# Exploring the effects of indoor air quality on sleep and sleep quality of older people

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**Purpose** We all are familiar with the phenomenon that when having a bad night's sleep we feel lousy the next day. This is also the case for people with dementia. We received a cry for help from a family carer claiming that his spouse with dementia displayed agitation and other symptoms of Behavioral and Psychological Symptoms of Dementia (BPSD) after a bad night while being exposed to poor indoor air. Nurses and family caregivers do report that some BPSD problems occur when heaters/air-conditioners are not switched on sufficiently early enough to maintain a comfortable indoor thermal environment (Wong et al., 2014). In a case study by Cremers (2015) findings showed that restlessness behavior (apnea, panic, humming) is observed in a person with dementia during the night when $CO_2$ levels in de bedroom exceed 800 ppm. Poor indoor air quality (IAQ), measured via carbon dioxide ($CO_2$) as a proxy, has a negative effect on people's health and performance (Wyon & Wargocki, 2013; Allen et al., 2016). Furthermore, it is known that bedroom air quality relates to sleep quality and next-day performance in healthy young adults (Strøm-Tejsen et al., 2015). Little is known though about the influence of indoor air quality on persons with dementia. To explore this, we first wanted to reproduce the study of Strøm-Tejsen, before moving to involve ageing people because of ethical and practical reasons. **Method** Therefore 3 studies (single case-cross-over) were executed involving 40 participants. The first study involved 18 healthy adults < 30 years, the second 10 ageing adults between 30 and 55 years, and the third study 12 older people > 55 years. All participated voluntarily after signing informed consent. Participants were healthy and were instructed to not use any medication, drinks, or food that might influence their sleep one week before and during the experiments. Participants were randomized to one of the two conditions, namely open or closed windows (study 1) or controlled mechanical ventilation with Low Ventilation (LV 15$m^3$/ h) or High Ventilation (HV 91$m^3$/h) (study 1 and 2). Measurements in one condition were during 1 week. After 1 week of rest, participants were assigned to the other condition. Sleep parameters such as Sleep latency, Length of sleep, No. of awakenings, and sleep efficiency were measured objectively via actigraphy. For that, participants were a Sensewear armband on the upper right arm. For sleep quality, the same parameters were measured subjectively including Sleep Depth using The Groningen Sleep Quality Scale (GSQS), and the Pittsburgh Sleep Quality Index (PSQI) that rates sleep over longer periods, and by filling in a sleep diary. The Indoor environment was measured by continuously measuring relative humidity (%), air temperature ($^oC$), and $CO_2$ concentration (ppm). Background noise (dB) was an interval measurement. The studies were executed in the Netherlands during the winter season to limit the possible influence of (day) light. Detailed information can be found in Mishra et al., 2018 and van der Veen et al., 2021. **Results and Discussion** The study of Strøm-Tejsen et al. could be reproduced. For ageing people < 30 years, sleep quality (sleep depth/sleep phase) worsens due to a reduction in bedroom ventilation. The $CO_2$ concentration went from 717 ppm (open) to1150 ppm (closed). In bedrooms of people aged 30 - 55 years sleep quality (length of sleep, sleep latency) worsens due to a reduction in the bedroom ventilation ($CO_2$ levels were 680 ppm (HV) to 1007ppm (LV)). In bedrooms of people, 55+ $CO_2$ concentrations went from 1007ppm (HV) to 1409 pp (LV). When comparing the people in study 2 with study 3, the number of awakenings was significantly higher in subjects 55+ ($p = .003$) while the depth of sleep was significantly lower for them ($p = .019$).

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