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Effects of sleep deprivation on the mental health of adolescents: a systematic review

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Abstract

This paper seeks to identify the factors and impact of sleep deprivation in the adolescent population and suggests pertinent preventive measures. We used diagnostic indicators and keywords to examine literature published from 2013 through bibliographic search tools. The risk of mental health problems is increasing, alongside cognitive and social impairments. Risk factors associated with sleep deprivation include circadian rhythm shifts, early school start times, and lifestyle choices. This may be catalyzed by additional factors such as excessive homework and utilization of social media, which contribute to inadequate duration and quality of sleep, leading to decreased academic and social challenges, higher risk-taking behaviors, stress, suicidal ideation, and diminished physical health. Delaying school start times, limiting electronic device usage before bed, promoting physical activity, and implementing sleep hygiene education can help improve sleep quality and overall well-being in adolescents by acting as preventative measures for this population. Parental involvement, through awareness and the implementation of consistent bedtimes, is also crucial for supporting healthy sleep habits. More research is needed to develop effective interventions within education and healthcare that can address the growing sleep and mental health crisis.

Introduction

Sleep is widely considered one of the most important factors responsible for adolescents' cognitive, physical, and emotional well-being. In adolescents specifically (individuals between the ages of 10 and 17), sleep is extremely fundamental in developing their physical, social, and academic functioning. It is recommended that adolescents sleep for around 8–10 h every day (Chaput and Dutil 2016). However, a large number of teenagers/ adolescents globally are not getting the required amount of sleep, impacting many aspects of their lives. In the United States, a study showed that 34.9% of individuals between the ages of 4 and 17 slept less than recommended for their age, and 31.2% of all adolescents suffered from sleep deprivation (Wheaton and Claussen 2021). Sleep deprivation refers to the inadequate sleep duration or sleep quality that a person gets.

During adolescence, the risk of being sleep-deprived increases around puberty. This is due to the Circadian rhythm, which shifts a couple hours later during the second decade of life (Reddy et al. 2023). It makes it harder for adolescents to sleep at bedtime, leading to more wake-ups during the night and resulting in less sleep overall. This is further compounded by the fact that although teens are sleeping later due to the rhythm shift, the school start times are not accordingly adjusted. Teens are expected to adhere to early school start times, resulting in a change in the circadian rhythm (Jamieson et al. 2020). This has several negative effects on people's

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minds, including depression, anxiety, and stress. It can also impair an individual's social development and family life (Montie et al. 2019). This could affect adolescents' academic performance (Owens and Weiss 2017). Furthermore, it creates negative consequences for their physical health, such as an increased risk for obesity, hypertension, and heart disease (Chaput and Dutil 2016). There has also been an escalation in self-injury, suicidal behavior, and thoughts among adolescents with a direct correlation to sleep deprivation (Zhang and Yu 2022).

While there have been innumerable studies on this, there has not been much of an improvement in the sleeping habits of adolescents. Without proper public awareness, protocols, and implementation of positive sleep practices, an adolescent's self-worth, behavior, day-to-day activities, and overall health could greatly affect their self-worth. Some practices, such as later school start times and awareness sessions on mental health and sleep deprivation with teenagers and their parents, would help alleviate the sleep problem.

This paper seeks to outline the impact of sleep deprivation on adolescents' mental health, while also emphasizing potential preventive strategies and treatments that could help those affected.

Methods

Information sources

The information in this research paper was obtained from many sources. We conducted a search in the PubMed database to search for studies from 2013 to 2023. The search included keywords such as Sleep deprivation, adolescents, mental health, anxiety, depression, teenagers, prevention, and treatment. The population included adolescents facing mental health conditions due to sleep deprivation. Figure 1 outlines the process used for selecting studies in the review.

Study abstraction and evaluation

This systematic review used a method of data extraction based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) and followed PRISMA guidance (Fig. 1). A total of 190 Records was identified from online databases through the inclusion criteria of the aforementioned keywords. An initial screening was conducted for the removal of irrelevances (such as records using non-human participants, records written in a non-English language, Records that do not meet Age Criteria, and Records removed for other reasons), which left a remaining 133 records. After this, a full-text screening was utilized to remove further unrelatedness, which left 73 reports that were sought for retrieval. Reports were finally checked for eligibility, wherein 36 articles were excluded. Articles were excluded if they did not meet the following criteria: (1) They did not meet the population requirements in terms of Age and the topic being studied; (2) They were not pertinent to the study of adolescent mental health and sleep patterns; (3) They showcased out-of-date circumstances by reflecting understanding which isn't pertinent to the study (prior to 2013); (4) It was not written in English. Table 1 shows the features of those studies which were included in the study.

