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Sleep in Normal Aging

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As of 2006 persons 65 years of age or older comprise approximately 12% of the United States population, but by 2030 the proportion of older adults will rise to 20%. This older portion of the national population is increasing twice as fast as other age groups, so that by 2030 the number of persons 65 year of age or older in the United States will effectively double to 72 million. In this rapidly expanding older portion of the national population, one of the major changes that commonly accompany the aging process is an often profound disruption of an individual's daily sleep-wake cycle. As many as 50% of older individuals complain about sleep problems, including disturbed or "light" sleep, frequent awakenings, early morning awakenings, and undesired daytime sleepiness [1–3]. Such disturbances can lead to impaired daytime function and seriously compromise quality of life.

The most striking change in sleep in older adults is the repeated and frequent interruption of sleep by long periods of wakefulness, possibly the result of an age-dependent intrinsic lightening of sleep homeostatic processes [4,5]. Further, older adults are more easily aroused from nighttime sleep by auditory stimuli suggesting that they may be more sensitive to environmental stimuli [6]. Both of these changes are indicative of impaired sleep maintenance and depth and contribute to the characterization of the sleep of older adults as lighter, or more fragile, than that of younger adults.

These age-associated increases of nighttime wakefulness are mirrored by increases in daytime fatigue, excessive daytime sleepiness (EDS), and increased likelihood of napping or falling asleep during the day. Aging is also associated with a tendency to fall asleep and awaken earlier [7] (ie, a tendency for older individuals to be "larks" rather than "owls"). Older individuals also tend to be less tolerant of phase shifts in time of the sleep-wake schedule, such as those produced by jet lag and shift work [8,9]. These changes suggest an age-related breakdown of the normal adult circadian sleep-wake cycle.

It is important to note that even carefully screened older adults who do not complain of sleep disturbance and with minimal medical burdens show the changes described previously when compared with younger adults [10,11]. This suggests that at least some of the sleep disturbance seen in older adults is part of the aging process per se, apparently independent of any medical or psychiatric illnesses or primary sleep disorders, and often referred to as "age-related sleep change" [12,13]. A 60-year-old generally does not expect to be able to do all things as well as they did when they were 20. Similarly, their ability to sleep need not be the same. Just as an older individual can no longer

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run a 100-yd dash with the speed of their youth because of the physiologic changes that accompany the aging process, so too they can no longer sleep with the relatively undisturbed length and depth of the sleep of their younger years. As to whether this age-related decline in the ability to generate sleep equates with a decreased need for sleep in the later years of the human lifespan remains unclear. Nevertheless, the available scientific evidence suggests it is important to remember that, as one ages it might be best to modify the expectations about "inalienable rights" to life, liberty, and 8 hours of sound, uninterrupted sleep.

Sleep in normal aging

Sleep changes with advancing age, but the question remains, exactly when do these changes occur. Since the classic publication of Roffwarg and coworkers in 1966 [14], the accepted wisdom has been that the age-related sleep changes that characterize the sleep of older adults begin to appear in early adulthood and progress steadily across the full continuum of adult human lifespan, including the older adult years. Nearly 50 years of regular republication of Roffwarg and coworkers' [15] figure illustrating sleep change across the human life span, by the current author among many others, essentially reified this assumption.

Recent findings, however, call this assumption into serious question. The results of an extensive meta-analysis of objective sleep measures across the human lifespan by Ohayon and coworkers [15] demonstrated that the bulk of the changes seen in adult sleep patterns occur between early adulthood, beginning at age 19 through age 60, and that changes in sleep macroarchitecture effectively asymptote, declining only minimally from age 60 to age 102 [15].

The adult life span sleep changes reported by Ohayon and coworkers [15] are summarized in Table 1. These results are based on meta-analyses conducted on data from 2391 adults ages 19 to 102. When the full adult life span was examined, Ohayon and coworkers [15] confirmed the four consistently reported age-related changes in polysomnographic studies of sleep macroarchitecture: decreases in total sleep time, sleep efficiency, and slow wave sleep; and increases in wake after sleep onset. Ohayon and coworkers [15] also demonstrated that less consistently reported age-related sleep changes, increases in stage 1 and stage 2 sleep, and decreases in rapid eye movement sleep were all confirmed by their meta-analyses. Ohayon and coworkers [15] reported that age-related changes in either sleep latency or rapid eye movement latency were minimal.

Table 1: **Summary of significant findings from meta-analyses examining the associations between various sleep measures and age across both the full adult life-span (19-102 yrs) and the older adult life-span (60-102 yrs)**

	Adults 19–102 y	Older adults 60–102 y
Total sleep time	⇓	⇔
Sleep latency	⇔	⇔
WASO	⇑	⇔
Sleep efficiency	⇓	⇓
Percent stage 1	⇑	⇔
Percent stage 2	⇑	⇔
Percent SWS	⇓	⇔
Percent REM	⇓	⇔
REM latency	⇔	⇔

Abbreviations: REM, rapid eye movement; SWS, slow wave sleep; WASO, wake after sleep onset; ⇔, unchanged; ⇓, decreased; ⇑, increased.
(*From* Ohayon MM, Carskadon M, Guilliminault 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 2004:27:1255–73; with permission.)

