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Sleep-Disordered Breathing and Functional Decline in Older Women

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Dr. Adam Spira: developed study concept and design, analyzed and interpreted data, prepared manuscript.
Dr. Katie Stone: obtained funding, developed study concept and design, interpreted data, provided review and revision of manuscript.
Dr. George Rebok: participated in data analysis and interpretation, and manuscript preparation.
Dr. Naresh Punjabi: assisted with interpretation of data and manuscript preparation.
Dr. Susan Redline: helped to develop the SOF sleep study protocol, directed the SOF Sleep Reading Center which oversaw all aspects of polysomnography data collection and scoring, and provided input into statistical design and critical review of the manuscript.
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Abstract

Objectives—To determine the association between sleep-disordered breathing (SDB) and decline in instrumental activities of daily living (IADLs) and mobility among older women.

Design—Prospective cohort

Setting—Minneapolis and Pittsburgh sites of the Study of Osteoporotic Fractures, participants' homes

Participants—302 women, mean ±standard deviation age of 82.3 ±3.2 years

Measurements—Participants completed a single night of unattended polysomnography and provided data regarding difficulty with IADLs and mobility. They repeated IADL and mobility measures 5.0 ±0.7 years later.

Results—After adjustment for age, obesity, Mini-Mental State Examination score, depressive symptoms, history of hypertension and chronic obstructive pulmonary disease, and number of IADL impairments at baseline, women with an apnea-hypopnea index (AHI) ≥15 at baseline had more than twice the odds of an increase in number of IADL difficulties (adjusted odds ratio (aOR) = 2.22, 95% confidence interval (CI) 1.09, 4.53) and of incident IADL difficulty (aOR = 2.43, 95% CI 1.0001, 5.92), compared to women with an AHI <5. There was no association between AHI and mobility difficulty. Compared to women in the tertile with lowest oxygen desaturation index, others had more than double the odds of an increase in number of IADL difficulties (middle tertile aOR = 2.64, 95% CI 1.38, 5.04), highest tertile aOR = 2.17, 1.13, 4.17) and approximately three times the odds of incident IADL difficulty (middle tertile aOR = 2.84, 95% CI 1.27, 6.36, highest tertile aOR = 3.07, 95% CI 1.31, 7.18). Neither sleep fragmentation nor sleep duration was associated with IADL outcomes.

Conclusion—SDB and associated hypoxemia are risk factors for functional decline in older women. Research is needed to determine whether treatment of SDB prevents functional decline.

Keywords

sleep; apnea; function; IADLs; older women

INTRODUCTION

Sleep-disordered breathing (SDB) is characterized by repeated interruptions or reductions in respiration during sleep, leading to both hypoxemia and sleep fragmentation. The most common SDB cause is obstructive sleep apnea, in which collapse of the upper airway interferes with breathing during sleep.[1] Increasing age is a well-established risk factor for SDB; older adults may be three to four times more likely than middle-aged individuals to have the condition.[2]

SDB has been linked to cognitive impairment and decline in older people,[3, 4] but little is known about the degree to which SDB might affect other important functional outcomes,

such as difficulty with instrumental activities of daily living (IADLs) or mobility. Some evidence for a link between SDB and poor functional outcomes comes from studies of patients undergoing rehabilitation following a stroke,[5–7] but less is known about the association between SDB and functional decline in the general population of older adults. A few studies have investigated the association between symptoms of SDB, such as daytime sleepiness or snoring, and functional impairment in community-dwelling elders.[8–11] SDB, measured by polysomnography (PSG), also has been linked to a greater likelihood of frailty in a cross-sectional study of older men,[12] and nocturnal hypoxemia has been linked to a greater risk of frailty or death in the same cohort.[13] However, we are unaware of any prospective study that has investigated the association between SDB and decline in IADLs and mobility. This is important because effective therapies are available for SDB; if SDB is associated with an increased risk of functional decline, treatment of SDB may be a means of preventing or slowing the progression of disability. We studied the association between SDB and functional decline in a sample of older women.