Findings

Sleep quality

Sleep deprivation remains a problem among adolescents. 68.4% of high school students in the US sleep 7 h or less on school nights which is less than the recommended 8–10 h for this age group (Watson et al. 2017). Sleep quality is characterized by an individual's overall satisfaction with various aspects of their sleep experience. It has four main components: (i) Sleep Efficiency, which measures the percent of the amount of total time asleep to the total time in bed (ii) Sleep latency referring to the duration to transition from wakefulness to sleep; (iii) Sleep duration (iv) Wake After Sleep onset– is how much time a person is awake after falling asleep (Nelson et al. 2022). It encompasses issues such as difficulties in initiating sleep, deviations in Rapid Eye Movement (REM) sleep latency, lighter sleep, and elevated REM density. It has been noted that prolonged sleep onset latency and insomnia are common in adolescents (Hysing et al. 2013). As the sleep schedule gets disturbed and unhealthy sleep cycles are developed, the mental well-being of an individual is also affected. Increased anxiety in adolescents is attributed to low sleep quality (Dickinson et al. 2018). Furthermore, the discrepancy in the sleep cycle between weekdays and weekends leads to negative effects on health, mental disorders, and poor scholastic achievement in adolescents. It increases the risk of substance use, obesity, and suicidal thoughts as well (Sun et al. 2019). This can take the form of delayed sleep-wake phase disorder (DSWPD), a disorder where the regular sleep and waking times are delayed causing difficulties in falling asleep. DSWPD results in poor concentration, fatigue, and contributes to absenteeism. Individuals with this disorder may also have neuroticism and anxiety which could further aggravate insomnia (Futenma et al. 2023).Additionally, numerous studies have indicated that a substantial number of adolescents may exhibit heightened emotional responses when fatigued. Consequently, the prevalent sleep deprivation seen during this developmental stage may be linked to increased emotional volatility, such as intense mood swings involving fear, distress, and anger. Quality sleep is crucial, as inadequate sleep can lead to health issues and negative health outcomes.

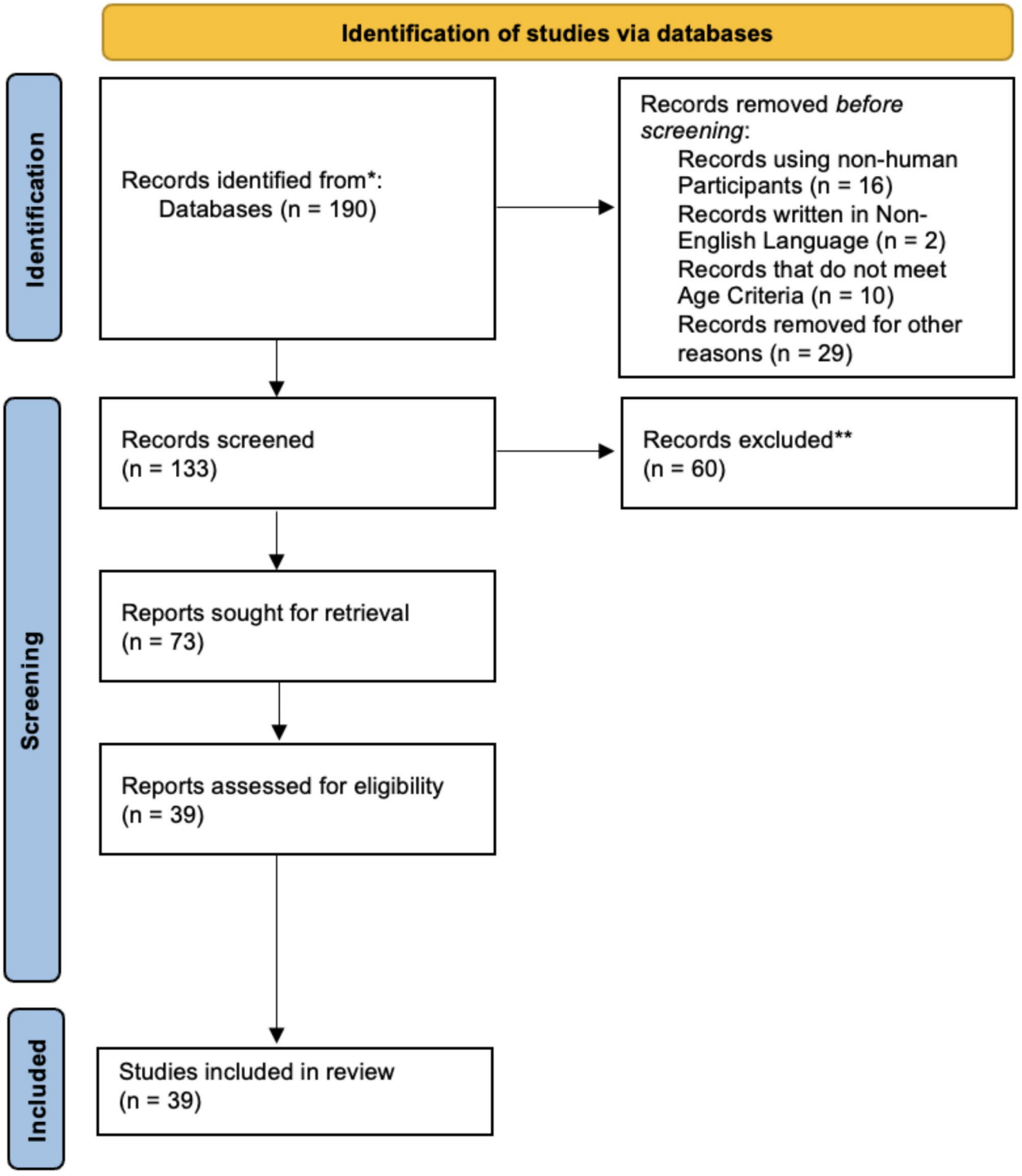

Fig. 1 PRISMA flow diagram

Sleep duration

In addition to the low sleep quality, there has also been a major decline in the average sleep duration among adolescents. Teenagers require about nine hours of sleep daily but due to the various factors, most of them don't meet this required amount of sleep. These factors include after school programs, heavy homework loads, caffeine intake, consumption of digital content, and early morning school start (Owens and Weiss 2017; Campbell et al. 2021). This, in turn, results in a delay in sleep onset which

