REVIEW ARTICLE

Health Effects of Acute and Chronic Sleep Deprivation in Different Age Groups

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Introduction

Sleep deprivation is becoming more common in our society today. Nearly 50 to 70 million Americans experience a deficiency in sleep[1]. This is a substantial increase compared to several decades ago and may be partly attributed to modern work, education, and lifestyle demands. While some people have environmental factors to blame for their poor sleep, others suffer from a variety of medical conditions that inhibit their ability to achieve a full night of restful sleep, including sleep apnea, restless leg syndrome, and insomnia[2]. No matter what the reason may be for getting less sleep, recent studies have shown that sleep deprivation has a number of health manifestations. Specifically, adults who sleep less than 7 hours a day tend to have higher rates of cardiovascular and metabolic disorders[2]. Older adults also suffer from detrimental health effects specific to their age group. Those who do not achieve sufficient sleep tend to be more likely to develop memory and cognitive deficits[3]. Adults are not the only ones suffering from the effects of sleep loss. Almost one quarter of adolescents admit to sleeping less than 6 hours a night, which has been linked to increased complications in psychological and physical health[4].

This article reviews the health effects of acute and chronic sleep deprivation in three subsets of population: adolescents (ages 12-17), young and middle age adults (ages 18-49), and older adults (age 50 and above).

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Adolescents

Contrary to what some people may believe, adolescents actually need more sleep than adults and even children. There is some evidence that adolescents need about 9 hours per night, where as adults usually need about 7-8 hours[5]. The reason for this has been partly attributed to the physiologic changes that occur with puberty. Adolescents going through puberty experience a phase delay that changes their sleep-wake cycle and causes the circadian sleep initiation to occur later in the night[4]. Add this phenomenon to growing academic pressures, earlier school start times, technologic advances, and social activities, and it becomes evident why so many teens suffer from sleep insufficiency[5].

Acute sleep deprivation impacts adolescents in a number of different ways. Teens with insufficient sleep tend to be less attentive and driven in school[6]. This has shown to lead to poorer grades and higher diagnoses of ADHD within these students[5]. It has also been shown that teens who sleep for a shorter duration of time report greater symptoms of fatigue, unhappiness, and lower satisfaction with life. In fact, adolescents with sleep deprivation have higher rates of major depression and depressive symptoms[4]. On the other hand, adolescents who achieve adequate sleep are more likely to display healthy behavior, including a balanced diet, exercise, and stress management[6].

Chronic sleep deprivation has not been well studied in adolescents compared to adults. There have been some findings that continued sleep insufficiency leads to fatigue, behavioral problems, and risks of being overweight in the future[5,6].

Young and Middle Age Adults

Nearly one-third of adults sleep less than seven hours a day[2]. This is about a two hour decrease in average sleep time from 50 years ago. While sleep is often neglected for various reasons, the effects of inadequate sleep are becoming more prevalent. Studies have shown that after only 12 hours of sleep deprivation, the body begins to experience an increase in sympathetic regulation, which leads to an elevated heart rate and blood pressure. Yet these results are not always reproducible in studies that limit their subjects to only the supine position[7]. It has also been found that misalignments in the circadian cycle have an even greater effect on the sympathetic nervous system. Circadian misalignment frequently occurs in individuals who perform shift work or suffer from jet lag, as their bodies are forced to stay awake during hours that are normally reserved for sleeping. This pushes their circadian cycle into a different rhythm. Studies have shown that individuals with circadian misalignment and sleep deficiency suffer from greater increases in heart rate and urine norepinephrine levels than those who are only sleep deficient[8]. When these sympathetic changes continue to occur on a regular and chronic basis, it increases the likelihood of having a stroke, myocardial infarction, and other cardiovascular complications[2]. There are other physiologic changes that occur even before these sympathetic changes are physically noted. Endothelial cell activation occurs early and can be viewed as an acute inflammatory response to sleep restriction. This activation, which was found hours before changes in blood pressure and heart rate, leads to vascular dysfunction and is found in early stages of atherosclerosis[9].

Cardiovascular changes are not the only ones seen in sleep deprived adults. Adults who sleep less than 5 hours are 1.5 times more likely to develop obesity[2]. This finding has been partly attributed to the fact that sleep loss causes an increase in ghrelin levels and a decrease in leptin levels. Since ghrelin is a hunger driving hormone, individuals with higher levels of ghrelin are more likely to consume greater calories and become overweight[10]. In fact, increasing body mass index has been shown to be proportional to decreasing sleep in people averaging less than eight hours a night[11]. The amount of energy used after acute sleep deprivation has also been measured. In a recent study, young healthy males who were subjected to one night of sleep loss were found to have reduced energy expenditures the following day[10]. This acute lack of physical activity combined with altered hunger hormones places sleep deprived individuals at an even greater risk of becoming overweight. Another study actually found that the changes in ghrelin and leptin are not the same in acute and chronic sleep deprivation. Individuals who suffered from acute sleep restriction tended to have greater changes in ghrelin levels while those who suffered from chronic sleep restriction tended to have more changes in leptin levels[11] .

