Published in final edited form as:

Am J Geriatr Psychiatry. 2008 January ; 16(1): 74–82. doi:10.1097/JGP.0b013e3181557b69.

Sleeping Well, Aging Well: A Descriptive and Cross-Sectional Study of Sleep in “Successful Agers” 75 and Older

Henry C. Driscoll, B.A., Linda Serody, M.S.W., Susan Patrick, B.S., Jennifer Maurer, M.L.I.S., Salem Bensasi, B.S., Patricia R. Houck, M.S.H., Sati Mazumdar, Ph.D., Eric A. Nofzinger, M.D., Bethany Bell, B.S., Robert D. Nebes, Ph.D., Mark D. Miller, M.D., and Charles F. Reynolds III, M.D.

From the Sleep and Chronobiology Program, Department of Psychiatry, University of Pittsburgh School of Medicine (HCD, LS, SP, JM, SB, PRH, EAN, BB, RDN, MDM, CFR), the University of Pittsburgh School of Public Health (SM, CFR), the Advanced Center for Interventions and Services Research in Late-Life Mood Disorders (HCD, LS, SP, SB, PRH, MDM, CFR), and the John A. Hartford Center of Excellence in Geriatric Psychiatry (CFR), Pittsburgh, Pennsylvania.

Abstract

Objectives—To examine diary-based, laboratory-based, and actigraphic measures of sleep in a group of healthy older women and men (≥ 75 years of age) without sleep/wake complaints and to describe sleep characteristics which may be correlates of health-related quality of life in old age.

Design—Cross-sectional, descriptive study.

Setting—University-based sleep and chronobiology program.

Intervention—None.

Participants—Sixty-four older adults (30 women, 34 men; mean age 79)

Measurements—We used diary-, actigraphic-, and laboratory-based measures of sleep, health-related quality of life, mental health, social support, and coping strategies. We used two-group t-tests to compare baseline demographic and clinical measures between men and women, followed by ANOVA on selected EEG measures to examine first-night effects as evidence of physiological adaptability. Finally, we examined correlations between measure of sleep and health-related quality of life.

Results—We observed that healthy men and women aged 75 and older can experience satisfactory nocturnal sleep quality and daytime alertness, especially as reflected in self-report and diary-based measures. Polysomnography (psg) suggested the presence of a first-night effect, especially in men, consistent with continued normal adaptability in this cohort of healthy older adults. Continuity and depth of sleep in older women were superior to that of men. Diary-based measures of sleep quality (but not psg measures) correlated positively (small to moderate effect sizes) with physical and mental health-related quality of life.

Conclusions—Sleep quality and daytime alertness in late life may be more important aspects of successful aging than previously appreciated. Good sleep may be a marker of good functioning across a variety of domains in old age. Our observations suggest the need to study interventions which protect sleep quality in older adults to determine if doing so fosters continued successful aging.

Keywords

sleep; successful aging; aging; health-related quality of life

Sleep quality is an important parameter of health-related quality of life in older adults, and it is possibly a correlate of continuing adaptability in later life.^{1,2} However, sleep disturbances are common in later life, particularly beyond 75 years, with loss of nocturnal sleep continuity and depth.^{1–3} Diminution in sleep quality may presage a decline in overall health status. Thus, as Shakespeare's Macbeth observed of "sleep that knits the raveled sleeve of care," (*Macbeth*, Act II, Scene II), learning how to protect sleep in later life may be important to continued healthy aging.

According to Rowe and Kahn,⁴ "successful aging" can be characterized by avoidance of disease, maintenance of high cognitive and physical function, and continued engagement with life. Given the evidence that behavioral factors like diet, smoking, and exercise affect one's ability to age successfully,⁵ studying the effect of sleep on adaptability and overall well-being observed in healthy aging may also be informative. As the discussion of how to define "healthy aging" continues,⁶ this study responds to the call to pursue "a more substantial empirical base for the emerging construct of 'successful aging'."⁷