Table 1 Summary of studies utilized for review

Study	Title	Summary
Chaput, Jean-Philippe, and Caroline Dutil. 2016	Lack of sleep as a contributor to obesity in adolescents: impacts on eating and activity behaviors	This article examines the link between sleep and obesity among adolescents. There is an association between sleep deprivation, poor sleep quality and overeating, poor diet and obesity. Hence a holistic approach to health, needs to target sleep, diet and physical activity as critical behaviors among adolescents.
Wheaton, Anne G, and Angelika H Claussen. 2021	Short Sleep Duration Among Infants, Children, and Adolescents Aged 4 Months-17 Years - United States, 2016–2018	This study evaluated data from the 2016–2018 National Survey of Children's Health to analyze the occurrence of inadequate sleep duration among individuals from 4 months to 17 years. It was found that 34.9% of adolescents slept less than the recommended duration. The proportion was even higher in southeastern states, among racial and ethnic minorities, individuals with lower socioeconomic status or special health needs. It also found that consistent bedtime was associated with better sleep duration.
Reddy, Sujana, et al. 2023	Physiology, Circadian Rhythm	This publication describes the physiology of the circadian rhythm. It is an internal body clock in our brain, which controls sleep and alertness by reacting to environmental changes. It helps humans adapt to external factors like energy, temperature, and availability of food thereby enhancing energy expenditure and internal body functioning.
Jamieson, Daniel et al. 2020	Investigating the links between adolescent sleep deprivation, fronto-limbic connectivity, and the Onset of Mental Disorders: a review of the literature	During adolescence, the risk of sleep deprivation increases due to circadian rhythm changes around puberty which is worsened by early school start times. This may result in an increased risk of mental health challenges. Studies have shown that for the myelination of axons (linking areas of grey matter; necessary for communication speed), sufficient sleep is required. It is concluded that sleep deprivation could lead to potential life-long mental health issues.
Montie, Koen et al. 2019	The impact of delayed sleep phase disorder on adolescents and their family	This study examined the effects of delayed sleep phase disorder (DSPD) on adolescents' school and social lives along with the lives of their parents. Adolescent DSPD impacts cognitive functioning, mental health, social and family lives. It requires increased awareness and support from physicians and the general public to reduce misunderstandings thereby enhancing their overall well-being.
Owens, Judith A, and Miriam R Weiss. 2017	Insufficient sleep in adolescents causes and consequences	This study analyses the various factors affecting sleep among adolescents and their consequences. It's prevalent due to various factors, including biological changes during puberty and external factors like extracurricular activities, excessive homework, use of internet and social media, caffeine intake, and early school start times. The effects of inadequate sleep include inattentiveness, reduced executive functioning, poor scholastic performance, obesity, cardio-metabolic concerns, mood swings, higher suicidal thoughts, risk taking behaviors like alcohol and substance use, and increased rates of accidents like driving, occupational, and those related to sports.
Zhang, Shan, and Chunyan Yu. 2022	The Link between Sleep Insufficiency and Self-Injury among In-School Adolescents: Findings from a Cross-Sectional Survey of Multi-Type Schools in Huangpu District of Shanghai, China	This study was conducted among adolescents in Shanghai, aiming to investigate the relationship between lack of sleep and self-harm. The results showed that insufficient sleep doubled the chances of self-harm. Girls had higher chances than boys and self-harm was more in ordinary schools than in key schools. This highlights the need for interventions and suggests changes in school environments and social contexts which could lead to stress in adolescents.
Watson, Nathaniel F et al. 2017	Delaying Middle School and High School Start Times Promotes Student Health and Performance: An American Academy of Sleep Medicine Position Statement	A position statement by the American Academy of Sleep Medicine (AASM) recommending that schools implement later start times to ensure students arrive at school healthy, alert, and ready for learning. Adolescence leads to changes in sleep and wake times, hence early middle and high school start times negatively impact students' health and well-being.
Nelson, Kathy L et al. 2022	Sleep quality: An evolutionary concept analysis	A concept analysis of sleep quality and its health consequences. Sleep quality is an individual's overall sleep satisfaction on four attributes: sleep efficiency, sleep latency, sleep duration, and wake after sleep onset. Factors affecting sleep quality include physiological, psychological, and environmental factors. Inadequate sleep leads to illness and negative health results. Nurses and clinicians must stress the value of good sleep for better health.
Hysing, Mari et al. 2013	Sleep patterns and insomnia among adolescents: a population-based study	The study examined sleep patterns and rates of insomnia in individuals in the 16–19 years age bracket. The study found that adolescents reported sleep deficiency of about 2 h on weekdays. Most adolescents reported sleep onset latency of more than 30 min. Girls had a longer sleep onset latency and a higher rate of insomnia than boys. It highlights the prevalence of sleep issues in adolescents and its importance as a public health issue.

