Normal and Abnormal Sleep in the Elderly

Steven H. Feinsilver, MD

KEYWORDS

• Elderly • Sleep apnea • Insomnia • Epidemiology • Sleep stages
• Polysomnography • Phase advance

KEY POINTS

- Sleep is a complex phenomenon with 4 distinct stages, including 3 stages of non-rapid eye movement (REM) sleep and REM.
- Sleep architecture changes with advanced age with reduced slow-wave (deepest) sleep.
- Circadian rhythm changes with normal aging often lead to a "phase advance" with earlier bedtimes and wake times.
- Sleep complaints increase with aging because of expected physiologic changes and the effects of illness and medication.

The elderly are the fastest growing segment of the world's population. One in 6 people in Europe and North America were estimated to be over the age of 65 as of 2019, rising to 1 in 4 by 2050; The number of persons aged 80 or over is expected to triple, from 143 million in 2019 to 426 million in 2050.[1] Sleep complaints increase with aging even in the absence of disease. In 1 epidemiologic study, more than half of elderly subjects had sleep complaints.[2] Many sleep complaints are indicators of poor health, and in a 3-year follow-up of elderly subjects with sleep complaints, many had resolution of their sleep symptoms with improved health,[3] seeming to imply that bad sleep is not a necessary consequence of normal aging.

WHAT IS NORMAL SLEEP?

The terminology for describing normal human sleep in stages has changed very little since originally described by Rechtshaffen and Kales[4] more than half a century ago.

Human consciousness can be divided into 3 states: wake, non–rapid eye movement (REM) sleep, and REM sleep. In a sleep laboratory polysomnogram (ie, a sleep study), measurements of electroencephalography (EEG), muscle tone with electromyography (EMG), and eye movements are used to distinguish the stages of sleep. Respiratory

Zucker School of Medicine at Hofstra Northwell Health, Center for Sleep Medicine, Lenox Hill Hospital, New York, NY, USA
E-mail address: sfeinsil@northwell.edu

Clin Geriatr Med 37 (2021) 377–386
https://doi.org/10.1016/j.cger.2021.04.001
geriatric.theclinics.com

monitoring includes measuring airflow by nasal pressure transducers and/or thermistors, respiratory effort by measuring chest and abdominal movement, and oximetry. End tidal or transcutaneous CO_2 sensors may be added. Electrocardiography is recorded, and leg movements may be monitored by EMG of the anterior tibialis muscle. Video is recorded using an infrared camera and light source. Additional recordings may be made for specialized studies.

Stages of sleep are summarized in **Table 1**. EEG during quiet wakefulness is a low-amplitude mixed frequency signal with relatively high muscle tone on EMG. The predominant EEG frequency is alpha rhythm (8–12 Hz; **Fig. 1**), which occurs during relaxed wakefulness with eyes closed. Sleep onset is characterized by the disappearance of alpha activity, reduction in EMG amplitude, and often slow ("rolling") eye movements. This period is the onset of stage 1 non-REM sleep, originally termed "transitional" sleep (**Fig. 2**). During this stage, sleep is light, and the subject is easily awakened. Stage 1 sleep is not considered to have much restorative value. About half of total sleep time (TST) is stage 2, identified by sleep spindles (episodes of 12–14 Hz activity lasting 0.5–1 second) and K-complexes (biphasic waves beginning with a sharp upward deflection). Spindles and K-complexes are seen in **Fig. 3**. In stage 3 sleep, at least 20% of the tracing consists of large slow waves (delta waves). Delta waves have a frequency of 0.5 to 1.5 Hz and an amplitude of at least 75 μV. Slow-wave sleep is seen in **Fig. 4**.

REM sleep was originally referred to as "paradoxic sleep," the paradox being that the brain is active while voluntary muscles are nearly paralyzed. The EEG may be difficult to distinguish from wakefulness. "REMs" are displayed in (**Fig. 5**), and the EMG shows muscle activity at the lowest level of the night. REM is thought to be the period of greatest respiratory and cardiac instability of sleep; because of the reduced muscle tone of accessory respiratory muscles, patients with diaphragmatic dysfunction may be at particular risk.

