

THE IMPACT OF SLEEP DEPRIVATION ON HUMAN HEALTH

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Abstract. *Sleep is a fundamental biological need, yet insufficient sleep has become widespread in modern societies. This review summarises the evidence on the consequences of acute and chronic sleep deprivation for human health. Adults are recommended to sleep at least seven hours per night, but about one-third of adults in some countries report sleeping less than this. Experimental studies show that restricting sleep to six hours per night for two weeks produces cognitive deficits comparable to those caused by two nights of total sleep deprivation, and that 17–19 hours of wakefulness impair performance to a degree similar to a blood alcohol concentration of 0.05%. Meta-analyses of prospective studies link short sleep to higher all-cause mortality, coronary heart disease, stroke, type 2 diabetes and obesity, while experimental studies demonstrate impaired glucose metabolism and reduced resistance to infection. The article discusses the mechanisms underlying these associations and considers the particular vulnerability of medical students and health workers. Promoting healthy sleep should be regarded as an essential component of public health and medical education.*

Keywords: *sleep deprivation, short sleep, cognitive performance, cardiovascular disease, metabolism, immunity, mortality, medical students.*

INTRODUCTION

Humans spend roughly one-third of their lives asleep. Far from being a passive state, sleep is an active, highly regulated process that is essential for memory consolidation, emotional regulation, metabolic and hormonal balance, immune function and the clearance of metabolic waste from the brain. Sleep is regulated by the interaction of a homeostatic process, in which the pressure to sleep increases

with the duration of wakefulness, and a circadian process driven by the internal biological clock.

In modern societies, however, sleep is often sacrificed for work, study, social activities and screen use. Shift work, long commuting times and the constant availability of electronic devices further reduce the time devoted to sleep. In the United States, an analysis of data from more than 440,000 adults found that 34.8% reported sleeping less than seven hours in a 24-hour period [1]. Insufficient sleep is therefore not an individual problem but a public health issue.

The aim of this article is to review the evidence on the effects of sleep deprivation on human health, to examine the mechanisms involved and to discuss the implications for medical students and health professionals.

MATERIALS AND METHODS

This article is a narrative review based on consensus recommendations of sleep medicine organisations, controlled laboratory studies of sleep restriction and meta-analyses of prospective cohort studies published in peer-reviewed journals. The results of meta-analyses are presented as relative risks (RR) or odds ratios (OR) with 95% confidence intervals (CI) where available. Key findings are summarised in figures and tables.

RESULTS

3.1. How much sleep do we need? Sleep needs change across the life span. The National Sleep Foundation, on the basis of a systematic review by an expert panel, recommends 14–17 hours for newborns, 9–11 hours for school-age children, 8–10 hours for teenagers, 7–9 hours for young adults and adults, and 7–8 hours for older adults (Figure 1) [2]. The American Academy of Sleep Medicine and the Sleep Research Society concluded that adults should sleep seven or more hours per night on a regular basis to promote optimal health, and that sleeping less than seven hours is associated with adverse health outcomes [3].

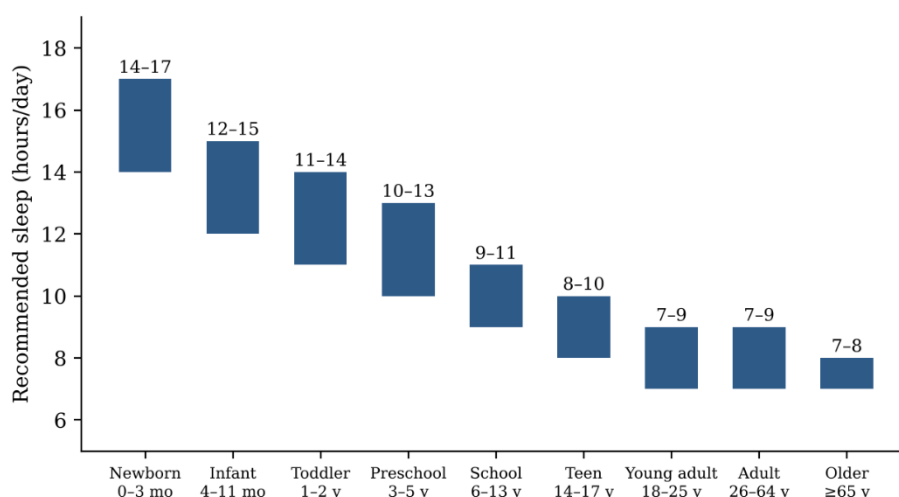


Figure 1. Recommended sleep duration by age group (data: National Sleep Foundation [2])

Sleep deprivation can be acute, when a person remains awake for an extended period, or chronic, when sleep is regularly shorter than needed. The second form, often called sleep restriction or “sleep debt”, is much more common and is particularly dangerous because people tend to underestimate its effects.