Table 1 (continued)

Study	Title	Summary
Dickinson, David L et al. 2018	Personal sleep debt and daytime sleepiness mediate the relationship between sleep and mental health outcomes in young adults	This study identifies potential moderators of the mental health risks associated with short sleep and evening chronotype. The findings suggest that health care providers should assess hyper insomnia and sleep deficit in university students.
Sun, Wanqi et al. 2019	Associations of weekday-to-weekend sleep differences with academic performance and health-related outcomes in school-age children and youths	This study examines the co-relation of weekend to weekday differences in bedtime, risetime and sleep duration with school performance and health issues in students. It was observed that students with a difference in the weekday-to-weekend sleep duration showed lower academic performance and symptoms of depression. They are also at a higher risk of being overweight or obese (especially Asians). While it is inconclusive, larger sleep differences were seen to have potentially increased behavioral issues and suicidality. Additionally, the effect of differences in sleep duration on specific cognitive abilities, anxiety, and cardiometabolic risks had very little evidence.
Futenma, Kunihiro et al. 2023	Delayed sleep-wake phase disorder and its related sleep behaviors in the young generation	Delayed sleep-wake phase disorder (DSWPD) is a disorder that results in fatigue, reduced concentration, and week-day sleep deprivation. It could have led to often absences from school/work. This disorder could eventually lead to depression and other mental health issues. This disorder is determined by many genetic, psychological, social, and physiological factors. During the COVID-19 pandemic, prolonged sleep duration and delayed sleep have been noticed. This could lead to DSWPD, and young people could have problems academically and socially. Patients with this disorder also tend to have neuroticism and anxiety, which may lead to insomnia.
Campbell, Rebecca L et al. 2021	Greater adolescent tiredness is related to more emotional arousal during a hyperventilation task: An area under the curve approach	The study aimed to understand how tiredness predicts higher emotional arousal and adverse emotional responses in general. It confirmed that daytime tiredness is linked to emotional arousal from psychobiological stressors, increasing the mental health risks in adolescents due to common sleep deprivation among adolescents.
Touitou, Yvan et al. 2016	Disruption of adolescents' circadian clock: The vicious circle of media use, exposure to light at night, sleep loss and risk behaviors	This paper analyzes the effect of circadian rhythm shift on adolescents, resulting from light exposure. It also discusses the relation between the clock and the pineal gland, the importance of melatonin, and impact of media and substance abuse by adolescents.
McLay, Laurie et al. 2023	The relationship between sleep duration and health among Pacific adolescents within New Zealand: Findings from the Pacific Islands families study	The aim of this study is to demonstrate that sleep insufficiency is bidirectionally linked to negative behavioral, physical, and mental health outcomes in adolescents. The study revealed a strong association between insufficient sleep and depressive symptoms. It was concluded that insufficient sleep affects the mental health of adolescents. It is suggested that public health strategies with positive sleep practices are required especially among teenagers.
Lee, Younghee. 2017	Sleep duration's association with diet, physical activity, mental status, and weight among Korean high school students	This Korean study investigated how sleep duration is related to diet, physical activity, mental health, and nutritional uptake among Korean adolescents. Shorter sleep was seen to increase stress and suicidal ideation. It was concluded that only 16% of the students had > = 7 h of sleep a day which highly affects their physical and mental wellbeing.
Zhai, Xiaobing et al. 2021	Influencing factors of sleep quality among Chinese junior and senior high school adolescents during the COVID-19 pandemic	A study conducted in China on teenagers in junior and senior high schools discovered that at the time of the COVID-19 pandemic, poor sleep quality was common. Inadequate sleep quality was associated with several factors, including gender, education, spending time online researching COVID-19, having a friend or family member who is sick, and using electronics frequently. Poor sleep quality was eight times more likely to occur in adolescents with anxiety, and three times more probable in those with FNE. Comprehending these variables can aid in ascertaining plausible measures to enhance the caliber of sleep amidst the pandemic.
Robillard, Rebecca et al. 2021	Profiles of sleep changes during the COVID-19 pandemic: Demographic, behavioural and psychological factors	This study was conducted during the COVID-19 outbreak and aimed to analyze the changes in sleep at the time. With a sample of 5,525 Canadians, a survey was done, and it was found that the wake-times had been delayed substantially as compared to pre-pandemic times. Additionally, it was noted that sleep difficulties had also increased from 36–50.5%. Various factors including family responsibility greater exposure to television and greater stress levels were related to these sleep difficulties. This emphasizes the need for interventions specifically made for sleep problems during the pandemic.
Wang, Dongfang et al. 2022	Does sleep disturbance predict posttraumatic stress disorder and depression among college students during COVID-19 lockdown? A longitudinal survey	The study conducted during the COVID-19 lockdown examined the associations between sleep disruptions, PTSD and depression at the time. Sleep disturbances were high predictors of PTSD and depression in adolescents. To prevent or treat depression and PTSD, early evaluation and action against sleep disturbances could be an effective approach.

