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Association between Depressive Symptoms and Sleep Disturbances among Community-Dwelling Older Men

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Abstract

Objectives—To examine the association between depressive symptoms, subjective and objective measures of sleep in community-dwelling older men.

Design—Cross-sectional

Setting—Six US clinical centers

Participants—3051 men aged 67 and older

Measurements—Depressive symptoms assessed using the 15-item Geriatric Depression Scale and categorized as 0–2 (normal, referent group), 3–5 (some depressive symptoms) and 6–15 (depressed). Objective sleep measures ascertained using wrist actigraphy (mean duration 5.2 nights), and subjective sleep measures assessed using the Pittsburgh Sleep Quality Index (PSQI) and Epworth Sleepiness Scale (ESS).

Results—There was a strong multivariable adjusted association between level of depressive symptoms and subjective sleep disturbances (p-trend<0.001). For example, compared with normal men, the odds of reporting poor sleep quality were 3.7-fold (95% CI 2.5 to 5.3) higher for depressed men, and 2.1-fold (95% CI 1.7 to 2.6) higher for men with some depressive symptoms. For objectively measured sleep disturbances, men with a greater level of depressive symptoms had an increased odds of sleep latency ≥1 hour (p-trend=0.006). There was no association between levels of depressive symptoms and reduced sleep efficiency, increased awakening after sleep onset, multiple long-wake episodes or total sleep time. Excluding 384 men taking antidepressants, benzodiazepines or other anxiolytic/hypnotics did not alter the results.

Conclusion—Depressive symptoms have a strong, graded association with subjective sleep disturbances; and are moderately associated with objectively measured prolonged sleep latency. Future studies should address temporality of depression and sleep disturbances.

Keywords

depression; depressive symptoms; sleep; elderly; actigraphy

INTRODUCTION

Complaints of sleep disturbances such as insomnia, sleep fragmentation and daytime sleepiness are common in the general population, estimated at 36%[1] with an even higher prevalence (50%) among the elderly.[2] Previous studies have reported that loss of sleep among the elderly is

associated with an increased risk of adverse outcomes including accidents, falls, poor health status,[3,4] and all-cause mortality.[5]

Depression is another common condition among older people, with 8–16% of older adults having depressive symptoms.[6] Studies evaluating subjects with depressive symptoms and/or depression have suggested that both conditions are associated with increased disability, poorer physical function, increased perception of poor health status,[6] falls, and fractures.[7]

The association between sleep disturbances and depressive symptoms is complex, bidirectional in nature, and not thoroughly understood. Both depressive symptoms and sleep disturbances are affected by a number of other factors including medication use, especially medications that have a known effect on sleep architecture (such as antidepressants, benzodiazepines and non-benzodiazepine anxiolytics/hypnotics);[8,9] comorbid conditions such as diabetes mellitus, cardiovascular disease and parkinsonism; alcohol use; pain; cognitive function; and anxiety.[10] The existing literature on depressive symptoms and sleep in the elderly is limited. While studies in the elderly, as well as younger cohorts, have suggested an association between depression and sleep disturbances, they have been largely limited by sampling methods, small sample sizes, and/or reliance on only one type of sleep measure, either subjective or objective.[10–12]

To determine whether higher levels of depressive symptoms are associated with a greater likelihood of subjective and objective sleep disturbances in older men, we assessed depressive symptoms; self-reported measures of sleep quality and daytime sleepiness; and measured objective sleep parameters using actigraphy in a cohort of community-dwelling men aged 67 and older enrolled in the Outcomes of Sleep Disorders in Older Men Study (MrOS Sleep Study).

METHODS

Participants

From March 2000 through April 2002, 5,995 men who were at least 65 years of age were recruited for participation in the baseline examination of the prospective Osteoporotic Fractures in Men (MrOS) study.[13] Men were recruited from population based listings in six areas of the United States: Birmingham, Alabama; the Monongahela Valley near Pittsburgh, Pennsylvania; Minneapolis, Minnesota; Palo Alto, California; San Diego, California; and Portland, Oregon.[14] Men with a history of bilateral hip replacement and men who were unable to walk without the assistance of another person were excluded.