A series of studies of the sleep characteristics of healthy older adults suggest the importance of sleep quality as a marker of overall health, well-being, and adaptability in later life. In a two-year observational study of laboratory- and diary-based sleep measures in two groups of healthy volunteers (age 60–74 and age 75 and older), Hoch et al.⁸ found that sleep efficiency (a measure of sleep consolidation) deteriorated to a greater degree over two years among subjects ages 75 and older than in subjects ages 60 to 74. Furthermore, a study by Dew et al.¹ found that "inefficient" sleep (i.e., fragmented sleep with frequent interruptions) in the very old (age 75 and over) predicted future declines in measures of mental and physical adaptation in older age, including diminished subjective sleep quality, fewer social activities, greater depressive symptoms, and more chronic medical burden. Dew et al.² also reported that after controlling for age, sex, and baseline medical burden, healthy elders with prolonged sleep latencies (>30 minutes) had 2.1 greater risk of death over a median follow-up interval of 13 years. Furthermore, in the same study, participants with poor sleep efficiency (<80%) had 1.9 greater risk of mortality; patients with either too much or too little rapid eye movement (REM) sleep percent (<16.1% or >25.7%) had 1.7 greater risk of mortality.

In this report, we describe measures of sleep and sleep quality in healthy older adults and how they relate to measures of health-related quality of life. We used as an organizing framework the domains of healthy aging elaborated by the MacArthur Foundation Research Network on Successful Aging.⁴ In the domain of disease avoidance, we examined such general health measures as body mass index and cumulative medical comorbidity burden. To reflect the maintenance of high cognitive and physical function, we examined measures of mental performance and mood as well as exercise level. Finally, relative to engagement with life, we report measures of self-esteem, social support, and coping strategies. In short, we have selected a group of participants and measures to look at aspects of aging that go beyond disease and disability, which are often the focus of aging research. We build on the work of the MacArthur Foundation Research Network on Successful Aging by seeking to relate what Jeste⁹ called "the long-term benefits of psychosocial support and perceptions of self-control" to sleep quality in healthy older adults.

An important aspect of the approach taken here is sex. More specifically, because women live longer than men and have better polysomnographic sleep measures,^{2,3,8} our strategy was to

compare measures of health and sleep between women and men in a group of elders aged 75 and older without any clinical manifestation of sleep disorders. In this context, we revisit the observation that women seem to have better electroencephalogram-defined sleep quality, overall, despite having more frequent complaints of insomnia in epidemiologic studies in later life.^{1,3,8} We also examine the differential “first-night effect” (i.e., improvement from the first to second night) between older men and women during their two-night stay in the sleep laboratory, because this measure may be a reflection of physiologic adaptability. Overall, our objective was to describe sleep characteristics that may be correlates of health, adaptability, and coping in “successful agers.” We thereby sought to provide a baseline against which to measure longitudinal health changes in relation to interventions designed to protect sleep quality and to prevent sleep “decay” in very old age. The outcomes of interventions to protect sleep will be the subject of a subsequent report of a randomized, controlled clinical trial in which healthy aging men and women were randomly assigned (stratified by sex) to programs of either good sleep practices or healthy dietary practices for 18 months.

METHODS

Subjects

Sixty-four healthy elderly men and women aged 75 and older (mean age: 79 years [both male and female subjects]) participated in the study, a component of a National Institute on Aging–funded program project (“AgeWise: Aging Well, Sleeping Efficiently”; T.H. Monk, PI, AG20677). Of the participants, 46.9% were female, and 10.9% were African American. We recruited subjects without complaints of insomnia, daytime sleepiness, and other sleep disturbances who had no current or past psychiatric disorder or sleep disorders as determined by the Structured Clinical Interview for the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*. To be eligible, subjects were also required to score seven or less on the 17-item Hamilton Depression Rating Scale and ≥ 24 on the Folstein Mini-Mental Status Exam. Potential subjects underwent the following: physical and neurologic examinations, electrocardiography, determination of complete blood cell count, thyroid function tests, and metabolic chemistry analysis. We conducted these tests to detect serious or uncontrolled physical health problems as well as medication use, which could affect sleep or mood. Subjects under a physician’s care for a stable medical illness (e.g., heart disease, hypertension, and arthritis) and with health conditions that pose no major limitations to activities of personal or instrumental daily living were enrolled in the study. A subject was excluded from the study if he or she had a mean sleep latency of less than six minutes on the Multiple Sleep Latency Test, because such a finding could indicate pathologic sleepiness.^{1,8} Two potential subjects, one out of 110 who were evaluated polysomnographically, were excluded from the study because of mean sleep latencies of less than six minutes. An additional seven patients were excluded because of elevated apnea–hypopnea indices (AHIs).