All of these significant age changes in objectively assessed sleep architecture, however, were found only when the full adult life span was examined. When the sleep of only older (60+ years) adults was examined, meta-analyses demonstrated that only sleep efficiency declined significantly from ages 60 to 70 to ages ≥ 70 years, and even then at a modest rate of approximately 3% per decade. None of the other eight sleep measures showed any significant age-related change within the older adult portion of the study sample. It is of interest to note that these findings were comparable for both older men and older women.

These findings seem counterintuitive, and fly against the wind of commonly held concepts of sleep-changes with aging. It is important to remember, however, that Ohayon and colleagues [15] used very rigorous selection criteria in choosing the study subjects for their meta-analyses. The approximately 2400 subjects were not representative of the older population, but rather were in excellent health and more likely represent individuals who are "optimally" or "successfully" aging. Ohayon and coworkers [15] findings report normative sleep architecture data representing only those older adults who are in very good health and not average data for the overall older adult population, an extremely important distinction.

To illustrate this crucial point better, it is informative to contrast the findings of Ohayon and colleagues [15] with those of a recent large (2685

subjects) cross-sectional study of objective sleep measures of adults (37–92 years), the Sleep Heart Health Study cohort [16]. In this large and well-conducted study, Redline and colleagues [16] concluded that "…sleep architecture varies with sex, (and) age…" and that "Men, but not women, show evidence of poorer sleep with aging…." These conclusions seem at odds with those of Ohayon and colleagues [15]. Several important differences in the two studies need to be considered, however, beyond the obvious one of Ohayon and coworkers [15] being a meta-analysis and Redline and coworkers [16] being the report of a prospective cohort study. First, and perhaps most importantly, the Sleep Heart Health Study cohort was "…recruited from 9 existing epidemiological studies in which data on cardiovascular risk factors had been collected…" forming a cohort that "…met the inclusion criteria (age $\geq$40 years), no history of sleep apnea, no tracheotomy, and no current home oxygen therapy…" This relatively mild screening is in marked contrast to the extensive screening criteria used to develop Ohayon and coworkers study sample [15]. Second, Redline and colleagues [16], when examining possible age effects, did not break down their sample to see if there were any age effects in the older half of their sample, but rather examined such effects across the full age range available.

Essentially, the two studies are complementary with Ohayon and coworkers [15] reporting on the impact of age in individuals who are aging "successfully," whereas Redline and coworkers [16], with their much more liberal selection criteria, reporting on the impact of age in a group of individuals who are likely much more representative of the older population as a whole, are reporting on "average" aging. It is of particular interest that Redline concludes that men, but not women, tend to show poorer sleep with aging. Likely, this is the result of excess subclinical morbidity in men, because when such morbidity is screened out, as in the case of Ohayon and coworkers [15], there are minimal sex differences in the sleep of men and women across the adult life span.

What all of these finding suggest is that sleep clearly changes significantly across the human life span. When the comorbidities that typically accompany the aging process are controlled for and "optimal" aging examined, however, then the bulk of age-related sleep changes occurs in early and middle adulthood (years 19–60) and that after age 60, assuming one is in good health, further age-related sleep changes are modest. Conversely, if comorbidities are present, it is clear that normal age-related sleep changes may well be exacerbated.

Circadian rhythms in normal aging

Not only does the quality of sleep change across the human life span, but the timing of that sleep also changes with aging. Circadian rhythms are those that occur within a period of 24 hours (from the Greek "about [circa] a day [dies]"), such as the adult human sleep-wake cycle. The impact of aging on human circadian rhythms has recently been comprehensively reviewed by Monk [17]. Interestingly, as with sleep, there is a considerably disparity with what is the conventional wisdom concerning circadian rhythms and aging, and what is the evidence supporting or not supporting those conventionally held beliefs. Monk [17] summaries the conventional wisdom regarding what happens to human circadian processes with aging as (1) circadian amplitude is reduced; (2) there is a circadian phase advance (ie, the circadian rhythm moves earlier relative to the environment); (3) there is a shortening of the circadian free-running period (tau); and (4) the ability to tolerate rapid phase-shifts (eg, shift work, or rapid transmeridian travel [jet lag]) declines [17].

The available evidence, however, convincingly supports only two of these assumptions: older people tend to have earlier circadian phases, with a corresponding tendency to go to and arise from bed earlier than younger adults (eg; 7); and, older people have more trouble than younger adults adjusting to the rapid phase shifts of shift work and jet lag, at least in terms of sleep quality, subjective complaint, and performance measures (e.g.; 8–9). Interestingly, the data in support of diminished circadian amplitudes and shortened circadian taus in healthy older adults are equivocal [17].