From December 2003 through March 2005, subjects were invited to participate in an ancillary study to identify outcomes of sleep disorders in older men (MrOS sleep study). Of the 5995 men enrolled in the overall MrOS study, 3135 (68%) were enrolled in the MrOS sleep examination. Of the 3135 men who completed the MrOS Sleep Study, 3051 had depression measures and technically adequate actigraphy data and are the subject of this analysis. The Institutional Review Board (IRB) at each center approved the study protocol and written informed consent was obtained from all subjects.

Measures of Depression

Depression status was evaluated using the 15-item Geriatric Depression Scale (GDS), a validated self-reported questionnaire designed specifically for elderly subjects consisting of 15 yes/no questions dealing with depressive symptoms. A standard cutoff of 6 or more symptoms was used to define clinically significant depression; this cutoff has a sensitivity of 91% and a specificity of 65% compared with DSM-IV diagnoses.[15] For this analysis, we examined whether higher levels of depressive symptoms were associated with a greater

likelihood of sleep disturbances. We categorized depressive symptoms into three groups based on clinical relevance: 0–2 (normal), 3–5 (some depressive symptoms) and ≥6 (depressed).

Measures of Sleep Parameters

Actigraphy—Sleep parameters were measured using an octagonal sleep watch actigraph (Ambulatory Monitoring, Inc., Ardsley, NY), a small device used to detect movement and provide information on sleep/wake patterns. Actigraphs are similar in appearance to a wristwatch and are usually placed on the wrist of the non-dominant hand. Accelerometers within the actigraph measure movement several times per second and store the information digitally. Actigraphy has been shown to provide a reliable estimate of sleep/wake activity including daytime napping habits and is highly correlated with polysomnography, which is still considered the gold standard.[16] Data for sleep/wake patterns, total sleep time and sleep fragmentation were analyzed with ActionW- 2 software (Ambulatory Monitoring, Inc., Ardsley, NY). The UCSD scoring algorithm was used for data collected in the DIM (PIM) and TAT modes, and the Cole-Kripke algorithm was used for data collected in the ZCM mode.[17] Data collected in the proportional integration mode (PIM) were used for analysis in this study.

Participants were instructed to wear the actigraph continuously for 5 nights/6 days. Participants were instructed to remove the actigraph only for bathing, or situations in which it might get submerged in water. Sleep efficiency was calculated as the percentage of time (0–100) the participant was sleeping from the first minute scored as sleep until the last minute scored as sleep the following morning. Sleep latency was calculated as the time from when the participant reported getting into bed until sleep onset. 'Onset of sleep' was defined as the start of the first period of time containing >19 minutes of continuous sleep. Awake after sleep onset was defined as the number of minutes scored as wake from sleep onset until the end of the last sleep episode while in bed. Total sleep time was calculated as the mean number of minutes scored as sleep while in bed. Long-wake episodes were calculated as the mean number of long wake episodes (≥5 minutes) while in bed. All actigraphy measurements were averaged over the total number of nights the actigraph was worn.

Self-reported Measures of Sleep and Daytime Sleepiness

Participants were asked to complete Pittsburgh Sleep Quality Index and the Epworth Sleepiness Scale. The Pittsburgh Sleep Quality Index (PSQI) is a validated measure of subjective sleep quality and sleep disturbances over a one-month time period. The questionnaire is divided into sections that assess subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medication and daytime dysfunction. Global PSQI scores range from 0–21, and a standard cutoff of greater than 5 is indicative of poor sleep quality. This cutoff has a sensitivity of 89.6% and specificity of 86.5% in distinguishing good vs. poor sleepers.[18]

The Epworth Sleepiness Scale (ESS) is a self-administered questionnaire which classifies subjective daytime sleepiness among people with sleeping disorders. Subjects are asked to rate how likely (from 1–3, with 1 being unlikely and 3 being highly likely) they are to doze off in eight typical daily situations. Scores range from 0–24, with a standard cutoff of greater than 10 indicating excessive daytime sleepiness.[19,20] To our knowledge, ESS has not been validated in older adults.

