

## REVIEW ARTICLE



# How to deal with sleep problems during heatwaves: practical recommendations from the European Insomnia Network

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## Summary

Heatwaves are occurring more frequently and are known to affect particularly night-time temperatures. We review here literature on how night-time ambient temperature changes affect body temperature and sleep quality. We then discuss how these temperature effects impact particularly vulnerable populations such as older adults, children, pregnant women, and those with psychiatric conditions. Several ways of dealing with sleep problems in the context of heatwaves are then suggested, adapted from elements of cognitive behavioural therapy for insomnia, with more specific advice for vulnerable populations. By better dealing with sleep problems during heatwaves, general health effects of heatwaves may be more limited. However, given the sparse literature, many links addressed in this review on sleep problems affected by temperature changes should be the focus of future research.

## KEYWORDS

heat waves, sleep problems, temperature

## MORE FREQUENT HEATWAVES, RISES IN NIGHT-TIME TEMPERATURE

Climate change causes more frequent heatwaves and also in those regions that typically have colder temperatures in the summer such as Northern European countries. A recent study found that on average in Europe, the number of days with extreme heat (>99% percentile) has tripled since 1950. Even temperatures on extremely hot days have increased by 2.3 °C throughout the same period (Lorenz et al., 2019). In the future, these heatwaves will be more frequent and of longer duration (Beniston et al., 2007; Guerreiro et al., 2018; Hausfather et al., 2020; Lhotka et al., 2018; Molina et al., 2020; Stillman, 2019). One very recent example is the heatwave in Europe in July 2022: on its hottest day, it was an unprecedented 40 °C in London, UK and 38 °C in Amsterdam, the Netherlands. In fact, recent studies indicate that it may be night-time temperatures in particular that will increase, less so than daytime temperatures (Cox et al., 2020). This is

particularly worrisome as increases in night-time temperatures have been related to mortality increases (Royé, 2017).

## HEATWAVES CAN DISRUPT SLEEP

Body heating before going to sleep, for instance by taking a warm bath, can have beneficial effects for sleep, such as increasing slow-wave sleep (SWS; Horne & Reid, 1985). However, heat exposure during sleep can lead to sleep disruption. An experimental study comparing different temperatures with different humidity levels showed that a higher ambient temperature (35 versus 29 °C) suppresses the normal decrease of body temperature at sleep onset, but also increases wakefulness, while decreasing duration of Stage 3 and rapid eye movement (REM) sleep as well as SWS (Okamoto-Mizuno et al., 1999). Min et al. (2021) found that the prescription of hypnotics, such as zolpidem and triazolam, increased with both strong increases and decreases of night-time

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ambient temperatures. Buguet (2007) proposed that these deleterious effects on sleep may particularly occur when there has not been an opportunity for gradual acclimatisation to temperature rises, as is particularly the case in sudden heatwaves that exceed the yearly seasonal average for a given country.

The most efficient and effective ways to rapidly reduce body temperature, typically applied in emergency services and the army, is forced ventilation: a fan directed over bare skin, which increases skin humidity loss by facilitating and promoting sweating by convection and evaporation (Jay et al., 2021). Outside emergency situations, a ceiling fan running overnight at low speed might be a recommendation to consider, although caution should be respected, particularly for vulnerable persons (older adults, children, those with a chronic condition) (Gupta et al., 2012; Kravchenko et al., 2013).

## TEMPERATURE REGULATION AND SLEEP: A BRIEF OVERVIEW

Sleep and temperature regulation are closely related. Thus, we would like to briefly summarise basic facts about the relationships between sleep and temperature regulation (Van Someren & De Boer, 2022). Humans have an average core body temperature (CBT) of 36.5 °C which varies at ~1 °C during the 24-h day; maxima are reached in the late afternoon, whereas minima occur during the early morning hours. The nocturnal secretion of the pineal hormone melatonin, controlled by the circadian pacemaker located in the suprachiasmatic nuclei, coincides with the endogenous down regulation of CBT in the evening and ‘opens the sleep window’ (Cagnacci et al., 1997). The maximal rate of decline in CBT initiated by increased skin blood flow, skin warming, and body heat loss coincides with sleep onset (Krauchi & Deboer, 2010). Ambient temperatures outside the thermal comfort zone interfering with this process disturb initiation and/or maintenance of sleep. Interestingly, the human body possesses two thermoregulatory compartments: the heat-producing homeothermic core and the heat-loss regulating poikilothermic shell. The latter’s size largely depends on ambient temperature conditions and decreases in warm climates and increases in cool climates. It thus acts as a buffer to prevent dangerous cooling. Data from studies with manipulating thermal nocturnal load in humans indicate that increased temperatures will lead to increased wakefulness and decreases in SWS and REM sleep. On the other hand, studies investigating tools to increase conductive body heat loss during sleep show beneficial effects on SWS (Kräuchi et al., 2018). In summary, environmental temperatures outside the thermal comfort can strongly affect human sleep by disturbing the fine-tuned interaction of heat transfer between the homeothermic shell and poikilothermic shell.