METHODS

Participants

We studied women enrolled in the Study of Osteoporotic Fractures (SOF), a prospective study of 9,704 mostly white older women enrolled from population-based listings in Baltimore, MD, Minneapolis, MN, Monongahela Valley (Pittsburgh area), PA, and Portland, OR between 1986 and 1988. Eligibility criteria required participants to be aged 65 and older, to be able to ambulate without assistance, to have no imminently terminal disease and no history of bilateral hip replacement. Between 1997 and 1998, 662 black women were recruited to join SOF. Data for the present study were from the Year 16 (2002–2004) visit, referred to as “baseline,” and the Year 20 (2006–2008) visit, referred to as “follow-up.”

In total, 2,732 participants took part in the baseline visit at the Minneapolis and Pittsburgh sites. Of these, a convenience sample of 461 women completed a single night of polysomnography (PSG) in their homes. All 461 with PSG data had complete data on either baseline IADL or baseline mobility. By follow-up, 79 terminated their participation or died, leaving 382 women eligible to attend the follow-up visit. Of these, 302 had complete data on IADLs or mobility at follow-up. Each SOF site’s institutional review board approved the research and participants gave written informed consent.

Sleep-Disordered Breathing

Participants completed one night of PSG in their homes within one month of completing the Year 16 visit at which they provided IADL and mobility data (see below). In-home PSG was scheduled at the time of the Year 16 visit, and therefore occurred after IADL and mobility data were collected. PSG was conducted using the Compumedics Siesta Unit (Abbotsford, AU) with monitoring of two central electroencephalograms (EEG), bilateral electrooculograms, airflow (nasal-oral thermocouple and nasal pressure recording), chin electromyogram, respiratory effort (thoracic and abdominal), electrocardiogram, finger pulse oximetry, body position and bilateral leg movement sensors. Data were scored by trained technicians using standard criteria.[14] Apneas were defined as cessation of airflow for ≥10

seconds, and hypopneas as a >30% decrease in airflow for ≥10 seconds with ≥3% oxygen desaturation. An apnea-hypopnea index (AHI) was calculated as the number of apneas and hypopneas per hour of sleep. Measures of hypoxemia included the number of desaturations (desats) ≥3% per hour of sleep (oxygen desaturation index; ODI), and the proportion (%) of the sleep period spent in apnea or hypopnea (with ≥3% desat). Measures of sleep fragmentation included the arousal index (number of EEG arousals/hours of sleep) and number of sleep-to-wake transitions per hour of sleep. Sleep duration was assessed as the total time in minutes scored as sleep between lights out and lights on.

Functional Decline

At both baseline and follow-up, study participants responded to questions about three IADLs: completing heavy housework, preparing meals, and shopping for groceries/clothes. They also responded to questions about three mobility-related tasks (i.e., walking 2 to 3 blocks, climbing 10 steps, descending 10 steps) based on items from the 1984 National Health Interview Survey Supplement on Aging.[15] Specifically, they were asked whether they had “any difficulty” with each IADL or mobility task; possible responses were “yes,” “no,” and “I don’t do it.” Those responding “yes” or “I don’t do it” were asked whether this was due to “a health or physical problem,” with response options “yes,” “no,” and “don’t know.” Those indicating “any difficulty” with a task were also asked about the degree of difficulty they had performing it by themselves “and without using aids”; response options were “some difficulty,” “much difficulty,” “unable to do it,” and “don’t know.” A final determination regarding difficulty with each task was made based on responses to these questions. Those who indicated that they didn’t perform a task for reasons other than a health/physical problem were not considered to have difficulty. We calculated the number of IADLs (out of three) and of mobility tasks (out of three) with which participants had difficulty at baseline and follow-up.

Other Measures

Participants provided information regarding demographic variables (e.g., age, education, race). At each study visit they reported whether a healthcare provider had told them that they have any medical conditions from an extensive list of comorbidities. In addition, they were asked to bring any prescription, over-the-counter, or nutritional supplements they had taken over the last 30 days to study visits. Medications were coded according to generic and brand names using a computerized dictionary.[16] At each visit, height and weight were obtained to calculate body mass index (BMI) (kg/m^2). Depressive symptoms were measured by the 15-item Geriatric Depression Scale,[17] anxiety symptoms by the Goldberg Anxiety Scale,[18] and global cognitive function by the Mini-Mental State Examination.[19] Further, at the follow-up visit, SOF participants completed an expanded neuropsychological test battery, and a subset were categorized as having normal cognition, mild cognitive impairment (MCI), or dementia; details of cognitive testing and the adjudication process are provided elsewhere.[20]

