57.5% - 62.5%), with 32.9% experiencing mild depression and 27% falling within moderate to severe categories. The mean global PHQ-9 score for the group was 6.86 ± 5.48, reflecting a mild to moderate burden of depressive symptoms.

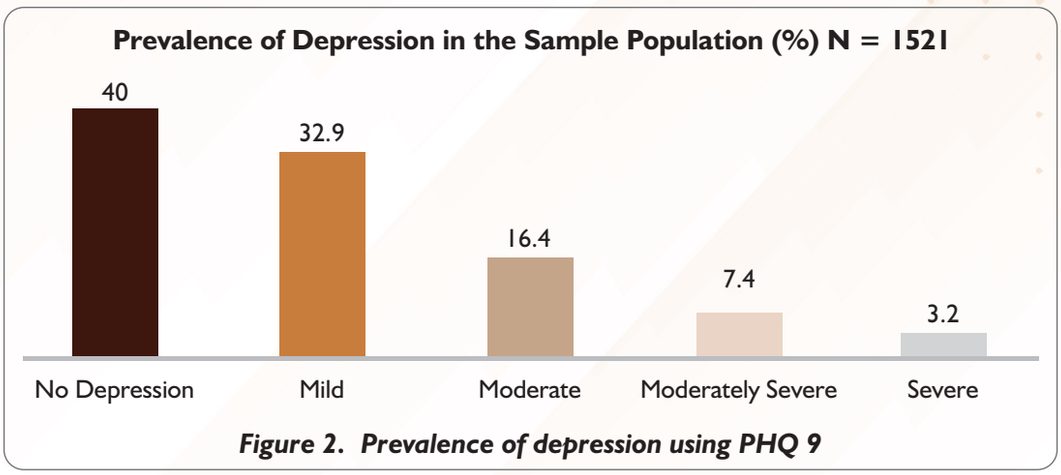

Figure 2. Prevalence of depression using PHQ 9

ASHS (Adolescent Sleep Hygiene Scale)

The mean ASHS score for the study population was 4.79 ± 0.60, indicating average sleep hygiene practices. Adolescents with better sleep hygiene demonstrated significantly lower levels of sleep deprivation, as evidenced by a negative correlation between ASHS and PSQI scores ($r = -0.353$, $p < 0.001$). This relationship underscores the positive effect of good sleep hygiene on sleep quality.

Montreal Cognitive Assessment (MoCA)

The mean MoCA score for the study population was 23.8 ± 3.55, with 65.7% of adolescents demonstrating poor cognitive function. (Figure 3). No significant correlation was found between MoCA and PSQI scores ($r = -0.006$, $p = 0.832$), and chi-square analysis similarly revealed no association between sleep deprivation and cognitive function ($X^2 = 0.058$, $p = 0.81$). SEC was significantly associated with cognitive function (Chi-square = 54.48, $p = 0.001$).