Table 1 (continued)

Study	Title	Summary
Gruber, Reut et al. 2021	Pre-pandemic sleep behavior and adolescents' stress during Covid-19: a prospective longitudinal study	This study aimed to compare the quality of sleep in adolescents before the COVID-19 pandemic and during it to investigate its influence on stress. 62 adolescents were assessed before and during the pandemic by reporting their sleep duration, schedule, quality, bedtime activities and daytime sleepiness. They also took information from the parents of the participants. The results showed that during the pandemic, there was an increased sleep duration along with a delay in daily schedules in comparison to before the pandemic. This along with cognitive-emotional arousal was connected with adolescent stress during the pandemic.
Stone, Julia E et al. 2021	In-person vs. home schooling during the COVID-19 pandemic: Differences in sleep, circadian timing, and mood in early adolescence	The study investigated the effect of online learning on sleep and circadian rhythm in adolescents in comparison to in-person classes. The sleep-wake time was monitored with the usage of wrist actigraphy and sleep diaries. Additionally, changes in the circadian rhythm were also assessed. It was noticed that adolescents had longer sleep durations during online learning due to the lack of commute which caused them to wake up later than when attending school in person.
Puteikis, Kristijonas et al. 2022	Sleep Quality, Mental Health and Learning among High School Students after Reopening Schools during the COVID-19 Pandemic: Results of a Cross-Sectional Online Survey	Aimed to study the difference in sleep quality and mental well-being of adolescents as in-person classes started after the pandemic. They conducted a survey at three competitive high schools. The results showed that while adolescents reported better study quality and physical health, they also reported worse sleep quality, shorter duration of sleep and worse mental health. This suggests the importance of in-person learning for academic quality and physical health but also highlights its negative impact on student mental health and sleep quality.
Comsa, Monica et al. 2022	The relationship between sleep and depression and bipolar disorder in children and young people	Aimed to investigate the association between sleep and bipolar disorder and depression. In adolescents, certain sleep disorders are closely related to depression and certain disorders such as insomnia, sleep apnea and other disorders related to the circadian rhythm are related to bipolar disorders and depression. It is also noted that depression and bipolar disorder can worsen sleep disorders and cause more sleep difficulties in young people as well.
Yeo, Sing Chen et al. 2020	Associations of time spent on homework or studying with nocturnal sleep behavior and depression symptoms in adolescents from Singapore	To investigate the relationship between time spent on academics and sleep behavior at night and symptoms of depression in teenagers. There was an inverse relationship between media use and the time spent in bed and academics. Scores of depression were greater in students who spent greater amounts of time on academics. A decrease in work outside of classes could improve adolescents' sleep, school-life balance, and mental health.
Evers, Katerina et al. 2020	Investigating the relation among disturbed sleep due to social media use, school burnout, and academic performance.	This study aimed to investigate the association between sleep disturbances due to usage of social media, school burnout and performance academically. It revealed a vicious cycle between the three with disturbed sleep being the common factor influencing the other two.
Hysing, Mari et al. 2016	Sleep and academic performance in later adolescence: results from a large population-based study	This study intended to investigate the link between the duration of sleep, sleep patterns, and scholastic performance in teenagers between the ages of 16 to 19. It concluded that weekday bedtime and delayed sleep schedules were closely linked to poor study performance. The study implies that sleep evaluation is crucial for adolescents underperforming at school.
Chan, Ngan Yin et al. 2017	Impact of a modest delay in school start time in Hong Kong school adolescents	Aimed to analyze how adolescent sleep, behavior and overall mood are affected by a delay in the start times at school. Students from the school with a later start time showed increased time in bed as compared to the regular school. A questionnaire showed that students from the intervention school showed improved mental health, fewer emotional problems, greater attentiveness, and lessened behavioral difficulties. School administrators and policymakers need to be committed in evaluating delayed school start-times to enhance adolescent sleep times and its effect on the mental state of teenagers.
Royant-Parola, S et al. 2018	The use of social media modifies teenagers' sleep-related behavior	The study aimed to assess how adolescent sleep patterns are affected by social media use and the consequences of sleep deprivation. It concluded that the availability of cell phones and social media in adolescents' bedrooms is related to reduced sleep and adverse effects on daily functioning and mood which are further amplified in older teenagers.
Lemola, Sakari et al. 2015	Adolescents' electronic media use at night, sleep disturbance, and depressive symptoms in the smartphone age	Adolescents tend to be more prone to poor mental health and sleep insufficiency is a major risk factor for this. The association between electronic use, sleep disturbances, and depressive symptoms was analyzed in this study. It was seen that smartphone usage led to later bedtimes but is not directly related to disrupted sleep and depressive symptoms. Sleep difficulties were seen to be negatively related to mental health. It is suggested that adolescents may gain from being educated on sleep hygiene and the various issues associated with electronic media use.
Charmaraman, Linda et al. 2021	Quantity, Content, and Context Matter: Associations Among Social Technology Use and Sleep Habits in Early Adolescents	The study looked at how early adolescents' access to, use of, and social context related to social media affected the amount and timing of their sleep. The usage of social media, its content, and its social environment were found to have a substantial impact on later bedtimes and shorter sleep durations on school evenings. Delaying smartphone ownership to a later age and parental rules limiting phone use were related to increased sleep duration and earlier bedtimes.

