PERSPECTIVE

Casting light on sleep deficiency

The use of electric lights at night is disrupting the sleep of more and more people, says **Charles Czeisler**.

There are many reasons why people get insufficient sleep in our 24/7 society, from early starts at work or school, or long commutes, to caffeine-rich food and drink. But the precipitating factor is an often unappreciated, technological breakthrough: the electric light. Without it, few people would use caffeine to stay awake at night. And light affects our circadian rhythms more powerfully than any drug.

Just as the ear has two functions (hearing and balance), so too does the eye. First, rods and cones enable sight; and second, intrinsically photosensitive retinal ganglion cells (ipRGCs) containing the photopigment melanopsin enable pupillary light responses, photic resetting of the circadian clock, and other sightless visual responses. Artificial light striking the retina between dusk and dawn exerts other physiological effects through sightless vision. It inhibits sleep-promoting neurons and activates arousal-promoting orexin neurons in the hypothalamus, and suppresses the nightly release of the soporific hormone melatonin. These factors reduce sleepiness, increase alertness and interfere with our sleep.

Paradoxically, the daily peak of waking energy driven by the brain's master circadian clock in the suprachiasmatic nucleus (SCN) of the hypothalamus occurs not at the start but near the end of our usual waking day, providing us with a 'second wind' that keeps us going as the day wears on. Before the widespread use of electric light, people probably experienced that second wind in the mid-afternoon, keeping them going until night fell. But light exposure after sunset signals 'daytime' to the SCN, shifting the clock later, postponing the second wind and delaying the onset of melatonin secretion. As a result, many people are still checking e-mail, doing homework or watching TV at midnight, with hardly a clue that it is the middle of the solar night. Technology has effectively decoupled us from the natural 24-hour day to which our bodies evolved, driving us to go to bed later. And we use caffeine in the morning to rise as early as we ever did, putting the squeeze on sleep.

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The more we light up our lives, the less we seem to sleep. As the cost of generating light has plummeted by two orders of magnitude over the past century, its consumption has increased accordingly. Between 1950 and 2000, for example, as the cost of light production fell sixfold, UK per capita light consumption rose fourfold. This increasing light consumption has paralleled the rise in sleep deficiency.

Today, 30% of all employed US adults and 44% of night workers report averaging less than 6 hours sleep per night[1], whereas 50 years ago less than 3% of the US adult population slept so little. Worldwide, children are sleeping about 1.2 hours less on school nights than a century ago[2]. Most of us also sleep at different times during the week than at weekends and holidays, inducing 'social jetlag', which further disrupts circadian rhythms (see 'Stepping out of time', page S10).

The US Institute of Medicine estimates that between 50 million and 70 million people in the United States suffer adverse health and safety consequences from sleep disorders and sleep deficiency[3], including greater risk of obesity, diabetes, heart disease, depression and stroke. The obesity boom has triggered a parallel epidemic of obstructive sleep apnoea, which disrupts sleep (see 'Heavy sleepers', page S8). Children become hyperactive rather than sleepy when they don't get enough sleep, and have difficulty focusing attention, so sleep deficiency may be mistaken for attention-deficit hyperactivity disorder (ADHD), an increasingly common condition now diagnosed in 19% of US boys of high-school age. Some 40% of people in the United States report that their sleep is often insufficient, with 25% reporting difficulty concentrating owing to fatigue. The WHO has even added night-shift work to its list of known and probable carcinogens. And the death toll from driving while tired is second only to that caused by drink driving.

The number of people with sleep deficiency seems destined to rise. With 19% of electricity consumption worldwide devoted to producing light, many governments are phasing out traditional incandescent light bulbs[4]. Energy efficient solid-state light-emitting diodes (LEDs) are now widely used in televisions and computer screens, laptops, tablets and hand-held devices, and will drive a further increase in per capita light consumption.

Solid-state white light is typically rich in blue light, and the colour composition matters. The ipRGCs are most sensitive to short-wavelength (blue and blue–green) light, so night-time exposure to LEDs is typically more disruptive to circadian rhythms, melatonin secretion and sleep than incandescent lighting.

But solid-state lighting could also provide some solutions. A solid-state white-light fixture can comprise multicoloured LEDs, so it is relatively easy to control not only the light intensity, but also the colour composition. The adverse effects of night-time light on sleep and circadian rhythms can be reduced by replacing blue-enriched light with red- or orange-enriched white light after sunset. Unfortunately, existing uses of this new-found colour control have tended to be wrong-headed: some airlines, for example, suffuse aircraft cabins with monochromatic blue light at night, the optimal colour for suppressing melatonin and disrupting sleep.

Sleep is essential to our physical and mental wellbeing, so it is vital that we learn more about the impact of light consumption and other ways our 24/7 society affects sleep, circadian rhythms and health. We must then use this knowledge to develop behavioural and technical interventions to mitigate these ill effects. It is time to reassess the early assurances of Thomas Edison that using electric light "is in no way harmful to health, nor does it affect the soundness of sleep". ■

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