Sleep deprivation also alters glucose metabolism and insulin sensitivity. It is thought that the sleep deprived brain does not use glucose as effectively as a fully rested brain and the increased sympathetic activation in a sleep deprived body decreases the amount of insulin released. This leads to a state of decreased glucose tolerance and insulin sensitivity[7,12]. This is particularly important in chronic sleep deprivation where long-term changes in glucose and insulin regulation can increase the risk of developing type 2 diabetes[2,7]. Several studies have shown that type 2 diabetes and obesity rates have increased over the same time period that sleep deprivation has increased[12].

Sleep deprivation also affects behavior and cognitive function. Individuals with sleep deficiency tend to have lower levels of alertness and impairment in cognition[13]. Reaction times are slower in sleep deficient individuals and are actually equally slow in both acute and chronic sleep deprivation, although the fastest ten percent of reaction has not been shown to be affected in either acute or chronic sleep restriction. While objectively individuals with acute and chronic sleep deprivation can perform similarly, subjectively, people tend to feel the sleepiest after the one night of sleep restriction and then have stable feelings of sleepiness for several continued nights of sleep restriction[14]. Acute sleep deprivation also decreases postural control, which is necessary for various daily motor tasks, such as driving and lifting objects. Similar to reaction times, one night of sleep deprivation has the same effect on posture as chronic sleep deprivation, especially when the sleep deprivation is due to poor quality sleep[15]. Both delayed reaction times and poor posture control are risk factors for accidents, including motor vehicle, occupational, and home. In fact, sleepiness is now becoming one of the leading causes of motor vehicle accidents and the cognitive and motor impairments caused by sleep deprivation are analogous to that of alcohol intoxication near the legal limit[2]. Although previously assumed, there is no conclusive data on the effects of sleep deprivation on impulsive behavior. One study found that risky behavior was actually decreased in women, but increased in men after acute

sleep deprivation. It is theorized that chronic sleep deprivation with stress may cause a more profound change in impulsivity[13].

Older Adults

While older adults have many of the same health issues as young and middle age adults, one of the biggest concerns for older adults is memory impairment. As adults age, total sleep time and sleep quality begins to decrease. Sleep becomes fragmented with increased nighttime awakenings. It also takes older adults longer to fall asleep and circadian rhythms shift so that they wake up earlier in the morning[16]. Several studies have shown cognitive deficiencies associated with poor sleep, particularly when certain phases are disrupted. REM sleep is known to be an important phase of sleep for integration of learning and memory, while slow wave phase sleep helps with creation of declarative memories. There have been increased findings of sleepiness and cognitive deficits when these two phases are interrupted[3, 16]. One area of the brain that seems particularly susceptible to sleep deprivation is the prefrontal cortex. This area plays a role in memory and attention, which may explain some of the memory difficulties found in sleep deprived individuals[3]. Sleep has also been shown to help with removing amyloid-β protein, a key marker in the development of Alzheimer's dementia. Thus it has been theorized that sleep impairment plays a role in the development of dementia[16] .

Cognitive deficits from sleep deprivation do not have equal effects on everyone. Older women tend to experience more effects of low sleep, such as fatigue, compared to men. This may be due to hormone changes and emotional factors. Individuals from low socioeconomic backgrounds were also found to have more sleep problems, possibly from environmental factors[3]. It was also found that when depression was accounted for when evaluating poor sleep in older individuals, the effects of cognitive dysfunction were not as pronounced. This raises additional questions about the association between depression, sleep and cognitive dysfunction[16].

Many older adults have underlying sleep disorders that impede their ability to get a full night of sleep and affect cognitive function. Obstructive sleep apnea (OSA) is one of the most common causes of sleep disorders. Studies have shown that OSA can lead to brain damage which can lead to dementia. Early treatment of OSA has been shown to improve cognitive dysfunction[16]. Poor sleep, especially disrupted sleep, can also increase risk of developing cerebral arteriosclerosis and stroke in older adults[17].

Conclusion

Acute and chronic sleep deprivations have a number of different health effects. Adolescents who are sleep deficient are more likely to be depressed, inattentive, and do poorly in school. Young and middle age adults who suffer from sleep loss are at increased risk of developing cardiovascular issues, diabetes, and obesity. Sleep restriction has been shown to cause decreased alertness and posture control, resulting in greater accidents. Older adults with sleep deprivation suffer from memory impairment and cognitive dysfunction making them more prone to developing dementia. Additional studies are needed to fully evaluate the differences between the health effects of acute versus chronic sleep deprivation, especially to evaluate the effects of sleep restriction from adolescence to adulthood.

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