## VULNERABLE GROUPS: AGE, PSYCHIATRIC COMORBIDITY

Particular societal groups may be more vulnerable to the sleep disruptive effects of such heatwaves. One study conducted during a heatwave shows that older adults in a group sleeping in higher ambient

temperature had lower sleep quality, but also higher levels of physiological stress (elevated galvanic skin responses and heart rate) than those that slept in lower ambient temperatures (Williams et al., 2019). An Australian study showed that hospital admissions for particularly mental disorders increased by 7.3% during heatwaves, while mortalities due to mental and behavioural disorders increased in particular for older adults during heatwaves (Hansen et al., 2008). Disrupted sleep has been suggested as one of the factors contributing to the vulnerability of those with psychiatric conditions to suffer more from their symptoms during heatwaves (Löhmus, 2018). As sleep problems are very prevalent in both older adults and those with psychiatric conditions (Ancoli-Israel, 2009; Wulff et al., 2010), particular care should thus be taken to preserve sleep quality for those groups during heatwaves.

## SLEEP ADVICE DURING HEATWAVES

Cognitive behavioural therapy, the most effective treatment of insomnia, contains numerous tips to improve sleep that are also temperature related (Baglioni et al., 2020a; Morin et al., 2005). Although not all who struggle with heatwave-related sleep problems may have insomnia, these tips about temperature management can also serve those who normally do not have sleep complaints. Those with a history of sleep or other health problems should always check with a medical professional which of the below tips are best suited for their individual situation.

- Keep the bedroom temperature preferably at an ~19 °C constant. If this is not possible, keep it as close as possible to 20–25 °C. Temperatures >25 °C can be disruptive for sleep.
- Before going to bed, with high ambient temperatures due to heatwaves, a cool or lukewarm shower (not cold) can help to induce sleep and reduce stress due to heat. Alternatively, a lukewarm foot bath can be effective.
- Ventilators can help to cool down the bedroom. Be careful with air conditioning, it can be useful to cool the bedroom in extreme circumstances, but temperatures <17 °C can also be sleep disruptive. Electric fans are up to 50-times less electricity consuming than air conditioning, which is important in the context of individual socio-economic factors and the environmental issues that contribute to climate change. As a rule, the use of energy-consuming devices should be seen as a last resort.
- In extreme heat, awakenings because of the heat can be shortened by cooling the body temporarily with a water spray or water mist, although benefits are debated and more research is needed on its beneficial effects (Jay et al., 2021).
- Drink plenty during the day to enhance temperature regulation during the night.
- If there are no cool periods during day and night-time, try to keep the house and bedroom as cool and dark as possible both during day and night.
- If there is a cool period during the day, ventilate house and bedroom as much as possible before going to sleep, then close the bedroom when temperatures rise.
- Limit clothing; choose cotton clothing over other materials.

- If you poorly sleep one night, do not go to sleep earlier on the next evening, but go to bed only when you feel sleepy.
- In extreme heat, naps may be useful, but be careful to keep the nap short (~20 min) and not too late in the afternoon (such as not later than 2:00 p.m.)
- Try to keep your sleep-wake rhythm as regular as possible: sleep regularity and continuity have been associated with better sleep quality than just the amount of sleep you get.
- During summer nights, you might experience early awakening. If you wake up earlier than planned, get up and start your day. Avoid staying in bed awake. You may use this extra morning time to go for a walk or to read on your balcony, or open window, before going to work or initiating other activities.
- In general, avoid sleeping elsewhere but in your bed, and avoid staying awake in your bed. Organise a 'reading corner' in your flat or house with books or magazines or comics you like. Use it when you still do not feel sleepy before going to bed, and when you do not manage to return to sleep in the middle of the night. Only go back to bed when you feel sleepy.
- A cold beer on summer night may be nice but be careful about the alcohol effects on sleep. Alcohol is an inhibitor of deep sleep, thus may disrupt sleep continuity, which is actually linked with feelings of tiredness and fatigue the next day. Alcohol also dehydrates and increases nocturnal sweating. Use alcohol very moderately during heatwaves and try to avoid smoking.
- Physical activity in the early morning, when it is still relatively cool outdoors, may help for contrasting daytime fatigue and to keep a regular sleep/wake schedule.

## SUMMER NIGHTS, HEATWAVES AND CHILDREN'S SLEEP

Summer nights may be associated with changes in children's sleep-wake rhythm for many reasons. First, as for adults, children's sleep may be affected by heat exposure, although different thermoregulation processes during sleep initiation and during the night have been suggested (e.g., Okamoto-Mizuno et al., 2018). Previous evidence quoted by Okamoto-Mizuno et al. (2018) reported higher distal skin temperature in children during intense heat exposure, as well as greater heart rate increases compared to adults. Alterations to thermal stability and thermoregulation can in fact induce respiration instability in infants (Bach et al., 2002). Secondly, for some children social rhythms may change due to school summer holidays. Thus, social changes may lead to delayed bedtimes, early daily lights may promote awakening in the morning and both shorter sleep duration and delayed circadian rhythm may affect bodily self-regulation and physiological processes. Although it is beyond the objectives of the present paper to fully review these dynamic psycho-socio-physiological interactions, one example is that in children and adolescents both sleep duration (e.g. Li et al., 2017) and later bedtimes (e.g., Anderson et al., 2016; Asarnow et al., 2015) are associated with changes in body mass