Table 1 (continued)

Study	Title	Summary
Lang, Christin et al. 2013	Increased self-reported and objectively assessed physical activity predict sleep quality among adolescents	The study aimed to test the association between exercise and sleep quality in students at adolescent vocational schools. The data collected using questionnaires confirmed the claim that adolescents with high Physical Activity (PA) levels would have more total sleep, lesser wakening at night, lesser symptoms of insomnia, and greater quality of sleep. Results implied that increased PA is related to recovering sleep patterns and is beneficial for both mental and physical health.
Choi, Heeseung et al. 2020	Relationship Between Sedentary Time and Sleep Duration Among Korean Adolescents	In adolescents, lack of sleep and greater sedentary period have more negative implications on mental and physical health. In this study, 50 Korean adolescents were observed over a 5-day period and the analyzed data from questionnaires and sleep logs showed that sedentary time had a substantial and negative relationship with sleep duration. Interventions were suggested for schools to reduce sedentary periods and improve sleep quality and duration.
Alanazi, Eman M et al. 2023	Sleep Hygiene Practices and Its Impact on Mental Health and Functional Performance Among Adults in Tabuk City: A Cross-Sectional Study	This study discovered a strong correlation between sleep issues, depression, daytime sleepiness and poor sleep hygiene practices. It outlines a comprehensive definition of sleep hygiene, according to the study, people who practiced poor sleep hygiene were more likely to experience melancholy, excessive daytime sleepiness, and sleep issues.
Gunderson, Justine et al. 2023	Association Between Insufficient Sleep, Depressive Symptoms, and Suicidality Among Florida High School Students	This study explored the association between sleep, symptoms of depression, and suicidal ideations. They investigated two predictors of depression– sadness and hopelessness along with suicidal ideations. The results showed that lack of sleep was correlated with higher feeling of sadness and hopelessness and greater suicidal ideation. Hence, it is crucial to give more attention to sleep in adolescents as a high-risk factor for depression and suicidal thoughts.
Illingworth, Gaby et al. 2019	The Teensleep study: the effectiveness of a school-based sleep education programme at improving early adolescent sleep	The study assessed the effects on teenage sleep and understanding of Teensleep, a school-based sleep education program. Ten lessons totaling the program were taught to sophomore students from 10 state-run high schools in UK. The findings indicated significant gains in knowledge about sleep, but only modest gains in hygiene and quality of sleep. According to the study, those who have trouble sleeping might benefit directly from sleep right away. However, more investigation is required to ascertain whether sleep education works as a preventative approach over the long run.
van Rijn, Elaine et al. 2020	Evaluation of an interactive school-based sleep education program: a cluster-randomized controlled trial	The study assessed an interactive Sleep Education Program (SEP) that was implemented in schools. 210 students participated in a cluster-randomized controlled experiment, where the control group was in a program with healthy living, and SEP was given to the intervention group. The SEP students gained knowledge on the value of sleep, obstacles to adequate sleep, and time management. At follow-up, the results revealed better sleep knowledge, but there were no changes in actual sleep patterns. According to the study, changing sleep behavior may require more than just sleep education.
Quante, Mirja et al. 2022	"Let's talk about sleep": a qualitative examination of levers for promoting healthy sleep among sleep-deprived vulnerable adolescents.	A series of focus group studies to analyze the mediating methods and strategies that teenagers employ to enhance sleep, as well as potential levers for promoting better sleep. Identified measures for improving sleep include highlighting poor sleep's health effects, increasing sleep hygiene awareness, addressing caffeine and screen use, and delivering sleep recommendations through more effective channels.
Biller, Anna M et al. 2022	Sleep improvements on days with later school starts persist after 1 year in a flexible start system	The study evaluated the potential benefits of flexible school start times on adolescent health and learning. By observing students and the sleep diaries maintained by them, it was noted that there was an increase in motivation, concentration, and quality of academic performance. Additionally, it improved both sleep quality and psychological wellbeing. The measure seems promising, but more research and experiments are needed.

combined with early morning school start times leads to sleep loss (Touitou et al. 2016). Additionally, internal biological processes that occur along with puberty such as a delay in the circadian rhythm also result in a lack of adequate sleep hours (Owens and Weiss 2017). This is evident from instances such as only 26.6% of adolescents in that population meeting the recommended amount of sleep (McLay et al. 2023). Additionally, with the sleep duration of adolescents averaging 5.7 h, individuals with shorter sleep duration were more likely to feel stress, hopelessness and have suicidal ideation (Lee 2017). It has been noticed that sleep deprivation is common, especially on weekdays, and is linked to lower academic performance, depressive symptoms, and an increased risk of overweight/obesity (Sun et al. 2019). Since chronic sleep deprivation threatens academic success and health in adolescents, it is critical to take measures that address the lack of sleep. Various suggestions have been made including later school start times that will enable sufficient sleep, and healthy sleep education for students and families so they can address factors under their control.

COVID-19 pandemic

A study conducted in the pandemic showed that revealed a substantial rise in sleep difficulties during the pandemic globally, which approximates to 36 – 50.5%.