Other Measures

Participants were interviewed by a trained technician. Blood pressure was measured and information was obtained on self-reported health status (assessed by SF-12),[21] alcohol intake, self-reported caffeine consumption, walking (assessed using the Physical Activity Scale for

the Elderly (PASE))[22] and Impairments in Activities of Daily Living (IADL) questionnaires. Information from a previous visit was used to assess current age, race/ethnicity, living situation and education. Information obtained from both current and previous visits were used to assess smoking status. Participants were asked to bring all current (defined as regular use or use in the last 30 days preceding the examination) prescription and nonprescription medications with them to clinic. Interviewers completed a medication history for each participant that included type of medication and frequency of use. A computerized dictionary was used to categorize type of medication from product brand and generic names obtained from containers.[23] A self-reported medical history was obtained, including a history of physician diagnosis of stroke, parkinsonism, diabetes mellitus, chronic obstructive lung disease, congestive heart failure and myocardial infarction. Cognitive function was assessed with the Teng Modified Mini-Mental State Exam (3MS),[24] and a cutoff of ≤80 was used to indicate cognitive impairment. Body weight was measured with a standard balance beam or digital scale. Height was measured using a standard held-expiration technique with a wall-mounted stadiometer. Height and weight were used to calculate a standard body mass index (kg/m^2).

Statistical Analysis

Differences in characteristics according to level of depressive symptoms (GDS score 0–2 [normal], 3–5 [some depressive symptoms] and ≥6 [depressed]), were compared using analysis of variance for normally distributed continuous data, Kruskal-Wallis for skewed continuous data, and chi-square tests for categorical data.

Objective and subjective sleep parameters were expressed as continuous variables using linear regression models, and the least-squared means procedure was used to estimate the mean (95% confidence interval) for each sleep parameter by level of depressive symptoms (0–2, 3–5 and ≥6), adjusted for age and site. Because the distribution of sleep efficiency, sleep latency and wake after sleep onset were skewed in this population, the data were transformed for normality using log(100−P+1) for sleep efficiency and log(P+1) for sleep latency and wake after sleep onset. Results were back-transformed for interpretation.

Sleep parameters were also expressed as dichotomous outcomes (sleep efficiency <70% vs. ≥70%, sleep latency ≥1 hour vs. <1 hour, awakening after sleep onset ≥1.5 hours vs. <1.5 hours, long wake episodes ≥8 vs. <8, Epworth Sleepiness Scale >10 vs. ≤10, and Pittsburgh Sleep Quality Index >5 vs. ≤5) based on consideration of clinical relevance of values for older adults and the availability of sufficient numbers of participants in each category. Total sleep time, or sleep duration was expressed as a three level outcome, ≤5 hours (short sleep duration) vs. 5–8 hours (normal sleep duration) vs. >8 hours (long sleep duration), based on clinical relevance and the presumption that people with depression may experience insomnia or hypersomnia.[25]

The association between depressive symptoms and dichotomous sleep outcomes was analyzed using logistic regression, and a test for linear trend performed. Total sleep time was analyzed using a multinomial regression model with 5–8 hours (normal sleepers) serving as the referent category. Covariates were included in multivariable models if they were either known correlates of sleep disturbance or depression and/or were characteristics related to depressive symptoms at P ≤0.10 in univariate analyses among the overall cohort. Multivariable models were adjusted for age, clinic site, race, body mass index, living alone, alcohol intake, smoking status, cognitive impairment, physical activity, certain medical conditions, education, self-reported health status, IADL impairments, and use of antidepressants, benzodiazepines and non-benzodiazepine anxiolytic/hypnotics.

