The National Healthy Sleep Awareness Project involves a partnership between the American Academy of Sleep Medicine, Center for Disease Control and Sleep Research Society. The long term goal of the project is to promote improved sleep health in the United States. The project will increase public awareness of the importance of healthy sleep. It also will promote the treatment and prevention of sleep disorders.

Teenagers: Sleep Patterns and School Performance

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INTRODUCTION

Sleep patterns of teenagers have been extensively studied and have revealed considerable variations between school nights and non-school nights of rest. Total sleep time tends to be less on school nights when compared with non-school nights. Bedtime and wake times appear to be influenced by external factors such as school start times and changes during puberty to later sleep onset time resulting in a diminished total sleep time and daytime sleepiness.

WHAT IS A NORMAL SLEEP PATTERN?

Sleep is classified into the two types: NREM (Non-rapid eye movement) sleep and REM (rapid-eyes-movement) sleep. Cycling through all of the sleep stages for an adequate amount of time is essential to achieving a good night's sleep and adequate functioning the next day. These sleep stages are defined by distinct polysomnographic features of electroencephalographic patterns, eye movements and muscle tone.

NREM sleep is characterized by distinct EEG patterns including sleep spindles, K complexes and slow (delta) activity. The respiratory and cardiovascular parameters are relatively regular. In contrast REM sleep, is characterized by asynchronized cortical activity with a high brain metabolic rate, dreaming, lack of normal thermoregulation, and irregular respiratory and cardiac rhythms. The hallmark features of REM sleep include absent of skeletal muscle tone with the exception of the diaphragm, middle ear and erectile muscle, and episodic burst of rapid eye movement.

WHY IS SLEEP IMPORTANT?

There are many theories concerning the need for sleep. However, what we know

has primarily evolved from research studies conducted in animals and humans examining the impact of sleep deprivation on the physiological and neurobehavioral systems. During sleep important body functions and brain activity occurs to create new pathways for learning and memory. Insufficient sleep alters activity in some parts of the brain that may interfere with the ability of making decisions, alertness, solving problems, controlling emotions and behavior, and coping with change.

WHAT IS CONSIDERED AN APPROPRIATE AMOUNT OF SLEEP FOR TEENAGERS?

The National Sleep Foundation released recommendations in February 2015 that school-aged adolescents (14 to 17 years) should obtain at least 8 to 10 hours of sleep per night. However, on average the amount of sleep that teenagers achieve is about 7 hours, particularly on school nights. Thus, teenagers are constantly coping with "sleep debt" during the school year. The amount of sleep reported by adolescents varies across countries and regions; but overall patterns of later sleep timing and diminished sleep across adolescents is reported by most investigators. If this sleep is cumulative, subjective and objective evidence of increased daytime sleepiness should appear.

The most recent US poll of sleep patterns in adolescents was reported by the National Sleep Foundation in 2006. This data showed that on average, adolescents get about seven and one-half hours of sleep on school nights. However, the amount of sleep varies by grade, with teenagers tending to get less sleep, as they get older.

This is of particular concern because chronic sleep deprivations, also known as sleep loss, insufficient or deficient sleep, leads to a myriad of health deficits. Disrupted sleep-wake cycles and sleep restriction contribute to significant negative effects on the renal, cardiovascular, thermoregulatory, digestive, and endocrine systems. For example, sleep loss can contribute to insulin resistance and the development of metabolic abnormalities, obesity, and diabetes mellitus.

Furthermore, inadequate sleep has also been associated with mental health and safety deficits. Sleep deprived teenegers have less interest to participate in physical activity or sports. They are more likely to be depressed, anxious, irritable, defiant, and impulsive than teenager who achieve optimal sleep amounts. They are at increased risk for suicidal ideation, substance use, as well as motor vehicle accidents related to drowsy driving.

Sleep restriction has been linked to cognitive and behavioral problems that adversely impact academic performance and functioning. For example, teenagers

who are chronically sleep deprived have worse academic performance. Teenagers achieving inadequate amounts of sleep have increased absenteeism and tardiness, decreased ability to learn and retain material, and diminished ability to actively participate in the classroom and perform decision-making tasks.

HOW DOES PUBERTY ALTERS SLEEP-WAKE CYCLE?

There are changes in the biological clock or circadian rhythms of teenagers. At about the time of puberty onset, most teenagers begin to experience a sleep-wake "phase delay" (later sleep onset and wake up time), manifested as a shift of up to 2 hours relative to sleep-wake cycles in middle childhood.