Evidence that supports correlational predicates has been found. These include contributory factors such as higher anxiety levels, increased electronic exposure, lower exercise time, and diet quality (Zhai et al. 2021).

Due to various factors such as family responsibilities, earlier wake-up times, and illnesses during the pandemic, there was an increase in sleep difficulties which led to higher stress levels, heavier alcohol use, and screen time (Robillard et al. 2021). Another study found that sleep deprivation during the pandemic was significantly associated with post-traumatic stress disorder and depression and was also a good predictor of new onset of these mental health issues (Wang et al. 2022).

An increase in sleep duration, a delayed schedule, and a greater number of adolescents surpassing minimum sleep were observed during the pandemic (Gruber et al. 2021). While school start times were fixed during remote learning, the removal of travel in the morning likely allowed adolescents longer rest and aligned with a postponed circadian phase (Stone et al. 2021). A study in Lithuania assessed the impact on sleep quality and mental health after schools reopened during COVID-19. Two-thirds of students reported having poor sleep while half reported significant anxiety levels. This study further underscores the need to seriously re-look at later school times as a means of improving sleep and mental health (Puteikis et al. 2022).

Outcomes

Sleep deprivation has been seen to adversely impact the mental health of adolescents worldwide. It has been associated with various mental disorders including depression, anxiety, and bipolar disorders (Dickinson et al. 2018; Campbell et al. 2021; Comsa et al. 2022). In adolescents, sleep deprivation also impacts cognitive functioning, social life, family life, and parental well-being, which consequentially affects their mental health as well (Montie et al. 2019). Those adolescents who spend more time working at home on studying and homework, experience a decline in their sleep hours thus increasing their susceptibility to depressive symptoms (Yeo et al. 2020).

Inadequate sleep is associated with a significant increase in the occurrence of depressive symptoms and indulging in risk-taking behaviors like alcohol and substance abuse (McLay et al. 2023). Sleep deprivation leads to decreased attentiveness, increased risk of obesity, cardio-metabolic dysfunction, diminished cognitive control, lower academic performance, higher incidence of car crashes, workplace injuries, and sports-related injuries (Owens and Weiss 2017). Disrupted sleep resulting from social media use is linked to diminished academic performance and school burnout, which is characterized by feelings of exhaustion due to academic demands, a jaded and disengaged outlook towards schoolwork, and a sense of inadequacy as a student (Evers et al. 2020). Weekday bedtime has an impact on academic performance, with adolescents going to bed between 22:00 and 23:00 h having the best academic performance, as indicated by the Grade Point Average (GPA). Specifically, postponed bedtime on weekends was associated with substandard scholastic performance (Hysing et al. 2016).

Due to various factors such as social media usage, screen time, and early school start times, there has been a major decline in sleep quality and duration in adolescents. Moreover, biological factors such as a delay in the circadian rhythm and puberty also contribute to an increase in sleep deprivation among adolescents.

Treatment and prevention methods

Since sleep deprivation has major consequences for mental and physical health, preventive measures and proper treatment plans must be taken to address sleep duration and quality in adolescents. Adolescent sleep duration and quality can be improved and maintained through various interventions at school, home, and on an individual level like delayed school start times, controlling mobile and social media usage, and increasing physical activity. Since internal circadian rhythms in adolescents change, early school start times reduce the sleep duration and quality which could affect the learning of students along with impacting their physical and mental health. To prevent this, delaying school start times could positively impact students and their academic performance (Watson et al. 2017; Chan et al. 2017).

Mobile phone and social media usage at night have been associated with reduced sleep duration during school days (Royant-Parola et al. 2018). Electronic media usage is also associated with increased sleep difficulties which in turn are related to depressive symptoms (Lemola et al. 2015). Parental rules restricting electronic device usage before bedtime and delaying giving smartphones to a mature age are linked to longer sleep duration (Charmaraman et al. 2021). Hence families should establish limits on the usage of smartphones, social media, and electronic devices before bedtime. In addition to this, exercise has been identified as a favorable predictor of sleep duration and quality. Increased physical activity is associated with restoring sleep (Lang et al. 2013).

Sedentary time at school is negatively associated with sleep duration hence measures to reduce sedentary time in schools can help with addressing sleep deprivation (Choi et al. 2020). Adolescents should also be educated on sleep hygiene, which is the set of environmental and behavioral factors that influence healthy sleep patterns (Alanazi et al. 2023) and the risks of using electronic devices at night. This could be done at school or through mental health programs (Gunderson et al. 2023). An outcome analysis of TeenSleep, a teacher-led sleep education program in the UK, shows that while the program helped in enhancing sleep knowledge among the students, improvement in sleep hygiene and quality are limited to poor sleepers (Illingworth et al. 2020). In addition

to the aforementioned, to be truly effective, sleep education may need to be accompanied by other measures like changing school times and active parental involvement (Rijn et al. 2020).

Moreover, parents should also be made aware of the risks of lack of sleep and should implement consistent bedtimes to promote healthy cognitive development (Wheaton and Claussen 2021). A decrease in workload outside of class will allow for earlier and longer bedtimes and may also benefit their sleep and mental health (Yeo et al. 2020).