Since any association between depressive symptoms and sleep measures might be confounded by use of pharmacologic agents, we performed a secondary analysis excluding 384 men who reported taking antidepressants, benzodiazepines and anxiolytics/hypnotics. We also

performed several additional sensitivity analyses for the actigraphy sleep outcomes. First the age-site-adjusted and multivariate models were re-run using the other two actigraphy modes (TAT and ZCM). Second, we restricted our models to men with at least 5 nights of actigraphy data to determine if the exclusion of men with fewer nights of actigraphy altered the observed associations between depression and sleep outcomes. We also repeated our analyses restricted to the men with better quality scores on their sleep diary by excluding men whose self-reported in-bed or out-of-bed times did not correspond well with their actigraphy data. Finally, we adjusted for hand tremor in the multivariate models to determine if this had any effect on the observed associations. Since the results from the sensitivity analyses were similar to the primary analyses only the findings from the primary analyses are presented. All analyses were performed using SAS 9.1 (SAS Institute, Inc. Cary, N.C.).

RESULTS

Characteristics of the Study Population

Of the 5,995 men enrolled in the MrOS study, 3,051 participated in the MrOS Sleep sub-study and had measurements of wrist actigraphy. Compared to the 2,944 men who did not have measures of wrist actigraphy, men in this cohort were generally younger, Caucasian, more educated, and a greater percentage reported being never-smokers, not living alone and having excellent or very good health status (P<.001) (data not shown).

Characteristics of the overall cohort including 3,051 men aged 67 and older is shown in Table 1. The majority of the cohort was Caucasian (90%), and well educated, with 79% reporting having some college or beyond. Only 13% of the population rated their health status as fair, poor or very poor, and 13% reported living alone. High levels of physical activity were common in the cohort with 47% of men reporting that they walked for exercise often (5–7 days/week).

A total of 204 (7%) men reported six or more depressive symptoms and were classified as being depressed, 537 (17%) reported 3–5 depressive symptoms and were classified as having some depressive symptoms, and 2310 (76%) reported 0–2 depressive symptoms and were classified as normal. Men with higher levels of depressive symptoms were on average, older; in poorer health; more likely to live alone; slightly less educated; more cognitively impaired; more likely to take antidepressants, benzodiazepines and anxiolytic/hypnotics; more likely to smoke; be obese and have IADL impairments; and less likely to exercise and consume alcohol. Characteristics including race (P=0.305), caffeine intake (P=0.176), and systolic blood pressure (P=0.441) did not differ across levels of depressive symptoms (Table 1).

Actigraphy data were collected for an average of 5.2 ± 0.9 nights (range 1–13). Reduced sleep efficiency, prolonged sleep latency, sleep fragmentation as manifested by frequent long wake episodes, nighttime awakening, short sleep duration and long sleep duration were common in this cohort of older men with 11% having a sleep efficiency less than 70%, 10% having a sleep latency of an hour or more, 33% experiencing eight or more long wake episodes, 32% experiencing awakening after sleep onset of at least 1.5 hours, 12% having a total sleep time of 5 hours or less and 7% having a total sleep time of more than 8 hours. Subjective sleep disturbances were also common in this cohort; 44% of men indicated poor self-reported sleep quality on the Pittsburgh Sleep Quality Index, and 13% reported excessive daytime sleepiness on the Epworth Sleepiness Scale (results not shown).

Distribution of Sleep Parameters by Level of Depressive Symptoms

After adjustment for age and site, men with higher levels of depressive symptoms had worse objectively measured sleep, i.e., poorer sleep efficiency (P<.001), prolonged sleep latency (P<.001), greater nighttime awakening (P<.001), a greater number of long-wake episodes (P<.001),

and subjectively reported greater impairment in sleep quality (P<.001) and greater daytime sleepiness (P<.001) (Table 2).

Although statistically significant, the absolute differences in mean objective sleep parameter measures across levels of depressive symptoms were modest. For example, men who were depressed took an average of 3 minutes longer to fall asleep (sleep latency) than men with some depressive symptoms, and 5 minutes longer on average than men who were normal. There was no evidence of an association between level of depressive symptoms and total sleep time (P=0.226).