The onset of sleep is triggered by the release of melatonin, a natural body hormone. Toward dawn, melatonin shuts off and cortisol increases and also core body temperature rises, signaling the individual to wake up. Two biological changes in sleep regulation are thought to occur during puberty. First, there is a delayed timing of nocturnal melatonin secretion, that parallels a shift in circadian phase preference. Therefore, teenagers have a biological tendency to fall asleep later in the evening and to wake up later in the morning. Additionally, sleep drive is altered across adolescence. Even those teenager, who have experienced sleep deprivation (and therefore accumulated a sleep debt) tend to feel more alert in the evening, thus making it more difficult to go to bed at a time that parents might consider a reasonable hour. There is a further "mismatch" in that early school start times for adolescents and teens that do not allow them to achieve their biological need to have a later out-of-bed/wake time and achieve an adequate amount of sleep for optimal daytime functioning.

ARE THERE OTHER FACTORS THAT CONTRIBUTE TO SLEEP DEPRIVATION IN ADOLESCENTS?

There are others reasons why teenagers do not get enough sleep. For example, caffeine consupmtion is increasing among adolescents to fight against the daytime sleepiness, resulting from not getting enough sleep. More worrisone is the increasing consumption of energy drinks and "super caffeinated" products like caffeine pills and gums to promote alertness. Daytime and evening caffeine consumption may further disrupt nighttime sleep. The ability to achieve an appropriate sleep onset time and adequate amounts of sleep may be further impaired by after school activities (part-time work), socializing and electronic devices. Erratic sleep schedules, principally during non-school nights, in an attempt

to compensate for the lack of sleep during school nights, seems to be a good idea, but can even make worse the situations. These behaviors impaired the ability to develop appropriate bedtime/sleep time and out of bed time/wake schedules that promote healthy and adequate sleep for teens. Later school start times, even as little as 30 minutes have been associated with improved academic performance and reduced vehicle accidents among teens.

WHAT SLEEP DISORDER SHOULD BE EVALUATED IN A SLEEPY ADOLESCENT?

Among adolescents and teenagers, common sleep problems include sleep disordered breathing, insomnia, and hypersomnolence. They may also experience other sleep disorders such as restless leg syndrome and parasomnias such as sleepwalking. Sleep problems occur very frequently in this age group. His important that all adolescents and teenagers be screened for sleep problems including questions regarding nighttime sleep, daytime sleepiness, and snoring.

HOW TO GET A GOOD NIGHTS SLEEP?

According to leading sleep researchers, there are techniques that may be implemented in order to decrease the common sleep problems such as keep a regular sleep-wake schedule that allows for a developmentally appropriate amount of sleep; avoid caffeine beverages four to six hours before bed and minimize daytime use; avoid alcohol and heavy meals before sleep; practice regular exercise; minimize noise, light and excessive hot or cold temperatures during sleep; establish regular bed time and go to bed at the same time each night; early morning bright light exposure may help to promote an earlier bedtime/sleep time.

REFERENCES

1. Moore M, Kirchner HL, Drotar D, Johnson N, Rosen C, Redline S. Correlates of adolescent sleep time and variability in sleep time: the role of individual and health related characteristics. *Sleep Med*. 2011;12(3):239–245.
2. Millman RP; Working Group on Sleepiness in Adolescents/Young Adults; AAP Committee on Adolescence. Excessive sleepiness in adolescents and young adults: causes, consequences, and treatment strategies. *Pediatrics*. 2005;115(6):1774–1786.
3. Owens J. Insufficient sleep in adolescents and young adults: an update on causes and consequences. *Pediatrics*. 2014;134(3):921–932.
4. Adolescent Sleep Working Group, Committee on Adolescence and Council on School Health. School start times for adolescents. *Pediatrics*. 2014;134(3):642-649.

5. Wolfson AR, Carskadon MA. Understanding adolescents' sleep patterns and school performance: a critical appraisal. *Sleep Med Rev*. 2003;7(6):491–506.
6. Carskadon MA. Sleep in adolescents: the perfect storm. *Pediatr Clin North Am*. 2011;58(3):637–647.
7. Crowley SJ, Acebo C, Carskadon MA. Sleep, circadian rhythm, and delayed phase in adolescence. *Sleep Med*. 2007;8(6):602–612.

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