Informed consent was obtained from all subjects. Participants were recruited from institutional review board–approved advertising (N = 52) or some other referral source (N = 12). We applied no sex, race, or ethnic group restrictions. The protocol was approved by the University of Pittsburgh Institutional Review Board.

Procedure

Before laboratory-based polysomnography, subjects kept a diary of daily activities and subjective sleep quality and a sleep–wake log for two weeks. Subjects also wore a wrist activity monitor (actigraph) during the same two-week period. We performed polysomnography in private bedrooms at the Clinical Neuroscience Research Center of the Western Psychiatric Institute and Clinic (WPIC) during each subject’s habitual sleep time, as ascertained from the

sleep–wake diary. During the first day of the sleep study, we assessed subjects for daytime sleepiness using a multiple sleep latency test.

Laboratory-Based Sleep Measures

At the initial sleep study, subjects underwent two consecutive nights of polysomnography, including (on the first night) monitoring of sleep-disordered breathing and periodic limb movements, using procedures described elsewhere.⁸ We measured airflow via oral and nasal thermistors. Respiratory effort was measured with pizo-electric crystal movement detectors. Oxygen saturation was measured via a finger probe. The major laboratory-based measures included total sleep time, sleep continuity (sleep efficiency), REM sleep percent, slow-wave sleep percent, AHI, and mean sleep latency during the daytime multiple deep latency test (Multiple Sleep Latency Test). We selected these measures because they reflect age-dependent changes in sleep, such as loss of continuity and depth and increased prevalence of sleep-disordered breathing.³

Diary-Based Sleep Measures

We determined measures of habitual bedtime and rise time for each subject during the 14-day period preceding laboratory-based assessment.^{10,11} Subjects completed the Pittsburgh Sleep Diary¹¹ providing data on bedtime, rise time, napping, subjective sleep quality, mood, and vigor. We averaged diary measures over the 14 days of data collection and obtained mean and variability estimates. We used the Pittsburgh Sleep Quality Index to assess subjective sleep quality.¹² A Pittsburgh Sleep Quality Index score of five or greater indicates a sleep disorder.

Measures of Medical, Affective, and Cognitive Status

We administered the Medical Outcome Survey (MOS)–Short Form (SF)-36¹³ to measure general physical and mental health and health-related quality of life, as well as the Physical Functioning Index, a subscale from the MOS-SF-36. We also used the Cumulative Illness Rating Scale–Geriatric¹⁴ to measure the extent of medical comorbidity together with the Hamilton Rating Scale for Depression¹⁵ and the Hamilton Rating Scale for Anxiety¹⁶ to assess psychological symptom burden. We assessed cognitive functioning via the Logical Memory Test for episodic memory,¹⁷ the Letter-Numbering Sequencing for working memory,¹⁸ a test of nonverbal intelligence for reasoning (Test of Nonverbal Intelligence–III),¹⁹ and the Folstein Mini-Mental Status Exam.²⁰

To provide an index of physical health, we inventoried all medications for each patient (including over-the-counter as well as prescription medications). Sleep and circadian functioning were described via the Composite Scale of Morningness²¹ to determine if someone is more alert and active in the morning or evening and the Epworth Sleepiness Scale²² to measure daytime sleepiness. We used the Life Experience Survey²³ to determine the number and severity of stressful life events, together with the Perceived Stress Scale²⁴ to gauge subjective stress associated with on-going events. The Brief COPE instrument²⁵ was used to determine individual coping strategies for a given stressor. We administered the Interpersonal Support Evaluation List²⁶ to assess perceived social support and self-esteem.

Statistical Analyses

We used two-group *t*-tests to compare baseline demographic and clinical measures between men and women. Because our goal was to provide a broad and detailed description of the study groups (stratified by sex), we report data from a large number of measures relevant to different domains of healthy aging. Given the risk of type I error inflation inherent in this approach, $p < 0.01$ was used as an indicator of true nonrandom variation in the data. Electroencephalogram sleep measures were transformed before statistical comparison to normalize distribution. To

examine any sex differences in first-night effects and capacity for adaptation to the sleep laboratory, we performed repeated-measures analyses of variance on selected electroencephalogram measures (such as sleep efficiency and time spent asleep) with sex as the between-group factor and night (first versus second) as the within-subject factor. A significant interaction term was included in the analyses. AHI for men and women was compared by a nonparametric Mann–Whitney *U* test. Finally, we computed Pearson correlation coefficients to examine cross-sectional relationships between self-report and laboratory-based measures of sleep with health-related quality of life (MOS-SF-36).