Levels of Depressive Symptoms and Objective Sleep Disturbances

Compared with men who were normal (referent group), men with some depressive symptoms and men with depression had an increased likelihood of objectively measured sleep disturbances in models adjusted for age and site (Table 3).

In multivariable-adjusted models, men with some depressive symptoms (Odds Ratio [OR] =1.40, 95% CI 1.03–1.90) and men with depression (OR=1.68, 95% CI 1.08–2.61) had greater odds of sleep latency ≥1 hour compared with normal men (referent group).

Compared with the referent group of normal men, sleep efficiency <70% was more prevalent among men with some depressive symptoms (OR=1.35, 95% CI 1.00–1.83) but was not statistically significant for men with depression (OR=1.25, 95% CI 0.79–1.97).

There was no association between depressive symptoms and multiple long-wake episodes (≥8) for men with some depressive symptoms (OR=1.17, 95% CI 0.95–1.45), as well as men who were depressed (OR=0.96, 95% CI 0.69–1.34).

The odds of spending ≥1.5 hours awake after sleep onset, were slightly, but not significantly, greater for men with some depressive symptoms (OR=1.15, 95% CI 0.93–1.42), and there was no association for men with depression (OR=0.81, 95% CI 0.58–1.14).

There was no evidence of an association between level of depressive symptoms and short sleep duration (TST<5 hours) for men with some depressive symptoms (OR=1.26, 95% CI 0.94–1.69) and men who were depressed (OR=0.93, 95% CI 0.58–1.50). Similarly, there was no association between level of depressive symptoms and long sleep duration (TST>8 hours) for men with some depressive symptoms (OR=1.13, 95% CI 0.77–1.66) and men who were depressed (OR=1.15, 95% CI 0.6.-2.08).

Levels of Depressive Symptoms and Subjective Sleep Disturbances

There was a strong graded association between levels of depressive symptoms and subjective sleep disturbances. These associations were independent of several potential confounding factors. (Table 4)

The odds of reporting poor sleep quality on the Pittsburgh Sleep Quality Index was 3.7-fold higher for men with depression (OR=3.68, 95% CI 2.54–5.33), and 2.1-fold higher for men with some depressive symptoms (OR=2.06, 95% CI 1.67–2.55).

Similarly, the odds of reporting excessive daytime sleepiness was 2.6-fold for men with depression (OR=2.61, 95% CI 1.77–3.85), and 1.7-fold for men with some depressive symptoms (OR=1.65, 95% CI 1.25–2.18).

Additional Analyses

The overall results were not altered when the 384 men who reported taking antidepressants, benzodiazepines and non-benzodiazepine anxiolytic/hypnotics were excluded from the analyses (data not shown).

DISCUSSION

Level of depressive symptoms among community-dwelling older men has a strong graded association with subjective sleep disturbances such as self-reported poor sleep quality and excessive daytime sleepiness and a moderate association with objectively measured prolonged sleep latency. However, although depressive symptoms were modestly associated with objectively determined measures of reduced sleep efficiency, awakening after sleep onset, multiple long-wake episodes and total sleep time, these latter associations were not statistically significant following adjustment for multiple potential confounders. This discrepancy in the association of depression with subjective as compared to objective sleep disturbances suggests that older men with depression are much more likely to report poor sleep quality, but only modestly more likely to demonstrate increased sleep disturbances with objective monitoring, including actigraphy.

No prior study has evaluated the association between level of depressive symptoms and subjective and objective sleep outcomes in a large sample of community-dwelling older men. Most prior cross-sectional studies of sleep in the elderly population have relied solely on subjective sleep measures although they also reported a strong association between subjective sleep disturbances and depression[4,5,10,26–30]. One previous prospective study of 2,370 Alameda County residents aged 50 years and older, reported that self-reported sleep disturbance (as assessed by DSM-12D) was a predictor of subsequent depression after one year of follow-up. However, this analysis utilized only self-reported sleep and consisted of only residents of Alameda County, which may not be representative of other geographical areas or populations.[11] To our knowledge, only two prior studies evaluating the association between depressive symptoms and sleep have included both subjective and objective sleep measures. Although both reported results that were similar to the present study, they included participants with a broad age range, excluded participants with clinical depression, and/or had small sample sizes.[26,31]