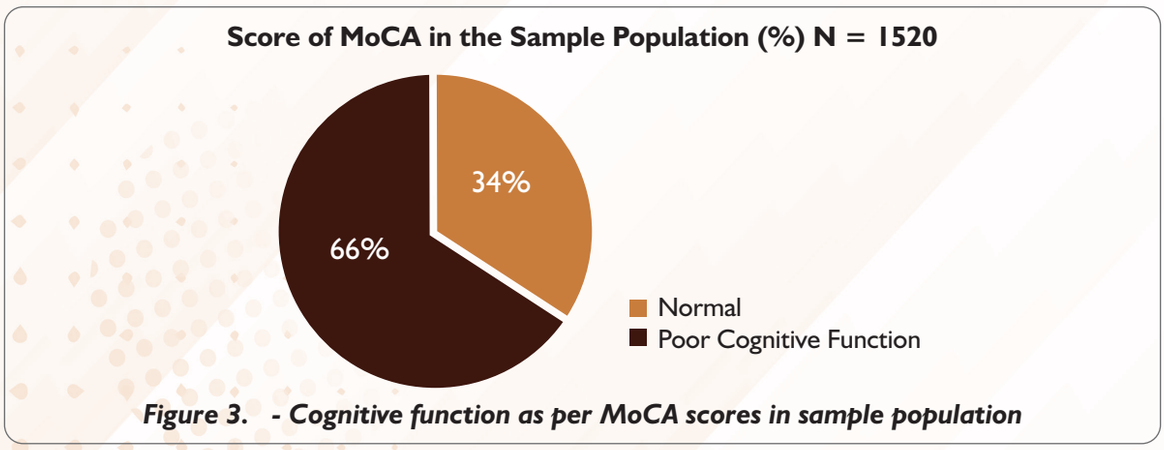

Figure 3. - Cognitive function as per MoCA scores in sample population

The correlation analysis (Table 2) revealed significant relationships between the Pittsburgh Sleep Quality Index (PSQI) scores and other measures. Global PSQI scores demonstrated a moderate positive correlation with PHQ-9 scores ($r = 0.480$, $p < 0.001$), indicating that higher levels of sleep deprivation were associated with increased depressive symptoms. Conversely, PSQI scores showed a moderate negative correlation with ASHS scores ($r = -0.353$, $p < 0.001$), highlighting that better sleep hygiene was associated with lower sleep deprivation. No significant correlation was observed between PSQI and MoCA scores ($r = -0.006$, $p = 0.832$), suggesting no direct association between sleep deprivation and cognitive function as measured in this population. Additionally, ASHS and PHQ-9 scores were negatively correlated ($r = -0.509$, $p < 0.001$), implying that better sleep hygiene is associated with lower levels of depression.

Table 2. Correlation between Sleep Deprivation, MoCA, PHQ9 and ASHS scores

	Global PSQI Score	MoCA score	Total ASHS score	PHQ 9 Score
Global PSQI Score	1	-.006	-.353**	.480**
MoCA score	-.006	1	-.044	.029
Total ASHS score	-.353**	-.044	1	-.509**
PHQ9 Score	.480**	.029	-.509**	1

** $p < 0.001$

Table 3 highlights the multivariate logistic regression analysis (adjusted), which identified several significant predictors of sleep deprivation among adolescents. Academic performance was inversely associated with sleep deprivation, indicating that better academic performance may decrease the likelihood of an adolescent being sleep deprived. Depression status was a significant predictor with adolescents experiencing depression being 3.5 times more likely to report sleep deprivation (95% CI 2.32- 5.33). Sleep hygiene, as measured by ASHS scores, also emerged as a critical factor, suggesting that better sleep hygiene substantially reduced the odds of sleep deprivation. Other variables, including age, sex, school attendance, type of family, BMI categories, and socio-economic status, were not significantly associated with sleep deprivation in this analysis ($p > 0.05$). No significant association was found between socio-economic class (SEC) and sleep deprivation (Chi-square = 9.16, $p = 0.06$).

Table 3. Multivariate analysis was carried out to understand the various factors influencing sleep deprivation

	B	Sig.	Exp(B)	95% C.I. for Exp (B)	
				Lower	Upper
Age	0.051	0.369	1.052	0.941	1.176
Sex (Male)	-0.121	0.477	0.886	0.634	1.238
School Attendance	0.005	0.280	1.005	0.996	1.015
Academic Performance**	-0.023	0.001	0.977	0.964	0.990
Type of family					
Nuclear		1.00			
Joint	20.160	0.145	0.770	0.590	1.02
Body Mass Index					
Underweight			1		
Normal	-0.346	0.335	0.708	0.351	1.428
Obese	-0.069	0.924	0.933	0.227	3.835
Overweight	0.115	0.802	1.122	0.455	2.770
Thin	-0.080	0.820	0.923	0.465	1.835
Socio Economic Class					
Upper	0.228	0.807	1.256	0.201	7.854
Upper-middle			1.00		
Upper lower	0.232	0.810	1.261	0.191	8.329
Lower middle	1.232	0.262	3.429	0.399	29.457
Lower	-0.334	0.722	0.716	0.114	4.511
Depression status**					
No			1.000		
Yes	1.256	0.000	3.511	2.315	5.325
Sleep Hygiene					
ASHS Score**	-0.819	0.000	0.441	0.333	0.584
MoCA					
Score	-0.264	0.153	0.768	0.535	1.103