index (BMI) and risk of obesity. Consistently, Moreno et al. (2021) recently pointed out, through a longitudinal study assessing sleep and BMI in 119 children aged between 5 and 8 years in three different seasons, that children's sleep midpoint (between sleep onset and offset as measured through actigraphy) was shifted ~1.5 h during summer nights compared to school-year nights, and later sleep midpoints during summer were linked with increased sedentary behaviour and BMI, especially in girls.

## SLEEP ADVICE DURING HEATWAVES FOR CHILDREN

- First of all, the above sleep advice for adults may be helpful also for children and adolescents.
- Be careful that your child manages to reach the correct amount of sleep during the 24 h (see Table 1 for age-related sleep duration recommendations).
- Although a certain delay in bedtime may be necessary to enjoy the less warm hours of the day, set an age-dependent 'latest' time and be careful to allow your child to keep a regular sleep-wake rhythm. If a child goes to bed a little later than usual, ensure that only light, low sugar snacks are consumed, or have the child only drink water if possible.
- Adhering to a high-hydration scheme could be particularly important for children and infants, particularly in the context of mechanisms to promote body temperature regulation by sweating.
- Pleasant outdoor activities may be very helpful to keep an active day and a restorative night.
- Naps may be useful and could be longer in children, but not too late in the afternoon (e.g., not later than 2:30 p.m.). If a nap is not possible, a quiet pause after lunch can be proposed, in which the child may read a book or listen to a story or to music.
- Pleasing but calm activities should be promoted the hour before going to bed, as reading a book, listening to a story or to music. This could help in cooling down and relaxing, thus promoting sleep onset processes.

## HEATWAVES, SLEEP AND WOMEN'S LIFESPAN

Girardi and Bremer (2022) recently pointed out that climate changes have potential for negative outcomes for women's sexual maturation, fertility, pregnancy and neonatal outcomes, lactation, and menopause. Sleep is a vital function necessary for adaptive physical and mental wellbeing. A gender asymmetry is known in sleep research, as women present higher percentages of poor sleep and insomnia symptomatology or disorder compared to men, with these differences already starting with puberty (e.g., Riemann et al., 2017).

Though all specific phases of women's lifespan are important, a focus on particular phases is warranted when considering heat

**TABLE 1** Age-related sleep duration recommendation for developmental age (Matricciani et al., 2012)

	Sleep duration, h					
	Newborns	Infants	Toddlers	Pre-schoolers	School-aged children	Adolescents
May be appropriate	11–19	10–18	9–16	8–14	7–12	7–11
Recommended	14–17	12–15	11–14	10–13	9–11	8–10

exposure. Peripartum is a critical period for women, which involves several physiological, emotional, and behavioural changes. Women's sleep during pregnancy and post-partum is altered by anatomical, endocrinological, physiological, psychological, behavioural, socio-economic and cultural factors (Baglioni et al., 2020b; Palagini et al., 2022). It is beyond the scope of this review to carefully describe sleep changes and interactions between sleep and bodily functions during pregnancy and in the first months after childbirth. Nevertheless, recent literature has indicated that exposure to heatwaves during pregnancy may be associated with health risks (e.g., Wang et al., 2019). Especially during pregnancy and peripartum, specific attention should be paid to sleep during heatwaves.

All advice given in previous paragraphs are relevant during pregnancy. Early morning hours may be used for light physical activity, while the warmest hours may be dedicated to relaxing activities, e.g., reading. If possible, moving to a cooler place for summertime may of course be useful. Nevertheless, this may not be available or practical in all cases. It is important to consider individuality, as for some women being alone, especially with a newborn, may be a positive factor, as the new mother may feel free to regulate her own timelines and day–night rhythm. For some other women, social help may be instead important and associated with health outcomes. Customised approaches to specific individual circumstances should be supported.

## DISCUSSION

This paper is considered to be important and timely to disseminate expert recommendations to the research and clinical community as well as to the general population. Nevertheless, it points out several areas of research that are still lacking, especially for specific populations. Even more important, published evidence is still scarce. Co-operation between sleep researchers with different expertise is required, such as combining knowledge on thermoregulation, cardiovascular regulation, behaviour regulation and sleep. As climate change accelerates and the probability of extreme heat events increases, we strongly encourage the sleep community to establish a task force with the aim of promoting multidisciplinary research to address the many related topics in need for investigation, in particular on the vulnerable groups of individuals here described.

## AUTHOR CONTRIBUTION

All authors have seen and approved the manuscript.

## CONFLICT OF INTEREST

None of the authors has potential conflicts of interest to be disclosed.

## DATA AVAILABILITY STATEMENT

Not applicable

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