The mechanisms underlying the discrepancy between subjective and objective sleep disturbances in depressed elderly men has been previously documented, and several studies have examined the roles of health status, medical conditions,[10,28,30,31] cognitive function,[29] and sleeping disorders such as obstructive sleep apnea,[32,33] but have been unable to fully explain the disagreement between subjectively reported sleep disturbances and objectively measured sleep. It is well known that objectively measured physiological abnormalities and subjective reports are often only modestly associated for numerous conditions, including lung function and cardiovascular function. Sources of discrepancies may be multifactorial and may include measurement error in either set of measurements; either set of measurements also may be validly measuring alternative or complementary health dimensions. In many cases, subjective symptoms may be more important to patients than objective impairment.

In our analysis we attempted to adjust for factors that might confound any association between depressive symptoms and sleep disturbances. Adjusting for multiple potential confounders including medical conditions, physical activity, cognitive function, alcohol intake, smoking status, living alone, body mass index, age, education, race, clinical site, self-reported health status, IADL impairments and use of antidepressants, benzodiazepines and non-benzodiazepine anxiolytic/hypnotics had a modest attenuating effect on the odds ratios. While older adults with depressive symptoms are more likely to use medications including

antidepressants, benzodiazepines and/or non-benzodiazepine anxiolytic hypnotics that may impair or affect sleep, it is unlikely that use of these medications explained the associations that we observed, because neither adjusting for their use nor excluding men who reported taking these medications altered the results.

This study has several strengths such as large sample size and comprehensive set of measurements including validated measures of objective and subjective sleep parameters. In addition, participants were not selected on the basis of depression status, sleep disturbance or other related medical conditions, and were enrolled from six clinical centers distributed throughout the United States.

However, this study was limited by its cross-sectional ascertainment of sleep and depressive symptoms, and therefore causality cannot be determined. Since the cohort included only community-dwelling, primarily white men over the age of 67, these results may not apply to other populations. The use of self-reported time in and out of bed may be inaccurate, and could introduce errors into the sleep parameters that rely on these times in their calculation (sleep latency). However, results were similar when restricting the analyses to men whose in-bed and out-of-bed sleep times corresponded well with their actigraphy data. A further limitation encompasses the inability of actigraphy to distinguish daytime napping from quiet restfulness or periods of inactivity in older people. Hence, the analyses presented in the paper are limited to measures of night time sleep.

CONCLUSION

In community-dwelling older men, level of depressive symptoms had a strong, graded association with subjectively measured sleep disturbances such as poor sleep quality and excessive daytime sleepiness; was moderately associated with objectively measured prolonged sleep latency; and was not associated with reduced sleep efficiency, awakening after sleep onset, multiple long-wake episodes and total sleep time in fully adjusted analyses. These results further exemplify the discrepancy between subjective and objective sleep in elderly individuals with symptoms of depression, and emphasize the need for future longitudinal research to understand the mechanisms behind these differences as well as the temporality of the association. Given the extensive data in younger adults that suggest that insomnia is a risk factor for future depressive symptoms, future research needs to focus on the same question in older adults.

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Table 1

Characteristics of 3051 Participants in Overall Cohort and According to Level of Depressive Symptoms

