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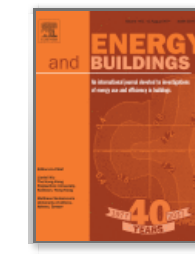


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# Thermal environment and sleep quality: A review

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## Highlights

- The effects of **thermal environment** on human sleep was reviewed.
- A thermal comfortable sleeping environment is important for sleep maintenance.
- **Air conditioner** should be controlled to avoid decrease in air temperature toward morning.
- Control of bed micro-environment may improve thermal comfort energy efficiently.

## Abstract

Thermal environment in bedrooms is still a largely neglected topic in thermal comfort research, although a thermal comfortable environment is important for sleep maintenance. Studies confirm that human body is sensitive to air temperature during sleep; even moderate heat or cold exposure decrease sleep quality significantly. In the present paper we reviewed air temperatures measured in bedroom and the effects of heat and cold exposure on sleep quality, and then proposed 5 aspects of approaches or technologies that could improve sleeping thermal environment at a low energy consumption. We concluded that there are two important research topics in sleeping thermal environment. One is to develop sleeping-mode control strategy for air conditioner used in bedroom to get slight increase or to avoid decrease in room air temperature when approaching morning. The other is to control bed micro-environment energy efficiently by using of local heating, cooling and/or ventilation system.

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## Abbreviations

AASM, American Academy of Sleep Medicine; EEG, electroencephalogram; EOG, electrooculogram; EMG, electromyogram; HF, high frequency; HR, heart rate; HRV, heart rate variability; LF, low frequency; NREM, non-REM; POAH, preoptic area/anterior hypothalamus; PSG, polysomnography; PV, personalized ventilation; REM, rapid eye movement; SE, sleep efficiency; SOL, sleep onset latency; SWS, slow wave sleep; TST, total sleep time; WASO, wake after sleep onset; WSNs, warm-sensitive neurons

## Keywords

Sleep; Thermal comfort; Sleeping environment; Bedroom; Air temperature

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