RESULTS

To provide a health-related context for our examination of sleep, we first present data relevant to each of the three MacArthur Foundation Research Network on Successful Aging–defined domains of successful aging: 1) avoiding disease, 2) maintaining high cognitive and physical function, and 3) continuing engagement with life. We then present descriptive information about sleep, including sex-related differences, first-night effects, and sleep–health correlations.

Avoiding Disease: General Health and Health-Related Quality Of Life

As a group, participants were slightly overweight by body mass indices (Table 1). Women and men did not differ in burden of medical comorbidity (Cumulative Illness Rating Scale–Geriatric)¹⁴ or in mental or physical health–related quality of life (MOS).¹³ Participants generally engaged in light to medium exercise, as reflected in diary-based reports, with no difference between sexes.

Maintaining Mental Health and Cognitive Function

Participants were well educated, with both women and men reporting >15 years of education (Table 1). They reported few symptoms of depression and anxiety on the Hamilton Rating Scales for Depression and Anxiety and scored high on the Folstein Mini-Mental Status Exam, with women performing some-what better than men (mean [SD]: 29.4 [0.7] versus 28.8 [1.0], respectively). No sex differences were detected in other cognitive performance measures.

Staying Engaged With Life and With Significant Others: Coping and Support

Another important aspect of successful aging is captured by measures that reflect how people engage life and the support they have from others (Table 1). Participants reported adaptive coping strategies, good social support, and manageable levels of perceived stress. In all, 21 of 30 female participants and 20 of 34 male participants acknowledged the occurrence of a life stressor in the prior 30 days and provided coping measures in relation to the stressful event. Briefly, most participants (eight women and eight men) reported daily hassles as being the greatest recent stressor. Five people (one woman and four men) reported death of a spouse or immediate family member as the greatest recent stressor, with five others reporting that the health of a spouse or immediate family member was their most significant recent concern. Other subjects reported crime or accidents (*N* = 4), relationships (*N* = 3), financial troubles (*N* = 3), and own health (*N* = 1) as being primary stressors. In general, no sex imbalance in the nature of stressors was evident.

With respect to coping, women and men endorsed similar strategies. Overall, they also did not differ significantly in the various domains of social support (Interpersonal Support Evaluation List), except that women reported a greater sense of belonging. Women and men did not differ in measures of self-esteem.

Sleep Characteristics in Healthy Aging: Self-Report, Actigraphic, and Polysomnographic Measures

We analyzed sleep characteristics within the context of healthy aging, using diary-based, actigraphic, and polysomnographic data (Table 2 and Table 3). In two-week diary-based measures, women and men did not differ in mean sleep quality, mood, or alertness. Mean level as well as variability in these measures was similar across sexes, reflecting a high level of perceived sleep quality (Table 2).

Wrist actigraphic data enabled us to bridge diary self-report data with polysomnographic measures. The median difference between actigraphic estimates of sleep onset (when physical activity ceases as measured by wrist actigraphy) and diary-based report (when a subject falls asleep) was similar for women and men and confirmed the reliability of self-reported measures of time to sleep onset. We observed a broad range of AHIs, with some elevations of >20 , but these subjects had no complaints or symptoms of sleep apnea or daytime sleepiness. For any subject with an AHI of >10 , we recommended a pulmonary sleep evaluation. Four subjects subsequently began treatment with continuous positive airway pressure or bilevel positive airway pressure.

We compared polysomnographic measures by sex and night (first versus second night) (Table 3). Women spent significantly more time asleep than men and were more stable sleepers across both nights; however, men achieved the same amount of sleep time by the second night. Women also demonstrated greater sleep efficiency (which expresses the ratio or percent of the total recording period that is actually spent sleeping) and delta sleep percent. Women and men had similar sleep latencies (i.e., the amount of time to fall asleep) for each night. This result was similar to actigraphic estimates of sleep latencies (mean [SD]: 27.3 [46.9] minutes for women and 20.6 [32.9] minutes for men).