Normal sleep consists of transitions between the 4 stages of sleep in roughly 2- to 3-hour cycles (**Table 2**). There is wide variability from night to night and among individuals. After a period of up to 20 minutes on average ("sleep latency"), sleep usually begins with stage 1 sleep. A typical cycle of 90 to 110 minutes includes variable amounts of stage 2 and 3 sleep culminating in an REM period. The time to the first REM period ("REM latency") is typically 70 to 100 minutes. Generally, more deep sleep (stage 3) is seen in the first half of the night, and more REM sleep is seen in the second half of the night. Awakenings during the night are universal, although they may not be recalled the next day if brief. The quality of sleep can be expressed as sleep efficiency (SE): the ratio of TST to time in bed (TIB), and as wake time after sleep onset. Normal SE is approximately 85% in healthy adults.

Table 1
Stages of normal sleep

Sleep Stage	Characteristics	Significance
Wakefulness	Mixed-frequency, low-amplitude EEG; may see alpha waves if relaxed, eyes closed	Awake
Stage 1	Alpha disappears, may see theta waves	Light ("transitional") sleep 5%–10% of sleep time
Stage 2	Spindles and/or K-complexes seen	About 50% of sleep time
Stage 3	Theta (slow) waves	Deepest sleep
REM	REM, EEG similar to wake, low muscle tone	Dreaming sleep

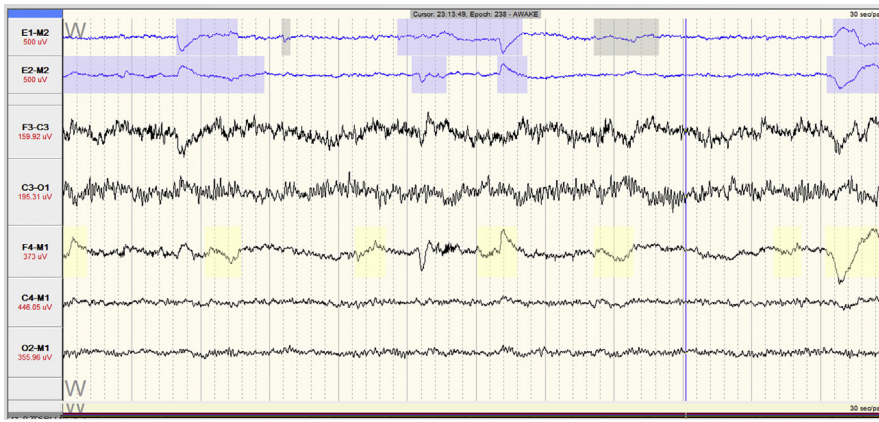

Fig. 1. Quiet wakefulness: alpha activity is prominent, seen best in central lead. All polysomnogram figures are 30-second samples. C, central; E, eye leads; F, frontal; M, mastoid; O, occipital.

WHAT IS NORMAL SLEEP IN THE ELDERLY?

Although changes appear to occur in both sleep timing and quality with aging, it is often difficult to separate normal aging from effects of both concomitant diseases and medications. The expected change in timing with aging is referred to as a "phase advance": peak sleepiness occurs earlier in the evening, normal bedtime becomes earlier, and sleep during the early morning hours is reduced. Societal pressure to keep "normal" hours may lead to elderly subjects staying awake later than optimal and becoming somewhat sleep deprived and may be one of the most important causes of poor sleep in the healthy elderly.

Common wisdom is that elderly patients need less sleep and are more likely to be sleepy during the day. The elderly do appear to get less sleep; a meta-analysis by Ohayon and colleagues[5] suggests a linear reduction in TST throughout adult life, with about 30 minutes less sleep at age 60 compared with age 40. Most studies show a reduction in SE, an increase in stage 1 (light sleep), and a reduction in stage

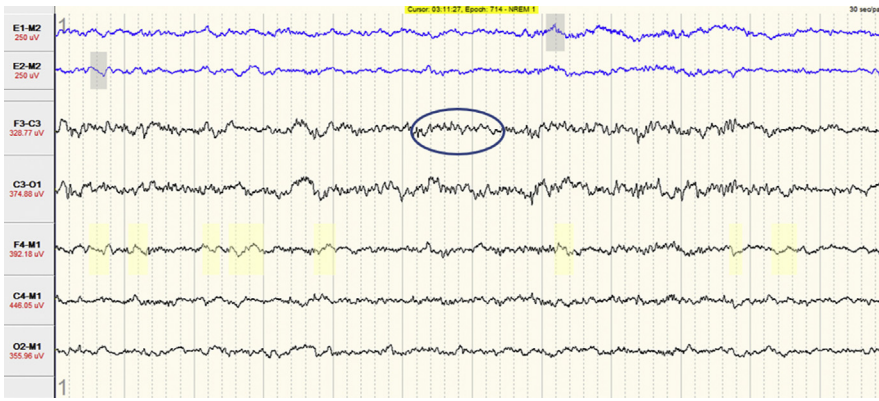

Fig. 2. Stage 1 sleep: low-amplitude, mixed-frequency, may have theta waves (*circle*).