** $p < 0.001$

CHAPTER 4

DISCUSSION

The study assessed the sleep deprivation among adolescents aged 12-18 years studying in schools of Delhi. The study highlighted the effect of various socio-economic, family, sleep environment factors on disturbances and deprivation of sleep among adolescents which may impact their cognitive performance, mental health as well as academic performance.

Sleep Quality among adolescents

The PSQI findings in the present study indicate that nearly one-fourth (22.5%) of the adolescents are sleep deprived, which is a significant cause of concern, particularly since sleep deprivation has been found to cause attention deficits in previous research. (60) Previous studies conducted for similar populations reported poor sleep quality among adolescents as well, although in varying proportions. (84,85) Research by Anderson et al., (86) highlights that children with fragmented sleep patterns exhibit slower processing speeds and increased lapses in attention, leading to difficulties with tasks requiring sustained focus. Similarly, Liu and Ji (32) found that shortened sleep duration and frequent awakenings interfere with memory consolidation, resulting in weaker recall abilities.

Cognitive function and sleep

Existing research shows that chronic sleep deprivation negatively impacts children's cognitive functioning. This is corroborated by Vriend et al., who observed that sleep-deprived children showed decreased performance on both fluid and crystallized intelligence measures, which assess reasoning skills and acquired knowledge, respectively.(87) These impairments may be due to inadequate brain maturation in regions associated with cognitive flexibility and problem-solving, as highlighted by the MRI findings of Taki et al., which link poor sleep quality to reduced gray matter volume in areas crucial for higher cognitive processes. (34) Additionally, another study by Touchette et al. shows that verbal intelligence is particularly susceptible to poor sleep quality, often resulting in delays in language and communication skills among affected children. (88) Interestingly, in the present study, while the MoCA results reveal that 65.7% of the sample population falls below the normal cognitive function threshold, no significant association between sleep deprivation and cognitive function was observed, depicting potential cognitive resilience in adolescents or the limitations of cross-sectional data. Interventions focusing on improving sleep and cognitive engagement, such as structured academic schedules and brain-stimulating activities, could benefit this population.

Socio-economic factors affecting sleep

Socioeconomic factors such as income, occupation, education may have significant impact on the sleeping habits of an individual, especially during adolescence, such that youth living in lower SEC conditions may experience poorer quality of sleep. (89,90) Nearly half of the participants

(46.3%) in the present study belonged to the lower-middle class, and 38.2% to the upper-lower class, however, the study does not show any associations between SEC and sleep deprivation, suggesting that other factors, such as lifestyle or environmental stressors, may play a major role. However, the strong association between SEC and cognitive function highlights the cognitive disadvantages faced by lower SEC groups, likely due to limited resources and higher stress, as highlighted in previous research among children. (91, 92)

The combined impact of sleep deprivation and socio-economic constraints might further exacerbate poor dietary habits, leading to suboptimal nutritional status. The findings from the present study highlight the need for targeted interventions addressing nutritional education and support, particularly in economically disadvantaged groups, to promote overall well-being in adolescents. Further research into dietary patterns, caloric intake, and potential micronutrient deficiencies may be explored to better understand and address the challenges of poor sleep caused due to nutritional disadvantage.