Statistical Analyses

The AHI was categorized as follows: AHI <5 (no SDB), AHI 5 to <15 (mild to moderate SDB), or AHI ≥15 (moderate to severe SDB). Other PSG indices (i.e., total number of desaturations ≥3%, % sleep time in apnea or hypopnea, arousal index, number of sleep-to-

wake transitions, sleep duration) were categorized into tertiles, based on their distribution in our entire analytic sample. We then fit a series of logistic regression models. Our first two outcomes were any increase in number of IADL difficulties between baseline and follow-up and any increase in mobility difficulties between baseline and follow-up. To examine the association between SDB and incident IADL and mobility difficulty, we repeated analyses after excluding those with prevalent difficulties at baseline. Model 1 contained one PSG-derived variable as the primary predictor, and for analyses with any increase in IADLs or mobility as the outcome, Model 1 also included baseline number of IADL or mobility difficulty as a covariate; it was unadjusted for analyses with incident difficulty as the outcome. In addition to covariates in Model 1, Model 2 included age, obesity (BMI ≥30 kg/m^2), MMSE score, GDS score, and history of hypertension and of chronic obstructive pulmonary disease (COPD). With the exception of MMSE score, these variables were selected because they were associated with one or more of our PSG variables and one or more of our four outcomes at the $p \leq 0.100$ level according to Kruskal-Wallis tests for continuous variables and χ^2 or Fisher's exact tests for categorical variables. We included MMSE score in the model to investigate the association of SDB with functional decline, independent of baseline cognitive status. One participant did not complete all GDS-15 items and was excluded from fully adjusted analyses.

To further investigate mechanisms accounting for significant associations between the AHI (the most common metric describing SDB) and our outcomes, additional analyses were conducted to determine whether metrics of hypoxemia, sleep fragmentation, and sleep duration were predictive of the outcomes examined. Additional sensitivity analyses were conducted as follows. First, we added adjudicated cognitive status at follow-up to Model 2 to investigate whether clinically significant cognitive impairment at follow-up accounted for observed associations between SDB and our outcomes. Next, we did the same for stroke at baseline, and then stroke at follow-up.

RESULTS

Participants had a mean ± standard deviation age of 82.3 ±3.2 years (range 73 to 93) (Table 1). At baseline, 71 participants (23.5%) had an AHI <5, 125 (41.4%) had an AHI ≥5 to <15, and 106 (35.1%) had an AHI ≥15; other PSG indices are presented in Table 2. SDB severity, as measured by AHI categories, was associated with obesity (BMI ≥30 kg/m^2), smoking status, and history of diabetes and COPD at the $p \leq 0.100$ level of significance. The mean interval between baseline and follow-up was 5.0 ±0.7 years (range 3.5 to 6.2). At follow-up, of the 295 participants with IADL data, 131 (44.4%) had an increase in the number of IADL difficulties, and 164 (55.6%) had no change or a decrease. Of the 299 participants with mobility data, 127 (42.5%) had an increase in mobility difficulties at follow-up, 172 (57.5%) had no increase or a decrease in difficulties. Out of the 177 participants with 0 IADL difficulties at baseline, 83 (46.9%) had incident IADL difficulty at follow-up; 89 (44.5%) of the 200 without mobility difficulty at baseline had incident mobility problems.

A greater proportion of women with an AHI ≥5 to <15 or an AHI ≥15 (47% and 51%, respectively) had an increase in the number of IADL difficulties, compared to women with an AHI <5 (29%), $p = 0.014$ (Table 3). In analyses adjusted for number of IADL difficulties

at baseline, those with an AHI ≥5 to <15 had more than twice the odds of an increase in IADL difficulties (odds ratio (OR) = 2.11, 95% confidence interval (CI) 1.12, 3.98), as did those with an AHI ≥15 (OR = 2.63, 95% CI 1.37, 5.04) (Table 3). After further adjustment, the latter association remained significant (OR = 2.22, 95% CI 1.09, 4.53).