As expected, several significant first-night effects were also detected, as evidenced by improvements from the first to second night (Table 3). Overall, participants had a significant increase in time spent asleep, sleep efficiency, and REM sleep percent from the first to second night of sleep recording. Significant group effects (greater for women than for men) were observed in slow-wave sleep percent and time spent asleep. A significant sex-by-night interaction in time spent asleep reflected a differentially greater improvement in men's sleep time from the first to second night (Table 3).

Relationships in Healthy Aging Between Sleep and Health-Related Quality of Life

We calculated Pearson correlations between health-related quality of life measures (MOS-SF-36) with self-report, diary-based, and polysomnographic sleep measures. We performed a total of 12 correlations for the pooled sample of women and men. Better physical health-related quality of life on the MOS-SF-36 was associated with better sleep quality on the Pittsburgh Sleep Quality Index (Pearson $r = -0.26$, $df = 62$, $p < 0.05$). Better mental health-related quality of life was associated with better sleep quality on the diary-based measure (Pearson $r = 0.30$, $df = 62$, $p < 0.05$). These associations represent a small-to-moderate effect size. If we impose α of 0.01 to control for the type I error rate, they fall short of meeting this criterion for statistical significance. We found no association between health-related quality of life and polysomnographic measures of time spent asleep, sleep efficiency, sleep latency, and REM sleep percent.

CONCLUSIONS

The primary challenge posed by increasing numbers of older adults in the United States is the promotion of "healthy aging": that is, increasing active life expectancy and compressing

functional comorbidity at the end of life.⁴ Otherwise, longevity will come at the cost of increasing dependency and poor quality of life. An understanding of how sleep and preservation of sleep quality may contribute to healthy aging is important, given the high rate of insomnia and other sleep disorders in old age.

Men and women age 75 and older, who are in generally good health, still can experience satisfactory nocturnal sleep quality and daytime alertness, as reflected in self-report and diary-based measures. Nocturnal sleep quality and daytime alertness can be well preserved in seniors who continue to enjoy good health and cope actively with the challenges of growing old. Thus, as previously observed by other investigators,^{3,27,28} older adults who report good sleep are functioning well in general: that is, good sleep is a marker for good functioning across a variety of domains. This observation suggests that good sleep quality and daytime alertness in late life may be an important, but perhaps underappreciated, aspect of successful aging, including ability to cope, to actively engage in life, and to bounce back from adversity. Our subjects had the characteristics that were frequently correlated with various definitions of healthy aging described by Depp and Jeste,⁶ including social support, good self-rated health, and general absence of depression and cognitive impairment.

Because this is a cross-sectional report of baseline (preintervention) data, no causal inferences are possible. It seems plausible that there would be a bidirectional relationship between healthy aging and sleep, but this relationship remains to be demonstrated. In these cross-sectional data, we observed an association between measures of sleep quality (especially self-report) and measures of health-related quality of life (mental and physical).

Men and women had similar mental and physical health, coping and well-being, and subjective and diary-based measures of sleep quality and daytime well-being. However, they had differences in polysomnographic measures of time spent asleep, sleep efficiency, and slow-wave sleep, findings consistent with previous reports in the literature: polysomnographically defined continuity as well as depth of sleep in older women is superior to that in men.^{3,8} Nonetheless, men were able to adapt to laboratory recording conditions and had improved sleep time by the second night. The question of why such polysomnographically superior sleep quality for women in our study persists in spite of more frequent complaints of insomnia in later life (an observation from other studies) remains a paradox.

The apparent presence of a first-night effect in this cohort was noted in measures of sleep that typically decline with aging (time spent asleep, sleep efficiency, slow-wave sleep percent, and REM sleep percent): that is, we observed improvement in measures of sleep continuity and architecture from the first to second night. One interpretation is that the presence of a first-night effect suggests a continuing capacity for physiologic adaptability in this cohort of healthy older adults. Another interpretation is that less intrusive instrumentation was used on Night 2 (i.e., no-respiratory or limb movement recording), thereby accounting for improvement in sleep.

What we cannot tell from these data is whether taking steps to preserve or enhance sleep quality will result in maintenance or improvement in health-related quality of life over the long run. Thus, we are now conducting a clinical trial with this same cohort of healthy older adults to test the effect of sleep hygiene education and restriction of time in bed on 1) stabilizing or reversing deterioration in sleep continuity and depth and 2) improving health-related quality of life. By testing the ways through which we can help maintain quality of sleep into very old age, we aim to add to evidence-based strategies that promote continued well-being in the final years of life.