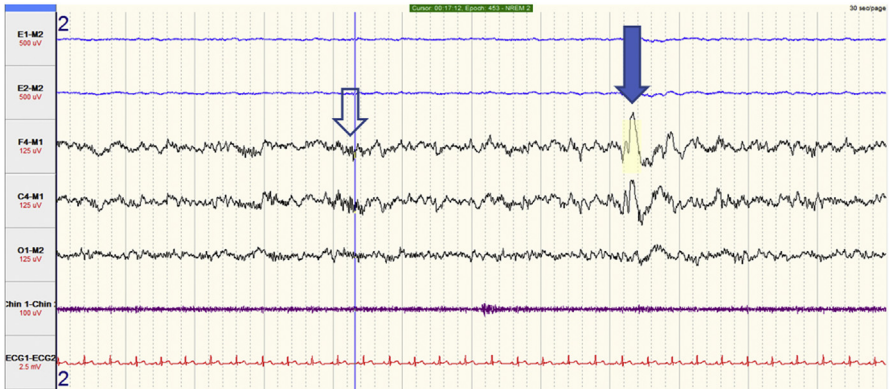

Fig. 3. Stage 2 sleep: sleep spindle (*open arrow*) and K-complex (*filled arrow*).

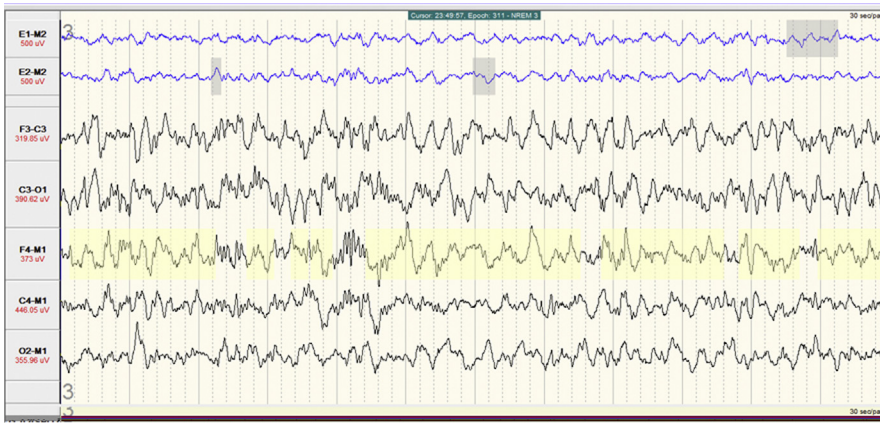

Fig. 4. Stage 3 sleep: slow (delta) waves seen in more than 20% of tracing. Here, most frontal tracing consists of slow waves.

Fig. 5. REM sleep: REMs marked with arrows. EEG is mostly low-amplitude mixed-frequency, some theta.

Table 2
Normal sleep

Measurement	Definition	Normal Range
Sleep latency (SL)	Time from lights out to sleep onset	<20 min
REM latency (REML)	Time from sleep onset to first REM period	70–120 min
Total sleep time (TST)	Total time asleep	360–480 min
Time in bed (TIB)	Total time in bed attempting to sleep	Variable
Wake after sleep onset (WASO)	Time spent awake during time in bed	<15% of time in bed
Sleep efficiency (SE)	TST/TIB	>85%

3 (slow-wave sleep). Sleep latency increases only minimally, less than 10 minutes from age 20 to 80.[5] The Sleep Heart Health Study[6] showed a decline in slow-wave sleep with aging in men but not women, and a reduction in REM sleep in both men and women. In the Ohayon meta-analysis, the percentage of REM sleep as well as the time to the first REM period (REM latency) decreased with age in both men and women.

The reduction in slow-wave sleep is one of the more significant changes from adulthood to middle age and beyond. Slow-wave sleep is considered the "deepest," most restorative stage of sleep. Normally, most growth hormone secretion occurs during slow-wave sleep. With reduced slow-wave sleep, there is a parallel reduction in growth hormone secretion, suggesting this does have physiologic significance.[7]

A summary of changes in sleep stages with aging is seen in **Table 3 Fig 6**.

