HOUSES OF PARLIAMENT
PARLIAMENTARY OFFICE OF SCIENCE & TECHNOLOGY

POSTNOTE

Number 585 September 2018

Sleep and Health

Like food and water, sleep is essential. This POSTnote describes what is known about sleep and sleep-wake disorders, the effects of poor sleep on performance, and physical and mental health. It describes implications for public and occupational health, road safety, education and consumer technology.

Overview

- Sleep is affected by physical and mental health and environmental and social factors.
- Short-term sleep disruptions increase the risk of workplace and driving accidents.
- Long-term sleep disruptions are associated with a range of poor health outcomes.
- School schedules and nightly use of digital devices may affect adolescents' sleep.
- Consumer sleep technologies may increase awareness of sleep but many are not validated for accuracy in measuring sleep.
- Public health strategies include increasing awareness of healthy sleep habits and sleep-related issues in workplaces, schools and other settings; optimising lighting; and improving the diagnosis and treatment of sleep-wake disorders.

Background

Sleep interacts with many biological processes, impacting performance, and physical and mental health.[1–3] Sleep problems may affect up to a third of the population and most sleep-wake disorders are likely underdiagnosed.[4,5] Night-time work, which disrupts sleep, is common to many sectors, covering 12% of the workforce.[6–8] Sleep deprivation increases the risk of workplace and driving accidents.[9,10] RAND Europe estimates that sleep-related productivity losses in the UK amount to £30bn annually.[11] Research also suggests that long-term sleep problems may be a factor in many health conditions.[2] Interventions that target sleep may help to prevent disease and improve public health.[2,3,5]

Sleep is regulated by two processes: circadian timing and sleep-wake homeostasis (Box 1).[12] Although its functions are not fully understood, sleep plays an important role in many processes, including memory consolidation, emotional regulation, metabolism, cell repair and the clearance of toxins.[2,14,15] Duration, quality and timing are important elements of sleep (Box 2).[16] Sleep quality includes the time taken to fall asleep, frequency and types of disturbances and the stages of sleep experienced (Box 2), which all contribute to the subjective feeling of being rested.[16–18] Sleep timing refers to when sleep occurs in the 24-hour day.[16] Changes in sleep timing can cause circadian disruption by misaligning the internal rhythm with the external environment.[1] This can occur through light exposure at night (for example, due to travel-related time differences, resulting in jet-lag).[1] Likewise, circadian disruption can affect sleep duration, quality and timing.[1] For example, impaired circadian biology underlies certain sleep-wake disorders.[19] These interactions make the effects of sleep and circadian timing difficult to separate.[1]

Box 1. Biological processes that regulate sleep

Two processes regulate sleep duration, quality and timing and determine a person's degree of "morningness" or "eveningness":[12,13,20]

- **Circadian timing** – a system that generates 24-hour bodily rhythms, adapted to Earth's light-dark cycle.[1] These define periods of sleepiness and wakefulness and schedule many other physiological processes, preparing the body for activity during the day and rest at night.[1] Rhythms are generated in most cells in the body by molecular clocks, which are synchronised through hormones, such as cortisol and melatonin, and neuronal signals.[1] These clocks synchronise with the outside world primarily through light, acting on the master clock in the brain, and through the timing of meals, physical activity and social cues.[1]
- **Sleep-wake homeostasis** – increases (or decreases) the pressure to sleep with the time spent awake (or asleep).[13] Its mechanism is not well understood but may involve the levels of the chemical adenosine in the brain.[13]

These processes are genetically determined and interact with each other and with each person's environment and behaviour.[12,13,20]

Box 2. Researching and evaluating sleep

The gold standard tool used to measure sleep duration and quality is polysomnography (PSG), which measures brain activity, muscle tone, eye movements, heart rate, respiration and blood oxygenation.[21] Circadian rhythms can be measured via analysis of the hormones melatonin and cortisol in saliva, plasma or urine.[22] Questionnaires can be used to approximate aspects of sleep duration, quality and timing through self-reports.[23] Wearable technologies can measure some aspects of sleep more objectively than self-reports and in more natural settings than PSG.[21] However, they are less accurate than PSG, especially in people with sleep problems.[21] PSG and other methods have been used to identify two main types of sleep:[13]