Characteristic	All Participants	Level of Depressive Symptoms			P-value
		0–2 (Normal)	3–5 (Some Depressive Symptoms)	≥6 (Depressed)	
Number of participants	3051	2310	537	204	
Age Groups, %					<.001
64–69	9	9	6	8	
70–74	34	36	31	25	
75–79	29	30	24	28	
≥80	28	25	39	40	
Race, %					0.305
Caucasian	90	91	90	89	
African American	4	4	4	6	
Other	6	6	6	5	
Self-reported health status, %					<.001
Excellent or Good	87	92	74	54	
Fair, Poor or Very Poor	13	8	26	46	
Lives alone, %	13	12	15	22	<.001
Education, %					<.001
Less than high school	5	5	6	10	
High school diploma	16	15	21	18	
College/Graduate school	79	81	73	73	
Alcohol intake, drinks/week, %					<.001
0–2 drinks per week	59	57	66	70	
3–13 drinks per week	35	37	31	26	
14 or more drinks per week	6	6	4	4	
Smoking status, %					0.016
Never Smoked	39	40	38	34	
Former Smokers	59	58	60	61	
Current Smokers	2	2	2	5	
Caffeine intake, mg/day, mean ± SD	235.5 ± 245.9	238.3 ± 245.8	233.6 ± 249.3	208.8 ± 238.3	0.176
Current antidepressant use, %	8	5	13	25	<.001
Current benzodiazepine use, %	5	4	6	13	<.001
Current non-benzodiazepine anxiolytic/hypnotic use, %	2	2	3	3	0.026
Cognitively impaired (3MS score <80%), %	5	3	7	13	<.001
Body Mass Index, %					0.022
Underweight/Normal weight (BMI <25)	30	30	30	27	
Overweight (BMI 25–30)	50	51	45	49	
Obese (BMI ≥30)	20	19	25	25	
Systolic blood pressure, mean ± SD	126.9 ± 16.4	126.7 ± 16.0	127.4 ± 16.7	128.0 ± 19.8	0.441
Takes walks for exercise, %					<.001
Never	10	9	12	18	
Seldom (1–2 days/week)	17	15	20	24	
Sometimes (3–4 days/week)	27	26	30	27	
Often (5–7 days/week)	47	50	37	31	
Any IADL impairments, %	21	15	36	54	<.001
≥1 selected medical conditions*, %	36	33	46	51	<.001

*History of one or more selected medical conditions includes stroke, diabetes mellitus, Parkinsonism, chronic obstructive lung disease, congestive heart failure and myocardial infarction

Table 2

Mean Sleep Parameters (95% Confidence Interval) by Level of Depressive Symptoms*

Parameter of Sleep Quality	0–2 (Normal) (n = 2310)	3–5 (Some Depressive Symptoms) (n = 537)	≥6 (Depressed) (n = 204)	P for trend
Objective Sleep Parameters				
Sleep Efficiency, %†	83.5 (83.1–83.8)	81.5 (80.7–82.3)	81.2 (79.8–82.4)	<.001
Sleep Latency, minutes†	21.3 (20.6–22.0)	23.7 (22.2–25.4)	26.7 (24.0–29.8)	<.001
Awake After Sleep Onset, minutes†	65.1 (63.6–66.6)	74.1 (70.7–77.7)	77.1 (71.4–83.3)	<.001
Number of Long Wake Episodes	6.7 (6.6–6.8)	7.4 (7.1–7.7)	7.7 (7.3–8.2)	<.001
Total Sleep Time, hours	6.4 (6.4–6.5)	6.3 (6.2–6.4)	6.4 (6.2–6.6)	0.226
Subjective Sleep Parameters				
Pittsburgh Sleep Quality Index (0–21)	5.1 (5.0–5.2)	6.9 (6.6–7.1)	8.6 (8.2–9.0)	<.001
Epworth Sleepiness Scale (0–24)	5.8 (5.7–6.0)	6.9 (6.6–7.2)	8.0 (7.5–8.5)	<.001

*Adjusted for age and site

†Transformed for normality using log(100−P+1) for sleep efficiency and log(P+1) for sleep latency and wake after sleep onset; results back-transformed for interpretation

Table 3

Association between Level of Depressive Symptoms and Objective Sleep Disturbances