3.2. Effects on cognitive performance and safety. In a landmark laboratory study, H. P. Van Dongen and colleagues restricted healthy adults to four, six or eight hours of time in bed per night for 14 days. Participants restricted to six hours per night developed cumulative deficits in attention and working memory equivalent to those observed after two nights of total sleep deprivation, yet they rated themselves as only slightly sleepy [4]. This dissociation between objective impairment and subjective awareness explains why chronically sleep-deprived people often fail to recognise the danger. A. M. Williamson and A. M. Feyer found that after 17–19 hours without sleep, performance on several tests was equivalent to or worse than that at a blood alcohol concentration of 0.05%, and after longer periods it reached levels equivalent to 0.1% [5]. Sleep deprivation therefore increases the risk of road traffic accidents, occupational injuries and medical errors.

3.3. Effects on metabolism and body weight. Sleep loss has profound effects on metabolism. K. Spiegel and colleagues showed that restricting sleep to four hours per night for six nights in healthy young men impaired glucose tolerance

and altered the activity of the hypothalamic–pituitary–adrenal axis and the sympathetic nervous system, producing changes similar to those observed in normal ageing [6]. Sleep restriction also alters the appetite-regulating hormones leptin and ghrelin, increasing hunger and the preference for energy-dense foods. Consistent with these mechanisms, a meta-analysis of cross-sectional studies found that short sleep was associated with obesity in both children (OR 1.89) and adults (OR 1.55) [7], and a meta-analysis of prospective studies found that short sleep increased the risk of developing type 2 diabetes (RR 1.28) [8].

3.4. Effects on the cardiovascular system and mortality. Short sleep is associated with elevated blood pressure, increased sympathetic activity and systemic inflammation. A meta-analysis of prospective studies by F. P. Cappuccio and colleagues found that short sleep was associated with a 48% higher risk of developing or dying from coronary heart disease (RR 1.48) and a 15% higher risk of stroke (RR 1.15) [9]. Another meta-analysis of 16 prospective studies involving more than 1.3 million participants found that short sleep was associated with a 12% higher risk of all-cause mortality (RR 1.12; 95% CI 1.06–1.18). Interestingly, long sleep was also associated with higher mortality (RR 1.30), suggesting a U-shaped relationship in which long sleep may be a marker of underlying illness [10]. The main associations are presented in Figure 2 and Table 1.

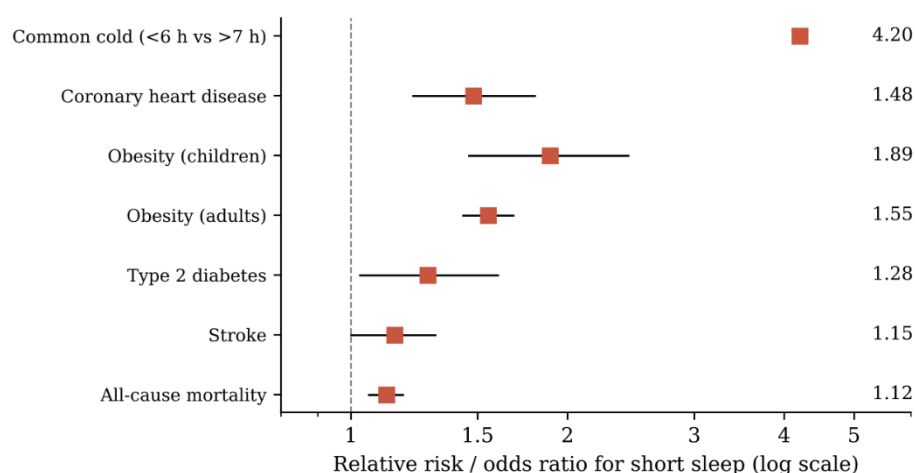


Figure 2. Health risks associated with short sleep: relative risks and odds ratios from meta-analyses and a prospective study [7–11]