Napping and excessive daytime sleepiness in normal aging

Two other commonly held assumptions about sleep and aging are that older adults typically nap more than younger adults and report more EDS. Although numerous community-based epidemiologic studies have reported prevalence rates for sleep disturbances, daytime sleep-related complaints, such as EDS, and possibly undiagnosed sleep disorders among older adults to be as high as 20% to 30% [1,18,19], few of these have reported the prevalence of regular napping and its association with sleep complaints and other mental and physical health problems, especially in relation EDS [18]. Perhaps surprisingly, although epidemiologic studies typically show a significant increase in the prevalence of regular napping with advancing age, EDS does not demonstrate a similar increase in prevalence among older adults [18,20].

Consistent with the findings described previously for nighttime sleep measures, very recent findings indicate that the presence of comorbidities (medical illness, depression, and so forth) is highly associated with the likelihood of an older adult reporting regular napping or EDS [21,22]. Healthy older adults, even those complaining of significant nighttime sleep disturbance, are much less likely to report regular napping or EDS than their more health burdened cohorts.

Regarding napping behavior, there is also considerable debate as to whether regular napping among older adults, particularly those in good health, may be beneficial to daytime wakefulness or perhaps detrimental to their nighttime sleep propensity [23–25]. The two studies that examined the impact of daytime napping on the nighttime sleep quality of healthy older adults found that napping had only a mild to moderate impact on nighttime sleep quality [24,25]; one of them further demonstrated that such napping resulted in improved cognitive performance postnap [24]. These results need to be interpreted with caution, however, because it must be emphasized that the subjects involved were healthy older adults without significant sleep complaints and neither older adults unhappy with their sleep quality nor geriatric insomniacs. It is unclear if similar results can be obtained, for example, with a sample of older insomniacs.

Causes of disturbed sleep in older adults

Much has been made of the often repeated fact that epidemiologic studies report as much as 50% of older adults complain of significant, chronic sleep disturbance. It is important to keep in mind, however, that 50% of older adults do not. Ohayon and coworkers [15] demonstrated that the bulk of age-related sleep changes occur in early to middle adulthood and that the sleep of very healthy older adults changes only very slowly across the later human life span. It has correspondingly been demonstrated that older adults who do not complain of any sleep problems nevertheless have objective sleep quality that is markedly compromised (eg, less total sleep time, sleep efficiency, slow wave sleep, and more wake after sleep onset) compared with that of healthy, non–sleep-complaining, younger adults. Nevertheless, there are many factors over and above age-related sleep (both sleep homeostatic and circadian) changes that can and do contribute to the significant sleep disturbance reported by nearly half of all older adults. These can include (1) medical and psychiatric comorbidities and their treatments, such as cardiovascular disease, arthritis, gastroesophageal reflux, or depression, and many of the drugs used to treat them; (2) primary sleep disorders, many of which, such as sleep apnea, restless legs syndrome, and rapid eye movement behavior disorder, tend to occur with

Table 2: **Causes of poor sleep in older adults**

Cause or problem	Examples
Physiologic	Age-related sleep change Age-related circadian rhythm change (phase advance)
Medical illnesses	Arthritis or other conditions causing chronic or intermittent pain Chronic cardiac or pulmonary disease Gastroesophageal reflux disorder
Psychiatric illnesses	Depression
Medications	Diuretics (leading to nocturnal awakenings) Inappropriate use of OTC medications
Primary sleep disorders	Sleep disordered breathing (sleep apnea) Restless legs syndrome REM behavior disorder
Behavioral or social	Retirement or lifestyle change reducing need for regular bed and rise times Death of a family member or friend Inappropriate use of social drugs Transmeridian air travel Napping
Environmental	Bedroom environment (eg, ambient noise, temperature, light, bedding) Moving to a new home or downsizing to a smaller space or a retirement community or related facility Institutionalization

Abbreviations: OTC, over-the-counter; REM, rapid eye movement.

increasing frequency in older adults; (3) the many behavioral, environmental, and social factors, often collectively referred to as "sleep hygiene," that can maximize or compromise an individual's sleep quality; or (4) some combination of these factors [12,13,26]. A more comprehensive listing of these factors is found in Table 2, and many of these issues are explored elsewhere in this issue.

Summary

There is no reason to assume, a priori, that the sleep of an older adult is necessarily disturbed or of poor quality; many high-functioning older adults are satisfied with their sleep, even though it is of objectively poorer quality compared with younger adults. It seems that, when the various factors that can disrupt sleep (health burden, primary sleep disorders, poor sleep hygiene practices, and so forth) are screened out, "optimally" or "successfully" aging adults can expect to undergo little change in their sleep, relative to those in the early to middle adult life span, and are not likely to experience EDS and the concomitant need to nap regularly during the day. Nevertheless, even successfully aging older adults can expect on average to be earlier to bed and to rise and to be less tolerant of circadian phase shifts, such as those induced by jet lag, than younger similarly healthy adults.

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