Acknowledgments

This work was supported in part by the following grants: P01 AG20677, P30 MH071944, R01 MH37869, R01 MH43832, and T32 MH19986.

The authors thank their subjects for participation in the study.

References

1. Dew MA, Reynolds CF, Monk TH, et al. Psychosocial correlates and sequelae of electroencephalographic sleep in healthy elders. *J Gerontol* 1994;49:P8–P18. [PubMed: 8282984]
2. Dew MA, Hoch CC, Buysse DJ, et al. Healthy older adults' sleep predicts all-cause mortality at 4 to 19 years of follow-up. *Psychosom Med* 2003;65:63–73. [PubMed: 12554816]
3. 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;27:1255–1273. [PubMed: 15586779]
4. Rowe, JW.; Kahn, RL. *Successful Aging*. New York: Pantheon Books; 1998.
5. Peel NM, McClure RJ, Bartlett HP. Behavioral determinants of healthy aging. *Am J Prev Med* 2005;28:298–304. [PubMed: 15766620]
6. Depp CA, Jeste DV. Definitions and predictors of successful aging: a comprehensive review of larger quantitative studies. *Am J Geriatr Psychiatry* 2006;14:6–20. [PubMed: 16407577]
7. Blazer DG. Successful aging. *Am J Geriatr Psychiatry* 2006;14:2–5. [PubMed: 16407576]
8. Hoch CC, Dew MA, Reynolds CF, et al. A longitudinal study of laboratory- and diary-based sleep measures in healthy "old old" and "young old" volunteers. *Sleep* 1994;17:489–496. [PubMed: 7809561]
9. Jeste DV. Feeling fine at a hundred and three: secrets of successful aging. *Am J Prev Med* 2005;28:323–324. [PubMed: 15766623]
10. Monk TH, Flaherty JF, Frank E, et al. The Social Rhythm Metric: an instrument to quantify the daily rhythms of life. *J Nerv Ment Dis* 1990;178:120–126. [PubMed: 2299336]
11. Monk TH, Reynolds CF, Kupfer DJ, et al. The Pittsburgh Sleep Diary. *J Sleep Res* 1994;3:111–120.
12. Buysse DJ, Reynolds CF, Monk TH, et al. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res* 1989;28:193–213. [PubMed: 2748771]
13. Stewart AL, Hays RD, Ware JE. The MOS short-form general health survey. Reliability and validity in a patient population. *Med Care* 1988;26:724–735. [PubMed: 3393032]
14. Miller MD, Paradis CV, Houck PR, et al. Rating chronic medical illness burden in geropsychiatric practice and research: application of the Cumulative Illness Rating Scale. *Psychiatry Res* 1992;41:237–248. [PubMed: 1594710]
15. Hamilton M. A rating scale for depression. *J Neurol Neurosurg Psychiatry* 1960;23:56–62. [PubMed: 14399272]
16. Hamilton M. The assessment of anxiety states by rating. *Br J Med Psychol* 1959;32:50–55. [PubMed: 13638508]
17. Wechsler, D. *Wechsler Memory Scale-Revised*. San Antonio, TX: The Psychological Corporation; 1987.
18. Wechsler, D. *Wechsler Adult Intelligence Scale-III*. San Antonio, TX: The Psychological Corporation; 1997.
19. Brown, L.; Sherbenou, PJ.; Johnsen, SK. *Test of Nonverbal Intelligence*. Austin, TX: Pro-Ed Inc.; 1998.
20. Folstein MF, Folstein SW, McHugh PR. Mini-Mental State: a practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975;12:189–198. [PubMed: 1202204]
21. Monk TH, Kupfer DJ. Which aspects of morningness-eveningness change with age? *J Biol Rhythms* 2007;22:278–280. [PubMed: 17517918]
22. Johns MW. A new method for measuring daytime sleepiness: the Epworth Sleepiness Scale. *Sleep* 1991;14:540–545. [PubMed: 1798888]