Table 1. Health outcomes associated with short sleep duration

Outcome	Study design	Effect size (95% CI)	Source
All-cause mortality	Meta-analysis, prospective	RR 1.12 (1.06–1.18)	Cappuccio et al., 2010 [10]
Coronary heart disease	Meta-analysis, prospective	RR 1.48 (1.22–1.80)	Cappuccio et al., 2011 [9]
Stroke	Meta-analysis, prospective	RR 1.15 (1.00–1.31)	Cappuccio et al., 2011 [9]
Type 2 diabetes	Meta-analysis, prospective	RR 1.28 (1.03–1.60)	Cappuccio et al., 2010 [8]
Obesity, children	Meta-analysis, cross-sectional	OR 1.89 (1.46–2.43)	Cappuccio et al., 2008 [7]
Obesity, adults	Meta-analysis, cross-sectional	OR 1.55 (1.43–1.68)	Cappuccio et al., 2008 [7]
Common cold after viral exposure	Prospective experimental	4.2 times higher (<6 h vs >7 h)	Prather et al., 2015 [11]

3.5. Effects on immunity. Sleep plays an important role in immune function. In a study by A. A. Prather and colleagues, 164 healthy adults had their sleep measured objectively for a week and were then exposed to a common cold virus. Participants who slept less than six hours per night were 4.2 times more likely to develop a clinical cold than those who slept more than seven hours, after adjustment for other factors [11]. Sleep deprivation has also been shown to reduce the antibody response to vaccination and to increase levels of inflammatory markers, which may contribute to the link between short sleep and chronic disease.

3.6. Effects on mental health. Sleep and mental health are closely interconnected. Sleep deprivation increases emotional reactivity, irritability and anxiety and impairs the ability to regulate negative emotions. Insomnia is both a symptom and a risk factor for depression, and persistent sleep disturbance predicts

the onset of depressive episodes. The mechanisms affected by sleep loss and their consequences are summarised in Table 2.

Table 2. Physiological systems affected by sleep deprivation and their consequences

System	Main changes	Clinical consequences
Central nervous system	Reduced attention, slower reaction, impaired memory consolidation	Errors, accidents, poorer learning
Endocrine and metabolic	Impaired glucose tolerance, lower leptin, higher ghrelin	Weight gain, type 2 diabetes
Cardiovascular	Higher sympathetic activity and blood pressure	Hypertension, coronary heart disease, stroke
Immune	Weaker antiviral defence, low-grade inflammation	Infections, reduced vaccine response
Emotional regulation	Increased reactivity to negative stimuli	Anxiety, depression

DISCUSSION

The evidence reviewed shows that sleep deprivation affects virtually every physiological system. The consistency of findings from controlled laboratory experiments and large prospective cohort studies strengthens the conclusion that insufficient sleep is not merely a marker of poor health but a contributing cause. Laboratory studies demonstrate plausible mechanisms – impaired glucose metabolism, altered appetite regulation, sympathetic activation and weakened immunity – while epidemiological studies show the long-term consequences of these changes at the population level.

At the same time, several limitations should be noted. Most epidemiological studies rely on self-reported sleep duration, which may differ from objectively measured sleep. Observational associations may be influenced by confounding factors such as socioeconomic status, shift work or undiagnosed illness. The U-

shaped relationship between sleep duration and mortality also indicates that both too little and too much sleep may be signs of poor health [10].

Medical students and health workers are a group of special concern. Long study hours, examinations, night shifts and on-call duties frequently lead to chronic sleep restriction. Since sleep deprivation impairs attention, memory and decision-making [4, 5], it may affect not only students' academic performance and well-being but also patient safety. Medical education should therefore include teaching on sleep physiology and sleep hygiene, and training programmes should be organised so as to limit excessive sleep loss.

Practical recommendations for maintaining healthy sleep include keeping a regular sleep schedule, ensuring at least seven hours of sleep for adults, limiting caffeine and heavy meals in the evening, reducing the use of electronic screens before bedtime, keeping the bedroom dark, quiet and cool, and engaging in regular physical activity. Persistent insomnia, loud snoring or excessive daytime sleepiness should prompt medical evaluation, since they may indicate sleep disorders such as obstructive sleep apnoea.

CONCLUSION

Sleep deprivation is a widespread and underestimated threat to human health. Even moderate chronic sleep restriction produces cognitive impairment comparable to total sleep loss, and prolonged wakefulness impairs performance to a degree similar to alcohol intoxication. Short sleep is associated with higher risks of obesity, type 2 diabetes, coronary heart disease, stroke, infection and premature death. These effects are mediated by changes in metabolism, hormonal regulation, the cardiovascular and immune systems and emotional regulation. Promoting at least seven hours of sleep for adults, raising awareness of sleep hygiene and addressing sleep loss among students and health workers should be recognised as important public health priorities.

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