- **non-rapid eye movement (NREM)** sleep comprises three stages, one of which is often called deep sleep, defined by slow waves in brain activity and a decrease in energy use, respiration, heart rate and body temperature.[13,24]
- **rapid eye movement (REM)** sleep is defined by eye movements, muscle paralysis, longer and more vivid dreams, and more irregular and higher frequency brain activity.[13,24,25]

NREM and REM sleep periods alternate in 90–110 minute cycles, with more NREM deep sleep earlier in the night and more REM sleep later.[24] The functions of each sleep type are debated.[14,25] NREM deep sleep may have a more direct role in recovery after sleep loss.[13,26] REM sleep, although considered important, is less well understood.[25]

Sleep variation throughout life

The duration, quality and timing of sleep changes throughout life.[27] Infants sleep for the majority of the day, until night-time sleep is established at around 3–6 months.[28] Sleep regulation changes during puberty, delaying adolescents' sleep-wake patterns.[29] In adulthood, sleep onset is earlier and duration decreases.[27] Older adults have earlier sleep onset, decreased duration and more awakenings.[27] However, some of these changes may be due to other age-related conditions; older adults likely need the same amount of sleep as younger adults.[27]

Sleep duration recommendations

Normal variation in sleep duration between people, especially children, makes it difficult to recommend specific durations.[2,30] Instead, the NHS recommends age-specific ranges of healthy sleep duration for children and around 8 hours for adults, with a range of 6–9 hours cited by experts.[31–35] Assessing daytime sleepiness and the amount of additional sleep needed on weekends or holidays can help determine individuals' optimal sleep duration.[36,37]

Are we sleep deprived?

Identifying sleep patterns in the UK is difficult due to the lack of regular, high quality surveys. A 2004 study found that average sleep duration in the UK is 7 hours, with two-thirds of the population sleeping 5.5–8.5 hours per night.[4] About a third reported at least one episode of difficulty sleeping on a majority of nights.[4] Whether sleep duration or quality has decreased is controversial.[38] According to one UK study (1983–2005), average adult sleep duration increased by 50 minutes, the prevalence of short sleep (less than 6 hours) decreased from 15% to 10%, and the prevalence of long sleep (greater than 9 hours) increased from 16% to 28%.[39] In terms of sleep quality, one study in the UK (1993–2007) found that the prevalence of people reporting sleep difficulties increased slightly from 35% to 39%, although this may simply reflect increased awareness of sleep problems.[40] Evidence on trends in children's sleep is mixed.[38] One UK study found that children's sleep increased by about 1 hour over the past century.[41] However, US data (1991–2012) show a rise in the number of adolescents reporting short sleep.[42] Even if sleep has not worsened, experts emphasise that insufficient sleep duration and quality is an important public health issue.[5,38]

Sleep, circadian rhythms and health

Sleep and circadian disruptions (SCDs) can occur as a result of a sleep-wake disorder, other physical or mental health conditions, or societal factors, such as work schedules.[43] Conversely, SCDs can affect many aspects of health in the short- and long-term, including mental and physical health and work and daytime performance.[2,3,44]

Short-term effects of SCDs

Short-term effects of SCDs are prominent and include sleepiness and impaired attention, memory, processing speed, reasoning, decision-making and emotional regulation.[2,45,46] This leads to increased risk of performance impairments, including accidents at work and while driving.[2,9,10] Many effects are amplified as sleep duration decreases and as sleep deprivation accumulates over consecutive days.[2] Impairments also worsen at naturally sleepy times in the circadian rhythm.[2] Effects depend on the task, including how monotonous and physically and mentally demanding it is, the environment and the performer's motivation.[45] Individuals differ in their susceptibility to these effects, with some research suggesting a genetic component.[20,47,48] The brain mechanisms underlying these impairments are poorly understood.[49]