The common stereotype of greater daytime sleepiness in the elderly may not be correct. One study showed a reduction in sleep propensity with aging,[8] and a study by Duffy and colleagues[9] suggests healthy elderly subjects may better tolerate sleep deprivation than younger adults.

Overall, the effect of these normal changes with aging lead to complaints of sleep maintenance more than sleep onset. As nocturnal sleep decreases, there may be more daytime sleepiness, although this is not universal, and there may be compensatory napping. However, daytime sleepiness should not be considered part of normal aging. If sleep complaints are significant, for example, affecting normal activities or cognitive functioning, or if there are other typical symptoms of a primary sleep disorder, diagnostic testing is warranted, as it would be in any other age group.

Table 3
Changes in sleep with aging

Sleep Parameter	Change
Total sleep time (TST)	Reduced
Sleep efficiency (SE)	Reduced
REM sleep	Reduced
Slow-wave sleep (SWS, stage 3)	Reduced
Sleep latency	Slightly increased
REM latency	Reduced
Wake after sleep onset (WASO)	Increased

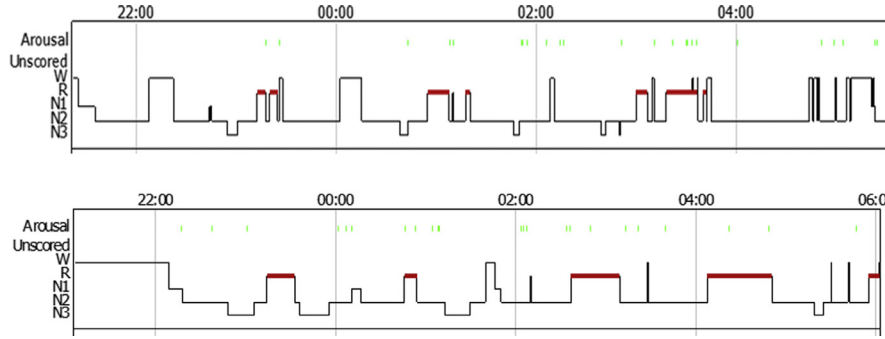

Fig. 6. Hypnograms from normal subjects. (*top*) Healthy 85-year-old. Note early sleep onset and early morning wakefulness, suggesting advanced sleep phase, several wakes, and less slow-wave sleep compared with bottom hypnogram from (*bottom*) healthy 33-year-old.

EPIDEMIOLOGY OF INSOMNIA IN THE ELDERLY

Behavioral Causes of Poor Sleep

Even in the completely healthy elderly, retirement and accompanying lifestyle changes often are accompanied by poor sleep. No longer being required to set a schedule for work may be gratifying, but a fixed schedule (and particularly a constant wake time) is the foundation of optimal sleep hygiene. It may become harder to exercise, or even to be exposed to natural light, both of which are important for establishing circadian rhythm. It may be easier to spend too much time in bed, or to nap excessively during the day. Most patients should adjust their schedule to the expected phase advance with aging, rather than try to stay up later than their peak sleepiness in the evening. All of these issues are more severe for those in any assisted living environment. Cognitive behavioral therapy for these issues may be particularly useful in the elderly (discussed elsewhere in this issue).

Medical Illness and Poor Sleep

Many illnesses, both medical and psychiatric, that are more common in the elderly, have profound effects on sleep.[10] Any disease associated with pain may lead to fragmented sleep. Cardiac and respiratory illnesses, including congestive heart failure, chronic obstructive pulmonary disease, and asthma, are commonly worse in sleep. Worsened breathing may be related to the recumbent position or by the respiratory drive reduction accompanying sleep. Hypoxemia and hypercapnia are slight at sleep onset, but are more noticeable in REM sleep. Chronic renal failure or anemia may cause or worsen symptoms of restless legs syndrome and periodic limb movements of sleep, leading to problems with sleep maintenance. Common medications may have changes on sleep architecture that are not always obvious. For example, beta-blockers are commonly associated with complaints of nightmares and increased dream recall, despite their effect of reducing REM sleep, because of increased awakenings. Sleep changes are more common with lipophilic beta-blockers.[11,12] Other conditions that commonly worsen sleep or worsen with sleep include arthritis, dementia, prostatic hypertrophy, depression, and anxiety.