Sleep deprivation and depression among adolescents

The prevalence of depressive symptoms in the present study, as indicated by a mean PHQ-9 score of 6.86 ± 5.48 suggested that the study population is burdened by depression. A study from the US showed a prevalence of depression in adolescents to be around 16% in 2019 and a study from Patna showed the overall prevalence to be around 51%. (93, 94) However, the present study showed an overall prevalence of mild to severe depression in individuals to be around 60%, which is significantly higher from existing studies in similar populations. The proportion of adolescents with moderate to severe depression (26.9%) is particularly concerning, as it reflects a substantial subgroup at higher risk for adverse outcomes such as academic decline, social withdrawal, and long-term mental health issues. The significant deviation seen in the results from the previous studies implies that the factors contributing to adolescent depression—such as academic stress, psychosocial challenges, and hormonal changes—may be harming adolescent populations' sleep patterns. Depressive symptoms were also significantly associated with sleep deprivation. The positive correlation ($r = 0.48$) between PSQI and PHQ-9 scores in the present study highlights a moderate to strong relation between sleep deprivation and depressive symptoms, consistent with evidence identifying poor sleep as both a risk factor and symptom of depression. (32,95) The current findings thus highlight the importance of early screening and intervention in school settings, as undiagnosed and untreated depression in adolescents can have far-reaching consequences on cognitive development, emotional regulation, and future productivity. Programs tailored to address the specific stressors faced by this age group, alongside mental health education and access to counselling, could mitigate the burden of depression and improve overall well-being.

Effect of sleep patterns on academic performance

The impact of sleep deprivation on academic performance has been extensively documented, with evidence suggesting that insufficient sleep disrupts learning and information retention. (2, 73, 78) A study by Liu and Ji found that students with prolonged sleep latency and frequent

awakenings had consistently lower academic grades. (32) The present study found a significant association between academic grades and sleep deprivation in adolescents. Those who were sleep deprived were found to have lower mean academic grades (64%) compared to those who were not (67%, p = 0.004). Similar findings have been highlighted in existing literature. In a population-based study from Norway, sleep deprivation indicated higher odds of poor academic performance, and a systematic review from the US (2020) showed some significant association between characteristics of poor sleep and deprived sleep in adolescents and lower academic grades. (96, 97). These studies corroborate that chronic sleep deficits hinder both academic performance and broader cognitive functioning, further emphasizing the critical role of adequate sleep in developmental stages. Further, the results also underscore the importance of quality and adequate sleep for cognitive functions critical to learning, such as memory consolidation, focus, and problem-solving abilities.

Additionally, previous research indicates that inadequate sleep is associated with an increased risk of school non-attendance. Specifically in a study, short sleep duration (OR=4.61, CI 95% 3.29–6.46) and sleep deficiency (OR=3.26, CI 95% 2.67–3.99) had the most elevated odds leading to non-attendance. Considerable bedtime discrepancies in weekend versus weekdays were also associated with non-attendance (OR=2.43, CI 95% 1.93–2.02), as well as insomnia (OR=2.25, CI % 1.89–2.67) and daytime tiredness (OR=2.09, CI 95% 1.70–2.57) (96). However, the present study found no significant association between sleep deprivation and school attendance, suggesting that while adolescents may physically attend school, their academic engagement and productivity could be compromised due to poor sleep.

High prevalence of daytime dysfunction was also observed in the present study, with 48.3% of adolescents reporting issues staying awake during daily activities at least once a week. Significant daytime sleepiness likely contributes to poor academic performance due to reduced attention, memory retention, and processing speed. While most adolescents reported good daytime functioning, a subset experienced significant issues, including frequent difficulty staying awake and low enthusiasm. Although in the present study, only the issues pertaining to daytime dysfunction in adolescents were reported, while the associations between daytime sleepiness and other factors were not explored. These findings highlight the potential impact of inadequate sleep and stress, emphasizing the need for interventions to improve sleep hygiene and mental health. These indicators of daytime dysfunction, associated with sleep deprivation, may impair cognitive functions and motivation, further contributing to reduced academic performance. Addressing sleep hygiene and daytime functioning could mitigate these impacts and enhance learning outcomes.