Compared to 33% of women with an AHI <5, 48% of those with an AHI ≥5 to <15 and 57% of those with an AHI ≥15 had incident IADL difficulty, $p = 0.045$. In unadjusted analyses, women with an AHI ≥15 had 2.8 times the odds of incident difficulty compared to those with an AHI <5 (OR = 2.79, 95% CI 1.23, 6.32); this association decreased slightly but remained significant after further adjustment (OR = 2.43, 95% CI 1.0001, 5.92). There was no association between AHI categories and either an increase in number of mobility difficulties, or with incident mobility difficulty.

To investigate potential mechanisms linking AHI to IADL outcomes, we repeated analyses with indices of hypoxemia, sleep fragmentation, and sleep duration as the primary predictors and with our IADL outcomes. Women in the middle and highest tertiles of the ODI were more likely to have an increase in the number of IADL difficulties in unadjusted analyses (54% and 50%, respectively), compared to those in the lowest tertile (29%), $p = 0.001$ (Table 4). In Model 1, those in the middle and highest tertile had between two and three times the odds of an increase in IADL difficulties, compared to those in the lowest tertile (middle tertile OR = 2.82, 95% CI 1.55, 5.11, highest tertile OR = 2.46, 95% CI 1.35, 4.46). Associations decreased slightly in magnitude but remained significant after further adjustment in Model 2. Further, a greater proportion of women in the middle and highest tertiles of % sleep time in apnea or hypopnea (53% and 48%, respectively) had an increase in the number of IADL difficulties, compared to those in the lowest tertile (32%), $p = 0.011$. In Model 1, those in the middle tertile had over twice the odds of an increase in IADL difficulties (OR = 2.38, 95% CI 1.33, 4.26) and those in the highest tertile had approximately twice the odds of an increase (OR = 1.95, 95% CI 1.09, 3.50). After further adjustment, the association between the middle tertile and this outcome remained (OR = 2.14, 95% CI 1.14, 4.01). In contrast, there were no associations between indices of sleep fragmentation or duration and an increase in number of IADL difficulties.

At follow-up, 30% of women in the lowest ODI tertile had incident IADL difficulty, compared to 54% and 59% of those in the middle and highest tertiles, respectively, $p = 0.004$. Compared to women in the lowest tertile of ODI, women in the other tertiles had 2.7 to 3.3 times the odds of incident IADL difficulty in unadjusted analyses (middle tertile OR = 2.73, 95% CI 1.31, 5.70; highest tertile OR = 3.31, 95% CI 1.52, 7.18); associations remained after multivariable adjustment (middle tertile OR = 2.84, 95% CI 1.27, 6.36; highest tertile OR = 3.07, 95% CI 1.31, 7.18). A total of 32% of women in the lowest tertile of percent sleep time in apnea or hypopnea had incident IADL difficulty, compared to 58% of those in the middle tertile and 52% of those in the highest tertile, $p = 0.009$. In Model 1, women in the middle tertile had almost three times the odds of incident IADL difficulty (OR = 2.95, 95% CI 1.43, 6.09) and those in the highest tertile had 2.3 times the odds of incident difficulty (OR = 2.33, 95% CI 1.08, 5.02). The association decreased but remained significant in Model 2 for the middle tertile (OR = 2.59, 95% 1.18, 5.66) and fell just below the level of significance for the highest tertile (OR = 2.28, 95% CI 0.99, 5.27).

When we adjusted for clinically adjudicated cognitive status at follow-up in a sensitivity analysis, the significance of the association between AHI ≥15 and incident IADL difficulty fell from the $p = 0.050$ level of significance to $p = 0.056$; there were no other noteworthy changes (data not shown). Similarly, incremental adjustment for history of stroke at baseline or follow-up had no meaningful effect on results (data not shown).

DISCUSSION

We determined the association between SDB and functional decline among older women in a community-based cohort study of aging. In general, compared to women with no or minimal SDB at baseline (AHI <5), those with more severe SDB, as measured by the AHI or the ODI, had more than twice the odds of an increase in the number of IADL difficulties an average of five years later; the association between both AHI and ODI and incident IADL difficulty was even stronger. There was no association, however, between SDB severity and change in mobility difficulty. In addition, we found no association between indices of sleep fragmentation or sleep duration and our outcomes. Our findings suggest that SDB is a risk factor for decline in IADLs among older women, and that intermittent hypoxemia, rather than sleep fragmentation or curtailed sleep duration is the likely mechanism by which SDB may promote such decline. To our knowledge, this is the first prospective study of the association between PSG-measured SDB and decline in IADLs and mobility conducted in a community-based study of older adults.