Parameter of Sleep Quality	Odds Ratio (95% CI)‡			
	0–2 (Normal) (n=2310)	3–5 (Some Depressive Symptoms) (n=537)	≥6 (Depressed) (204)	P-trend
Sleep efficiency <70%				
Age and site adjusted*	1.0 (referent)	1.62 (1.23–2.14)	1.77 (1.19–2.64)	<.001
Multivariable adjusted†	1.0 (referent)	1.35 (1.00–1.83)	1.25 (0.79–1.97)	0.104
Sleep latency ≥1 hours				
Age and site adjusted*	1.0 (referent)	1.63 (1.23–2.18)	2.29 (1.56–3.37)	<.001
Multivariable adjusted†	1.0 (referent)	1.40 (1.03–1.90)	1.68 (1.08–2.61)	0.006
Awake after sleep onset ≥1.5 hours				
Age and site adjusted*	1.0 (referent)	1.40 (1.15–1.71)	1.25 (0.92–1.69)	0.004
Multivariable adjusted†	1.0 (referent)	1.15 (0.93–1.42)	0.81 (0.58–1.14)	0.787
≥8 long-wake episodes				
Age and site adjusted*	1.0 (referent)	1.46 (1.20–1.78)	1.53 (1.14–2.06)	<.001
Multivariable adjusted†	1.0 (referent)	1.17 (0.95–1.45)	0.96 (0.69–1.34)	0.582
Total sleep time (TST)§				
TST ≤5 hours				
Age and site adjusted*	1.0 (referent)	1.47 (1.12–1.93)	1.36 (0.90–2.06)	0.010
Multivariable adjusted†	1.0 (referent)	1.26 (0.94–1.69)	0.93 (0.58–1.50)	0.598
TST >8 hours				
Age and site adjusted*	1.0 (referent)	1.18 (0.83–1.70)	1.33 (0.79–2.25)	0.185
Multivariable adjusted†	1.0 (referent)	1.13 (0.77–1.66)	1.15 (0.63–2.08)	0.513

*n= 3051 men in age and site adjusted models

†n= 3032 men in multivariable adjusted models. Model adjusted for age, site, race, BMI, living alone, alcohol intake, smoking status, cognitive impairment, physical activity, medical conditions, education, IADL impairments, self-reported health status, antidepressant use, benzodiazepine use and non-benzodiazepine anxiolytic/hypnotic use

‡Odds Ratio (OR) of sleep disturbances for men with 3–5 depressive symptoms compared with men with 0–2 depressive symptoms, and men with 6–15 depressive symptoms compared with men with 0–2 depressive symptoms

§Total Sleep Time estimated using multinomial regression comparing 376 short sleepers (TST≤5 hours) to normal sleepers (TST=5–8 hours), and 220 long sleepers (TST>8 hours) to normal sleepers (TST=5–8 hours)

Table 4

Association between Level of Depressive Symptoms and Subjective Sleep Disturbances

Parameter of Sleep Quality	Odds Ratio (95% CI)‡			
	0–2 (Normal) (n=2310)	3–5 (Some Depressive Symptoms) (n=537)	≥6 (Depressed) (204)	P-trend
Pittsburgh Sleep Quality Index >5				
Age and site adjusted*	1.0 (referent)	2.59 (2.13–3.15)	5.43 (3.87–7.63)	<.001
Multivariable adjusted†	1.0 (referent)	2.06 (1.67–2.55)	3.68 (2.54–5.33)	<.001
Epworth Sleepiness Scale >10				
Age and site adjusted*	1.0 (referent)	1.91 (1.47–2.48)	3.20 (2.27–4.50)	<.001
Multivariable adjusted†	1.0 (referent)	1.65 (1.25–2.18)	2.61 (1.77–3.85)	<.001

*n= 3051 men in age and site adjusted models

†n= 3032 men in multivariable adjusted models. Model adjusted for age, site, race, BMI, living alone, alcohol intake, smoking status, cognitive impairment, physical activity, medical conditions, education, IADL impairments, self-reported health status, antidepressant use, benzodiazepine use and non-benzodiazepine anxiolytic/hypnotic use

‡Odds Ratio (OR) of sleep disturbances for men with 3–5 depressive symptoms compared with men with 0–2 depressive symptoms, and men with 6–15 depressive symptoms compared with men with 0–2 depressive symptoms