Sleep Hygiene Among Adolescents

The Adolescent Sleep Hygiene Scale (ASHS) scores play a crucial role in assessing sleep hygiene practices among adolescents, which may significantly influence sleep quality and, in turn, cognitive functioning. Elevated ASHS scores, indicative of poor sleep hygiene, have been associated with various sleep-related challenges, including difficulty falling asleep, sleep-

disordered breathing, and disrupted sleep patterns. These issues often lead to chronic sleep deprivation, which adversely affects cognitive abilities, mood regulation, and overall mental well-being. The present study reported a mean ASHS score of 4.79 reflecting average sleep hygiene practices. These findings on sleep hygiene practices among the study population are generally on par with other previous studies conducted in different settings. (98,99) The previous studies from India reported strong associations between ASHS dimensions, particularly sleep stability and daytime sleep, indicating that stable sleep routines contribute to reduced daytime dysfunction (100). However, the present study has not explored the associations. The significant inverse relationship ($r = -0.353$, $p < 0.001$) between sleep hygiene and sleep deprivation through PSQI scores in the present study highlighted the crucial role of sleep-related habits in promoting healthy sleep patterns. The findings emphasize the importance of educational interventions aimed at improving sleep hygiene. Promoting consistent sleep schedules, reducing screen time before bed, and creating a conducive sleep environment could help mitigate sleep deprivation and its associated consequences, such as impaired academic performance and mental health challenges.

LIMITATIONS AND IMPLICATIONS

- The present study utilised a homogenous sample of students, thus limiting the diversity of students that the study may be generalized to. Hence, future research may explore a diverse sample for good replicability. However, quality control measures at all levels ensured that the results are valid for each group of individuals.
- Daytime dysfunction was not measured longitudinally in the present study, thus limiting the identification potential for possible causal relationships attributable to time. Future research should utilise a temporal design to ensure better identification of causality.
- The study did not explore the other factors such as screen time, physical activity, and dietary patterns, thus limiting understanding the role of these factors in the sleeping patterns of adolescents. Studies conducted further should clarify the roles of these factors in daytime dysfunction could provide a more holistic understanding of adolescent well-being.

CONCLUSION

This study highlights the high prevalence of sleep deprivation among school-going adolescents and its significant impact on cognitive function, academic performance, and mental health. Poor sleep hygiene and depression were found to be major predictors of sleep deprivation, while daytime dysfunction further contributed to reduced attentiveness and overall productivity.

These findings emphasize the urgent need for targeted interventions, including structured sleep education programs, parental awareness initiatives, and school policies that promote healthier sleep habits. Addressing sleep deprivation through improved sleep hygiene, mental health support, and lifestyle modifications can help mitigate its negative effects and enhance adolescent well-being, academic success, and long-term cognitive development.

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LIST OF CONTRIBUTORS

Department of Adolescent Health, Institute of Child Health, SGRH, New Delhi	National Health Systems Resource Centre, MoHFW, New Delhi
Col (Dr) Jyoti Kotwal Head, Dept of Hematology	**Maj Gen. (Prof) Dr. Atul Kotwal** Executive Director
Dr. Latika Bhalla Sr. Adolescent Health Paediatrician	**Dr Neha Dumka** Lead Consultant, KMD
Dr. Jyoti Bala Officer, Deptt. of Rehabilitation Medicine	**Dr Vineeta Sharma** Senior Consultant, KMD
Dr. Amit Kumar Officer, Deptt. of Rehabilitation Medicine	**Dr Sachina Rana** Consultant, KMD
Dr. Deepti Pandey Physiotherapist, Deptt. of Rehabilitation Medicine	**Mr. Sameer Ahmed** Fellow, KMD
Ms. Khushi Nagpal Research Associate	**Mr. Avik Kumar Ghosh** Fellow, KMD
Ms. Anjali Rawat Research Associate	**Ms. Vidhi Tyagi** Former Senior Consultant
Ms. Prachi Kaushik Research Co-ordinator	**Dr. Vahini Anand Kumar** Former Consultant
Ms. Gauri Sharma Data collector	**Experts**
Ms. Himani Kalra Data collector	**Dr Seema Patrikar** Senior Lecturer, Statistics, AFMC Pune
	Col (Dr) Arun K Yadav AFMS (Health), New Delhi

NATIONAL HEALTH SYSTEMS RESOURCE CENTRE

Ministry of Health & Family Welfare, Government of India