Long-term effects of SCDs

Sleep is important for long-term health because the effects of SCDs accumulate over time (see POSTbrief 29).[2,50] One large UK study found that decreases in sleep quality and duration, and increases in sleep medication use, are associated with worse health and well-being outcomes.[51] Chronic short sleep duration (less than 6 hours) and poor sleep quality may be associated with increased risk for: obesity, type 2 diabetes, cardiovascular disease, cognitive impairments, mental health conditions, neurodegenerative disease, cancer and impaired immune function.[2,52]

Chronic long sleep duration (more than 9 hours) may also be associated with increased risk for many of these conditions, but the reasons for this are not well understood.[2] Intervention studies that test whether improving sleep can affect long-term health outcomes are lacking.[2,53] How SCDs contribute to long-term health is also not well understood.[2] Experimental studies show that SCDs may affect many physiological functions; including brain processing, the stress response, appetite regulation, metabolism, inflammation, toxin clearance, the cell cycle, and gene regulation.[49,54–58] Some researchers question SCDs' effect on long-term health relative to factors like diet and physical activity and highlight other research limitations.[53]

Sleep-wake disorders

There are six categories of sleep-wake disorders.[59] Two of the most common are obstructive sleep apnoea (OSA) and insomnia.[40,60] Some disorders, such as narcolepsy, have neurological origins.[19] Others relate to breathing (OSA) or to behaviour (shift work sleep disorder, caused by inadaptation to night-time work; see POSTnote 586).[19,61] Treatments for sleep-wake disorders include psychological and behavioural therapies, drugs and medical devices.[19]

Underdiagnosis of sleep-wake disorders

Researchers and clinicians are concerned that sleep-wake disorders are underdiagnosed and thus undertreated, possibly linked to a lack of training for health professionals.[5,62] Accredited sleep medicine courses are addressing this gap, but are not widely available.[63,64] A related issue is the lack of sleep medicine specialists in the UK, possibly due to the absence of a direct training path for this relatively novel and cross-disciplinary field.[60,65–67]

Obstructive sleep apnoea (OSA)

Most referrals to sleep clinics are for OSA, which is caused by a recurrent blockage or narrowing of the upper airway during sleep, leading to frequently interrupted breathing, sleep disturbance and daytime sleepiness.[59,60] OSA is associated with increased risk of cardiovascular disease, diabetes and sleep-related driving accidents (Box 3).[60] Studies have found that adults with OSA are more than twice as likely to have a stroke compared to those without OSA.[68,69] Treating the symptoms of OSA is cost-effective and includes the use of a pressurised mask (continuous positive airway pressure), dental devices or weight loss, depending on severity.[60] However, at least 1.5 million UK adults are estimated to have OSA, with up to 85% of them undiagnosed.[60,70] Prevalence is likely rising due to increasing obesity and ageing.[71,72] The British Lung Foundation (BLF) estimates that treating moderate to severe OSA could save the NHS £28m and prevent up to 40,000 driving accidents.[60,70] According to the BLF, underdiagnosis is due to a lack of awareness of OSA among the public and primary care professionals, a lack of sleep clinics in the UK and a mismatch between clinic locations and areas with high prevalence of OSA.[60]

Insomnia

Insomnia is a persistent, subjective disturbance in initiating or maintaining sleep, despite adequate opportunity, which results in daytime impairment (see POSTbrief 29).[50,59,73] Depending on the definition, it affects an estimated 6–40% of people.[40] Its symptoms are the most common expression of mental health conditions in the UK, regardless of gender, age, location or ethnicity.[74,75] New guidelines note that insomnia should be actively treated, rather than regarded as a symptom of mental health conditions, such as depression and anxiety.[73] Studies suggest that this can improve both insomnia and symptoms of such conditions.[76–78]

Treatment of insomnia in primary care includes provision of information about healthy sleep habits (sleep hygiene), which alone is ineffective.[79,80] Sleeping tablets are also often prescribed, although they are not recommended as a first-line treatment, with a risk of tolerance, dependency and side effects.[73,79,81] Although they work in some cases, experts highlight the misuse of sleeping tablets in primary care.[82,83]