Our findings are consistent with those from studies linking SDB to poor outcomes in clinical populations. Among middle-aged and older adults on a stroke unit, a greater number of nocturnal blood oxygen (SaO_2) desaturations (≥4%) was associated with poorer recovery on a composite measure of ADLs, mobility, and cognition.[6] Similarly, an AHI ≥10 was associated with greater ADL impairment among older adults undergoing rehabilitation following a stroke.[5] Findings from a randomized trial of continuous positive airway pressure (CPAP) suggested that treatment of SDB may improve ADL independence among individuals undergoing poststroke rehabilitation,[21] providing support for SDB as a potential contributor to disability in this population.

Results also are consistent with those from epidemiological studies that examined self-reported sleepiness, a symptom of SDB or other disorders of sleep insufficiency. Gooneratne et al. found that older adults with excessive daytime sleepiness had greater impairment on the Functional Outcomes of Sleep Questionnaire (FOSQ),[9] a self-report measure of sleepiness-related impairment with a range of subscales representing different functional domains.[22] Further, in a cross-sectional study of over 1,500 community-dwelling older adults, reports of more frequent daytime sleepiness were associated with a greater odds of impaired physical function,[8] and reports of greater daytime sleepiness were independently associated with IADL limitations in over 5,000 older people in the Cardiovascular Health Study,[10, 11] although snoring and observed apneas were not.[11]

Our results indicate that intermittent hypoxemia is more closely associated with IADL difficulty than is sleep fragmentation, yet further studies are needed to clarify the mechanism by which hypoxemia might contribute to decline in IADL performance. In a

prior study in this cohort, we showed that SDB was associated with subsequent diagnoses of MCI and dementia, and that hypoxemia rather than sleep fragmentation was the component of SDB that drove this association.[4] In the present study, however, associations between SDB indices and increased or incident IADL problems remained after adjustment for baseline MMSE score and clinically adjudicated cognitive status at follow-up. Thus, either cognitive decline did not mediate the association between SDB and decline in IADL function, or we had inadequate power or insufficiently sensitive measures of cognition to detect mediation by cognition. In addition, SDB is associated with an increased risk of stroke,[23] and stroke may mediate the association between SDB and increases in IADL impairment. In our sample, however, none of our predictors were associated with history of stroke at baseline, and incremental adjustment for stroke at baseline or follow-up failed to affect associations. Additional studies are needed to further evaluate potential mediators of the link between SDB and functional decline.

This study's strengths include a well-characterized sample of 302 older women, data from unattended PSG, and a prospective design with five years of follow-up. Limitations include a primarily white sample that was restricted to women. It is unclear whether results will generalize to male or non-white populations. In addition, because this was an observational study, we cannot determine whether SDB is in fact a cause of functional decline. Further, although we found associations between SDB and IADL outcomes, our IADL measures were based on self-report. It is unclear whether SDB would be associated with objective, clinically significant impairment in IADL performance.

In conclusion, our findings suggest that SDB and SDB-associated hypoxemia are risk factors for functional decline among older women. Although the precise mechanisms linking SDB and functional decline remain unclear, prevention and treatment of SDB may help prevent adverse functional outcomes in this population. In light of the high prevalence of SDB in the rapidly growing US population of older adults, prevention and treatment of SDB may have important implications for quality of life and disability-related healthcare expenditures.

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Table 1

Participant Characteristics by Apnea-Hypopnea Index.