23. Russo J, Vitaliano PP. Life events as correlates of burden in spouse caregivers of persons with Alzheimer's disease. *Exp Aging Res* 1995;21:273–294. [PubMed: 7493596]
24. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav* 1983;24:385–396. [PubMed: 6668417]
25. Carver CS. You want to measure coping but your protocol's too long: consider the Brief COPE. *Int J Behav Med* 1997;4:92–100. [PubMed: 16250744]
26. Williamson G, Schulz R. Physical illness and symptoms of depression among elderly outpatients. *Psychol Aging* 1992;7:343–351. [PubMed: 1388854]
27. Vitiello, M.; Prinz, P. Sleep and sleep disorders in normal aging. In: Thorpy, MJ., editor. *Handbook of Sleep Disorders*. Marcel Dekker; New York: 1990. p. 139-152.
28. Foley DJ, Monjan AA, Brown SL, et al. Sleep complaints among elderly persons: an epidemiologic study of three communities. *Sleep* 1995;18:425–432. [PubMed: 7481413]

TABLE 1

Sociodemographic and Clinical Measures in Healthy Elders Without Sleep Complaints (Mean [SD]): Contrasts Between Women and Men

	All (N = 64)	Women (N = 30)	Men (N = 34)	t or χ^2	dfp
Demographic					
Age, years	78.9 (3.3)	78.9 (3.4)	78.9 (3.2)	0.10	620.92
White, %	89	80	97		0.044 ^a
Education, years	15.3 (2.2)	15.1 (2.1)	15.5 (2.4)	0.66	620.51
Marital status, no.				15.89	30.0001
Divorced	5	5	0		
Married/living with partner	37	10	27		
Never married	5	4	1		
Widowed	17	11	6		
General health					
BMI	26.6 (3.9)	27.7 (4.4)	25.6 (3.2)	2.22	610.030
Cumulative Illness Rating Scale–Geriatric	7.3 (2.9)	7.1 (2.5)	7.4 (3.3)	0.32	600.75
Quality of life					
MOS-P	48.5 (5.6)	47.7 (5.4)	49.1 (5.8)	0.98	620.33
MOS-M	58.5 (5.0)	58.9 (4.5)	58.1 (5.5)	0.58	620.56
Physical Functioning Index	82.5 (14.3)	80.0 (13.8)	84.7 (14.5)	1.33	620.19
Physical activity					
Median exercise	0.76	0.47	0.67	2.97	10.085
Cognitive function					
Folstein Mini-Mental Status Exam	29.1 (1.0)	29.4 (0.7)	28.8 (1.0)	2.69	610.009
TONI-III	103.2 (12.0)	99.7 (9.6)	106.1 (13.1)	2.16	610.034
Number-Letter Sequencing Test	9.4 (2.3)	9.1 (2.6)	9.7 (2.0)	1.02	600.31
Logical Memory Test–Immediate Recall	23.0 (5.6)	24.0 (5.6)	22.3 (5.6)	1.19	600.24
Logical Memory Test–Delayed Recall	18.8 (6.3)	20.1 (6.2)	17.7 (6.2)	1.50	600.14
Mental health					
HRSD	1.7 (1.5)	1.7 (1.6)	1.6 (1.4)	0.05	620.96
HRSA	2.5 (1.9)	2.2 (1.6)	2.7 (2.1)	1.12	620.27
Social support					
Interpersonal Self Evaluation List–Tangible	10.1 (1.7)	10.1 (1.7)	10.2 (1.7)	0.31	610.75
Belonging	9.8 (1.7)	10.5 (1.6)	9.3 (1.6)	2.96	610.004
Appraisal	9.8 (1.8)	10.1 (1.8)	9.5 (1.8)	1.40	610.17
Self-esteem	9.0 (1.7)	9.1 (1.9)	9.0 (1.4)	0.23	610.82
Perceived stress	2.2 (2.0)	2.1 (2.0)	2.2 (2.0)	0.15	620.88
Coping strategy		N = 21	N = 20		
Acceptance	6.4 (1.9)	6.7 (2.0)	6.2 (1.8)	0.78	390.44
Active coping	5.9 (1.9)	6.3 (1.9)	5.5 (1.8)	1.43	390.16
Behavioral disengagement	2.3 (0.8)	2.2 (0.7)	2.4 (1.0)	0.61	390.55
Denial	2.8 (1.5)	2.9 (1.6)	2.7 (1.5)	0.32	390.75
Emotional support	4.9 (2.2)	4.9 (2.1)	5.0 (2.3)	0.13	390.89
Humor	3.0 (1.6)	3.1 (1.5)	3.1 (1.8)	0.00	390.99
Self-distraction	3.4 (1.8)	3.6 (2.0)	3.2 (1.7)	0.65	390.52
Planning	5.8 (2.0)	6.0 (2.2)	5.5 (1.8)	0.79	390.43
Positive reframing	4.9 (2.1)	5.5 (2.1)	4.3 (2.0)	1.85	390.072
Religion	5.0 (2.5)	5.7 (2.6)	4.2 (2.3)	1.90	390.065
Venting	3.3 (1.5)	3.8 (1.7)	2.9 (1.1)	2.03	390.049