The recommended first-line treatment is cognitive behavioural therapy for insomnia (CBT-I), which pairs sleep hygiene with techniques to change beliefs and behaviours around sleep.[73,81] Despite its effectiveness and potential to reduce sleeping tablet prescriptions, CBT-I is limited by the lack of access and professionals trained to deliver it.[73,79,80,84] One strategy to improve training for healthcare professionals is through online training developed by the Resources for Effective Sleep Treatment project.[79,85] For access, digital CBT-I can be cheaply delivered at scale with computers or smartphones, with some studies indicating similar effectiveness as face-to-face CBT-I.[73,86] Sleepstation and Sleepio are two clinically validated services available in some areas on the NHS, with Sleepio assessed by the National Institute for Health and Care Excellence.[80,87–89]

Sleep-related driving accidents

At least 20% of driving accidents are sleep-related and more motorway accidents occur between 2:00–6:00am than at any other time.[90,91] Most healthy drivers would be impaired with only 3–5 hours of sleep, and 24 hours of sleep deprivation is comparable to exceeding the blood-alcohol limit.[10] There is wide consensus that more should be done to prevent sleep-related driving accidents (Box 3).[10]

Box 3. Preventing sleep-related driving accidents

One approach to preventing sleep-related driving accidents is to prioritise drivers most at risk, such as professional drivers.[92–94] Professional drivers are involved in 33% of sleep-related motorway accidents in the UK, possibly due to their typically long shifts and their greater exposure to driving, especially at night.[92–96] They are also at increased risk of OSA (and therefore daytime sleepiness) due to their sedentary lifestyle and poor diet.[93] Because suspicion of OSA-related sleepiness may result in suspension of driving licenses until treatment, drivers are often reluctant to be screened for OSA.[97] The OSA Partnership Group is piloting voluntary screening programmes with road haulage companies and campaigning for expedited access to treatment.[93,94] Other strategies include raising awareness (such as the "Tiredness can kill" campaign), improved road infrastructure to encourage rest breaks, and vehicle technology to detect and warn sleepy drivers.[90,98] Drowsiness-detection systems are built into some cars, with technologies regularly advancing.[90] Experts argue that these systems need to be validated to prove their reliability.[90]

School start times and adolescent sleep

The American Academy of Pediatrics (AAP) argues that the delay that adolescents experience in their sleep-wake patterns is incompatible with early school start times, leading to chronic sleep deprivation and effects on well-being and academic attainment.[29,99,100] The AAP has recommended delaying school start times, and studies suggest that this has a positive effect on sleep duration and daytime sleepiness.[100–102] However, a review has highlighted the low quality of evidence in this area and suggested that larger and more well-controlled studies are needed.[101] Establishing effectiveness is important in the UK, where start times are later and commute times shorter than the US.[103] Potential issues include adjusting family and

teacher schedules.[101] The SchoolSleep and Teensleep studies are investigating this in the UK.[104,105] Some research suggests that night-time light exposure (such as from phones) may contribute to the delay in adolescents' sleep timing and that addressing this may be more effective.[103]

The workplace

Workplace factors that can affect sleep include workload, lack of control or social support, long commutes, night-time work, and long or irregular hours (Box 4; see POSTnote 586).[61,106–108] Conversely, poor sleep can affect performance.[2] A toolkit from Public Health England and Business in the Community highlights the relationship between sleep and the workplace, and provides employers with strategies to support healthy sleep.[109] Evidence for workplace-related interventions is limited, although recent studies suggest benefits of CBT-I.[110,111]

Box 4. Areas of work with implications for sleep

- **Gig economy** – An estimated 2.8m people work in the UK gig economy and this is expected to rise.[112] Such workers may be working and driving for an unregulated number of hours for multiple employers and without health and safety protections.[112,113] It is argued that it is important to understand how such work affects sleep, health and public safety.[112,113]
- **Night-time economy** – Night-time work, which can disrupt sleep, is common in many sectors, with 12% of the UK workforce regularly working at night (see also POSTnote 586).[6,61,108]