Discussion

To prevent the deterioration of mental health among adolescents, one of the first steps is to build proper sleep cycles and maintain sleep hygiene. It is necessary to ensure that adolescents are aware of the benefits of a good sleep schedule such as improved concentration, better mood, enhanced academic performance, and overall physical and mental well-being. Bringing attention to the drawbacks of sleep deprivation is essential: the increased danger of mental disorders, mood swings, long-term impacts on physical health, and increased trouble in focusing. Building awareness about sleep hygiene and addressing common barriers to achieving good sleep like curbing electronic device usage and caffeine consumption is equally important (Quante et al. 2019). This can be achieved through various methods including interactive awareness sessions at schools. This should also be started earlier in one's childhood as learning is much more effective at a younger age. Bringing in experts to introduce and explain the aforementioned points could persuade adolescents to pay more attention to their sleep schedule. This can be combined with parental reinforcement and monitoring to further help adolescents get better and longer sleep every day.

There is mounting evidence that delaying school start times can have a positive effect on the sleep duration of teenagers (Watson et al. 2017; Chan et al. 2017). This has been evidenced in the discrepancy in the increase in sleep duration during the COVID-19 pandemic, however, conflicting results may showcase an increased presence of sleep problems as well (Robillard et al. 2021; Gruber et al. 2021). It may be interpreted that the increase in the longevity of sleep is not impactful on the sleep quality during the pandemic, which in turn results in poor sleep. However, adoption of these delayed school start times is still quite limited due to low confidence in the available evidence and lack of clarity regarding the long-term impacts of delayed start times. These concerns can be addressed by solutions like flexible start times where students can choose a daily start between 8:00 to 8:50 AM and missed study time in that period can be compensated for during gap periods or after (Biller et al. 2022). Further research and experimentation in this area can help us find effective solutions. School administrators and policymakers should seriously evaluate options to provide delayed class times to enhance adolescents' duration of sleep, school performance, as well as overall mental health.

Those adolescents, who are already facing mental disorders because of sleep deprivation, must seek professional help from psychiatrists or therapists. It is essential to identify and resolve any mental health issues in earlier stages to prevent them from getting worse and causing excessive harm to the individual. For example, later identification could lead to higher chances of developing more serious mental disorders. It could also increase suicidal ideation and withdrawal from society. It is important to incorporate sleep as an important factor to address as part of mental health programs (Gunderson et al. 2023). Furthermore, it becomes more difficult to treat the disorder if it is identified late. To provide more favorable conditions to adolescents hesitant to seek help, there should be prevention programs, mental health programs, and easily accessible guides and facilities for all to use. This requires involvement from the government and school systems. Some measures that can be taken include the implementation of policies protecting adolescents regarding these issues, appointing counselors in schools, increasing the funding for mental health services, training for teachers, staff, and other healthcare professionals to identify mental health issues, and by collaborating with mental health organizations. Such services may be unaffordable for several adolescents, particularly when sought through private service providers. Hence, policymakers must institute measures that address the affordability and accessibility of these facilities.

Moreover, it is essential for parents and other adults to also be aware of the consequences of sleep deprivation. By ensuring that parents are conscious of the importance of good sleep quality and adequate sleep duration, they may be able to establish a good sleep schedule for their children. Furthermore, they might be able to enforce limits on screen time that their children are exposed to, especially before their bedtime (Charmaraman et al. 2021). This could increase the possibility of prevention of mental health disorders and ensuring early treatment if required. As another method, using the peer group to bring improvements in one's sleep and social media usage could be more effective, as an adolescent's peer group tends to be much more influential than their parents or teachers. Using online means to garner attention and raise awareness of the matter, is also an effective method of preventing sleep deprivation and its associated mental health issues. By creating websites and apps to relay information on sleep deprivation, a more global reach is achievable (Quante et al. 2019). Some apps promote this information and provide methods to prevent

and improve these issues. Additionally, websites which focus on promoting mental health awareness and protection of emotional well-being among adolescents and young adults have yielded positive results. Governments and non-profit organizations can take advantage of the reach social media has among adolescents and use interactive and attention-grabbing posts to laud the merits of a good sleep schedule and the harmful effects of sleep deprivation. To prevent the further rise in mental health issues among adolescents, it is crucial to maintain one's sleep cycle. Failing to do so would have several detrimental effects. It would negatively affect an individual's cognitive abilities by impairing various cognitive processes such as memory, decision-making, and emotion regulation along with decreasing reaction time. This would lead to an increase in the risk of multiple mental disorders. Consequentially, these mental disorders could cause a decline in academic performance and physical health while increasing suicidal ideation among adolescents as well. Adequate sleep will have a positive impact on mental well-being, physical health, learning outcomes, and social development of adolescents.

Implications and contributions

This research paper investigates the rise in sleep deprivation among adolescents, thereby urging stakeholders to set regulations to address mental well-being. Current research establishes an association between sleep deprivation and mental health, yet specific research regarding interventions for sleeplessness would help identify solutions for education and healthcare sectors.

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RB, KJ, RP conceptualized paper and performed literature review. KJ wrote first manuscript draft that was revised by RP, AK and RB. All authors reviewed manuscript.

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