Notes: BMI: body mass index; MOS-P: Medical Outcome Study–Physical; MOS-M: Medical Outcome Study–Mental; TONI-III: Test of Nonverbal Intelligence–III; HRSD: Hamilton Rating Scale for Depression; HRSA: Hamilton Rating Scale for Anxiety.

^aExact p.

TABLE 2

Self-Reported and Diary-Based Measures of Sleep (Mean [SD]): Contrasts Between Women and Men

	All (N = 64)	Women (N = 30)	Men (N = 34)	t or χ^2	dfp
Sleep questionnaire and polysomnographic data					
Pittsburgh Sleep Quality Index	3.1 (1.8)	3.1 (1.8)	3.1 (1.7)	0.02	620.99
Smith Morningness	44.9 (5.4)	44.5 (5.9)	45.2 (5.1)	0.52	610.61
Epworth Sleepiness	6.5 (2.6)	6.2 (2.4)	6.7 (2.8)	0.81	620.42
Median Multiple Sleep Latency Sleepiness Index	26.0	23.7	29.8	0.05	10.82
Median AHI	12.2	11.0	14.4	1.05	10.31
Range of AHI scores	0.5–80.2	0.5–51.3	0.4–80.2		
Diary data (2 weeks before laboratory study)					
Median no. of naps	3	3	1	0.73	10.39
Subjects who napped, %	69	77	62		0.28 ^a
Length of naps, minutes	38.2 (18.5)	34.7 (19.1)	42.8 (17.1)	1.42	390.16
Sleep quality, nocturnal ^b	77.0 (11.5)	76.1 (11.7)	78.0 (11.4)	0.42	10.52
Mood on awakening ^b	80.6 (11.5)	78.8 (12.9)	82.4 (9.9)	0.88	10.35
Alertness on awakening ^b	79.7 (12.9)	78.3 (14.2)	81.1 (11.4)	0.45	10.50

Note: AHI: apnea–hypopnea index.

^aExact p.

^bVisual analogue scale (0 – 100), where higher score indicates better quality.

TABLE 3

EEG Sleep Measures by Sex and Night (Mean [SD])

	Women		Men		Effect (df = 1,62) F, p	
	Night 1	Night 2	Night 1	Night 2	Group	Night
TSA, minutes	324 (50)	348 (43)	281 (73)	339 (48)	5.49, 0.0223	25.72, 0.0001
Sleep latency, ^a minutes	23.9 (24.9)	19.5 (15.5)	26.7 (21.0)	21.0 (21.9)	0.53, 0.47	3.61, 0.062
Sleep efficiency ^b	74.7 (9.1)	80.2 (7.4)	66.4 (14.5)	78.0 (8.6)	4.96, 0.030	31.69, 0.0001
REM sleep percent	19.1 (5.3)	21.4 (7.1)	16.1 (6.4)	21.5 (5.5)	1.11, 0.30	19.54, 0.0001
Delta sleep percent ^a	4.4 (6.0)	3.1 (3.8)	1.4 (2.7)	0.8 (1.3)	12.99, 0.0006	3.16, 0.0805
						0.30, 0.59

Notes: We noted sex differences (greater for females) in TSA ($F[1,62] = 5.49, p = 0.022$) and sleep efficiency ($F[1,62] = 4.96, p = 0.030$); first-night effect on TSA ($F[1,62] = 25.72, p = 0.0001$), sleep efficiency ($F[1,62] = 31.69, p = 0.0001$), and REM sleep percent ($F[1,62] = 19.54, p = 0.0001$); and a sex-by-night interaction in TSA ($F[1,62] = 4.23, p = 0.044$), reflecting an increase in TSA in men from Night 1 to Night 2. EEG: electroencephalogram; GxN: Group-by-night; TSA, time spent asleep; REM: rapid eye movement.

^a Square root transformation before statistical comparison.
^b Natural log transformation before statistical comparison.