EPIDEMIOLOGY OF SLEEP APNEA IN THE ELDERLY

Data regarding the prevalence of sleep apnea in the elderly are limited by inconsistent definitions. An apnea is a cessation of breathing lasting at least 10 seconds. Apneas

Box 1
Taking a sleep history

What time do you go to bed?

How long does it take to fall asleep?

Do you wake during the night (how many times)?

What time do you get out of bed in the morning?

Have you been observed to snore, gasp, choke, or stop breathing during your sleep?

Do you have trouble staying awake during the day?

may be obstructive (absent airflow with continued respiratory effort) or central (no effort). Hypopneas may be equally important in assessing breathing during sleep, but they have been defined by at least 2 separate conventions. In the 2012 standard of the American Academy of Sleep Medicine, a hypopnea is defined as a 30% or greater reduction in airflow accompanied by either an EEG arousal or a 3% oxygen desaturation.[13] The Centers for Medicare and Medicaid Services requires a 4% oxygen desaturation and does not accept an arousal. It may be difficult to distinguish obstructive from central hypopneas. The number of apneas per hour is the apnea index (AI). The number of apneas and hypopneas per hour is expressed as the apnea-

Box 2
Epworth sleepiness questionnaire

How likely are you to nod off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you haven't done some of these things recently, try to work out how they would have affected you. It is important that you answer each question as best you can. Use the following scale to choose the most appropriate number for each situation:

Would never nod off: 0

Slight chance of nodding off: 1

Moderate chance of nodding off: 2

High chance of nodding off: 3

Sitting and reading :_____

Watching TV: _____

Sitting, inactive, in a public place (eg, in a meeting, theater, or dinner event): _____

As a passenger in a car for an hour or more without stopping for a break: _____

Lying down to rest when circumstances permit: _____

Sitting and talking to someone: _____

Sitting quietly after a meal without alcohol: _____

In a car, while stopped for a few minutes in traffic or at a light: _____

Add up your points to get your total score. A score of 10 or greater raises concern: you may need to get more sleep, improve your sleep practices, or seek medical attention to determine why you are sleepy.

Adapted from Johns MW. A new method for measuring daytime sleepiness: The Epworth Sleepiness Scale. Sleep 1991;14:540.

hypopnea index (AHI). Depending on the definition for hypopnea used, this number can vary greatly, and it can be difficult to compare some epidemiologic studies. Although there are drawbacks to using this measure to quantify sleep apnea, it has become standard in the literature.

Obstructive sleep apnea is far more common than central sleep apnea. The prevalence of obstructive sleep apnea clearly increases among older and less healthy individuals. In 1 study of patients referred for sleep evaluation, the prevalence of an AI of 10 or more was 10% among independent older adults, 21% on a medical ward, and 26% in nursing home residents.[14] In the Sleep Heart Health Study, a random sample of nearly 6000 subjects, with hypopnea defined by 4% desaturations, the prevalence of an AHI of 15 or greater increased by 24% for each 10-year age increment, with a possible leveling off after 60 years of age.[15] The prevalence of central sleep apnea was extremely low in this healthy population: 91% had less than 1 central event per hour. Central sleep apnea, which may be associated with periodic breathing (Cheyne-Stokes pattern), is commonly associated with cardiac or neurologic disease.

In general, the most common symptoms of sleep apnea are snoring and daytime sleepiness in both the elderly and younger adults.[16] However, cognitive deficits and nocturia may also be frequent presentations in the elderly. Sleep apnea is generally more common in men than women and is associated with obesity. However, the gender difference ends at about the time of menopause.[17] After the age of 50, gender becomes an unimportant variable, and the association with body mass index becomes insignificant.[18]

SUMMARY

Sleep changes with aging, but poor sleep is not necessarily universal and should be investigated. All evaluations should start with a sleep history (**Box 1**): at a minimum, patients (and their bed partner, if available) should be asked about usual bedtime, average time to fall asleep ("sleep latency"), number of awakenings, usual time to get out of bed in the morning, presence of daytime sleepiness, and observations of snoring. A sleep log may be informative, but is highly subjective and may be inaccurate, as it is difficult for anyone to accurately assess their own sleep. Patients must be questioned about medications, alcohol, and caffeine use. Given the number of illnesses that can cause or be associated with poor sleep, all patients need a general physical examination and basic laboratory tests. The complaint of excessive daytime sleepiness (EDS) is an important clue. Although this is very subjective, the Epworth questionnaire (**Box 2**) may be helpful. This questionnaire asks about the propensity to become sleepy on a scale of 0 to 3 under 8 conditions, so that a higher score indicates greater sleepiness.[19] A score greater than 10 is considered abnormal. The Epworth scale is not well validated in the elderly, however.