Lighting and other environmental features

Light plays a key role in circadian timing (Box 1) and researchers therefore suggest that more attention be paid to the role of natural and artificial lighting when designing homes, schools, workplaces, hospitals and care facilities.[114] This includes both improving daytime and minimising night-time light exposure (see below).[114] For example, some studies suggest that bright daytime light in the workplace may improve sleep, daytime alertness and mood.[115,116] Adapting hospital lighting may reduce sleep disruptions prevalent in intensive care units and aid recovery.[117]

Digital device use at night

Researchers and clinicians have raised concerns about the nightly use of digital devices, such as phones and computers, and their effects on sleep, particularly in children and adolescents.[118–121] An Ofcom survey found that a third of those who binge-watch media list sleep loss as a result.[122] Two reviews concluded that device use is associated with delayed bed-times, decreased sleep duration, and in some studies, poor sleep quality and daytime sleepiness.[123,124] The few available studies in adults also link device use to short sleep duration.[119,120] More research is needed to understand the causal effect of device use on sleep and the potential mechanisms.[118,125,126]

Light exposure from devices may disrupt or delay sleep.[118] The body is sensitive to brief exposures of light, particularly the blue light usually emitted by digital devices.[121,127,128] Blue light exposure at night decreases sleepiness and can shift the circadian rhythm.[121,125,126] Device use can also disrupt sleep by displacing time for sleep or by psychologically affecting users through its content.[118] Conversely, people who cannot sleep may spend their time on digital devices.[118]

Sleep hygiene intervention studies, which include the restriction of devices in the bedroom, have shown mixed or no effects.[129] Another strategy is the "right to disconnect" policy used by companies in Germany and France to limit after-hours work-related emails, although no data are available on its impact.[130] Interventions may be difficult to implement or may have adverse effects, such as anxiety about missing emails or social media.[129]

Consumer sleep technology

Growing awareness of the importance of sleep has led to the rapid development of consumer products of varying quality for monitoring and improving sleep.[131] Smartphone apps, wearables and other technologies claim to track sleep-wake patterns and stages.[131] Most devices measure movement, while others measure heart rate, breathing or brain activity.[21] Sleep tracking is marketed as a way to monitor personal sleep trends and use "smart alarms" to wake users up during light sleep and reduce morning grogginess.[131] Aiming to improve falling asleep or waking up, many devices alter the sleeping environment using personalised light and sound control.[132] Other devices seek to improve sleep quality by aiming to track and enhance NREM sleep.[133]

More research is needed to understand the impact of sleep technology on users, especially considering the advice to avoid nightly digital device use.[134] While technologies may increase awareness of the importance of sleep and of poor sleep habits, many are not clinically validated.[21,132] For example, comparisons to lab-based measures show that wearables tend to overestimate sleep duration and are less accurate in those with sleep-wake disorders or other conditions.[132] There is insufficient evidence that consumer technology can distinguish REM and NREM sleep or that "smart alarms" work.[21,135] Inaccuracy in the technology or consumer misunderstanding can falsely indicate sleep problems to normal sleepers or vice versa.[136] Clinicians worry about normal sleepers becoming anxious about non-existent sleep problems.[137] In addition to product validation, researchers and clinicians suggest that companies should be clearer with consumers about the limitations of their products and possible misinterpretations.[134]

Public awareness and education

Experts argue for increasing public awareness about the importance of sleep, sleep disorders, and establishing healthy sleep habits, especially in early childhood.[5,43] For example, the Royal Society of Public Health has suggested that the Government publish a national sleep strategy.[5] One approach is to introduce sleep education into settings such as workplaces or within national school curricula.[5,109]

POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of policy issues that have a basis in science and technology. POST is grateful to Lev Tankelevitch for researching this briefing, to the Nuffield Foundation for funding his parliamentary fellowship, and to all contributors and reviewers. For further information on this subject, please contact the co-author, Dr Sarah Bunn.

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