Patients whose complaints appear consistent with normal aging need not be further investigated. Daytime napping may be normal or even beneficial, but EDS should not be considered normal in the healthy elderly. Any patient who appears to be getting a reasonable amount of sleep (perhaps 7 hours) who has difficulty staying awake should have further evaluation. This further evaluation might include overnight polysomnography or home sleep testing. With the increased availability of polysomnography and improved accuracy and simplicity of home testing, sleep evaluation is becoming increasingly convenient. Some patients should be screened even in the absence of significant sleep symptoms: those with a history of stroke or transient ischemic attack have such a high prevalence of sleep-disordered breathing that testing should be routine. Patients with early dementia also might be routinely tested, as there is

increased evidence that improvement or delaying of progression of symptoms with treatment for sleep apnea may occur, and symptoms may be difficult to assess.

CLINICS CARE POINTS

- Sleep changes with aging but complaints of poor sleep or daytime sleepiness should be investigated.
- Sleep disordered breathing may be a risk for stroke or dementia in the elders.

REFERENCES

1. United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019: Highlights (ST/ESA/SER.A/423).
2. Foley DJ, Monjan AA, Brown SL, et al. Sleep complaints among elderly persons: an epidemiologic study of three communities. Sleep 1995;18(6):425–32.
3. Foley DJ, Monjan A, Simonsick EM, et al. Incidence and remission of insomnia among elderly adults: an epidemiologic study of 6,800 persons over three years. Sleep 1999;22:S366–72.
4. Rechtshaffen A, Kales A. A manual of standardized terminology, techniques and scoring system for sleep stages of human subjects. Los Angeles (CA): UCLA Brain Information Service/Brain Research Institute; 1968.
5. Ohayon MM, Carskadon MA, Guilleminault C, et al. Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan. Sleep 2004;27(7):1255–73.
6. Redline S, Kirchner HL, Quan SF, et al. The effects of age, sex, ethnicity, and sleep disordered breathing on sleep architecture. Arch Int Med 2004;164: 406–18.
7. Van Cauter E, Leproult R, Plat L. Age-related changes in slow wave sleep and REM sleep and relationship with growth hormone and cortisol levels in healthy men. JAMA 2000;284:861–8.
8. Dijk DJ, Groeger JA, Stanley N, et al. Age-related reduction in daytime sleep propensity and nocturnal slow wave sleep. Sleep 2010;33:211.
9. Duffy JF, Willson HJ, Wang W, et al. Healthy older adults better tolerate sleep deprivation than young adults. J Am Geriatr Soc 2009;57:1245–51.
10. Quan SF, Zee P. Evaluating the effects of medical disorders on sleep in the older patient. Geriatrics 2004;59:37.
11. Betts TA, Alford C. Beta-blockers and sleep: a controlled trial. Eur J Clin Pharmacol 1985;28(suppl):65–8.
12. Westerlund A. Central nervous system side-effects with hydrophilic and lipophilic beta-blockers. Eur J Clin Pharmacol 1985;28(suppl):73.
13. Berry RB, Budhiraja R, Gottlieb DJ, et al. Rules for scoring respiratory events in sleep: update of the 2007 AASM manual. J Clin Sleep Med 2012;8(5):597–619.
14. Ancoli-Israel S. Epidemiology of sleep disorders. Clin Geriatr Med 1989;5:347.
15. Young T, Shahar E, Nieto FJ, et al. Predictors of sleep-disordered breathing in community-dwelling adults. Arch Intern Med 2002;162(8):893–900.
16. Lévy P, Pépin JL, Malauzat D, et al. Is sleep apnea syndrome in the elderly a specific entity? Sleep 1996;19:S29.
17. Young T, Finn L, Austin D, et al. Menopausal status and sleep-disordered breathing in the Wisconsin Sleep Cohort Study. Am J Respir Crit Care Med 2003;167(9): 1181–5.

18. Tishler PV, Larkin EK, Schluchter MD, et al. Incidence of sleep-disordered breathing in an urban adult population: the relative importance of risk factors in the development of sleep-disordered breathing. JAMA 2003;289(17): 2230–7.
19. Johns MW. A new method for measuring daytime sleepiness: the Epworth Sleepiness Scale. Sleep 1991;14:540.