	Apnea-Hypopnea Index			
Characteristics	**<5**	**≥5 to <15**	**≥15**	***p*-value**
mean ±SD or *n* (%)	***n* = 71**	***n* = 125**	***n* = 106**	
Age	82.3 ±3.3	82.1 ±3.1	82.6 ±3.1	0.464
Non-white	7 (9.9)	14 (11.2)	9 (8.5)	0.790
Education > high school	16 (22.5)	44 (35.2)	31 (29.3)	0.173
BMI ≥30 (kg/m^2)	15 (21.1)	45 (36.0)	38 (35.9)	0.066
Current smoker	5 (7.0)	0 (0)	0 (0)	0.001
Alcohol (# drinks/week)	0.9 ±2.7	0.9 ±2.9	0.7 ±2.1	0.618
Caffeine intake (g/day)	0.2 ±0.2	0.2 ±0.1	0.1 ±0.1	0.673
Walks for exercise	24 (34.3)	44 (35.2)	37 (34.9)	0.992
MMSE score (0–30)	28.6 ±1.5	28.4 ±1.4	28.6 ±1.3	0.407
Geriatric Depression Scale (0–15)	2.1 ±2.4	2.0 ±2.3	2.0 ±2.4	0.877
Goldberg Anxiety Scale (0–9)	1.5 ±2.4	1.5 ±2.4	1.3 ±2.2	0.786
Antidepressant use	8 (11.3)	8 (6.4)	9 (8.5)	0.491
Benzodiazepine use	7 (9.9)	7 (5.6)	9 (8.5)	0.510
Non-benzodiazepine sleep aid	1 (1.4)	4 (3.2)	2 (1.9)	0.794
Diabetes	3 (4.2)	16 (12.8)	17 (16.0)	0.055
Hypertension	38 (53.5)	81 (64.8)	70 (66.0)	0.193
Coronary artery disease	19 (26.8)	30 (24.0)	16 (15.1)	0.122
Congestive heart failure	2 (2.8)	9 (7.2)	10 (9.4)	0.228
Stroke	11 (15.5)	16 (12.8)	11 (10.4)	0.600
COPD	15 (21.1)	16 (12.8)	8 (7.6)	0.031
Osteoarthritis	30 (42.3)	43 (34.4)	47 (44.3)	0.271

Note: $N = 302$ for all except for walking and Geriatric Depression Scale ($n = 301$ for both) and MMSE ($n = 291$). p-values are from Kruskal-Wallis tests (with rank ties) for continuous variables and from χ^2 or Fisher's exact test for categorical variables. BMI = body mass index; COPD = chronic obstructive pulmonary disease; MMSE = Mini-Mental State Examination.

Table 2

Descriptive Statistics for Hypoxemia, Sleep Fragmentation, and Sleep Duration Variables.

Mean ± Standard Deviation	Full Sample	Tertile 1	Tertile 2	Tertile 3
Oxygen desaturation index	18.0 ±14.1	6.2 ±2.4	14.7 ±2.9	33.3 ±14.2
n	299	100	100	99
% sleep time in apnea or hypopnea	7.3 ±9.4	0.9 ±0.7	4.5 ±1.4	16.4 ±11.6
n	302	101	101	100
Arousal index	20.4 ±11.4	10.1 ±2.9	18.2 ±2.2	33.0 ±10.2
n	301	101	100	100
# of sleep-to-wake transitions/hr	3.9 ±1.9	2.1 ±0.5	3.5 ±0.4	5.9 ±1.9
n	302	101	101	100
Sleep duration (min.)	351.6 ±74.7	272.4 ±53.4	360.7 ±16.1	426.4 ±39.4
n	302	104	100	98

Table 3

Associations Between Apnea-Hypopnea Index and Functional Outcomes.

Outcome	*n* (%) with outcome	Model 1 OR (95% CI)	Model 2 OR (95% CI)
Increase in # of IADL difficulties		*N* = 295	*N* = 283
AHI <5 (reference)	20 (29.4)	(ref)	(ref)
AHI ≥5 to <15	57 (46.7)	**2.11 (1.12, 3.98)**	1.89 (0.95, 3.77)
AHI ≥15	54 (51.4)	**2.63 (1.37, 5.04)**	**2.22 (1.09, 4.53)**
Incident IADL difficulty		*N* = 177	*N* = 172
AHI <5 (reference)	15 (32.6)	(ref)	(ref)
AHI ≥5 to <15	37 (48.1)	1.91 (0.89, 4.09)	1.72 (0.75, 3.98)
AHI ≥15	31 (57.4)	**2.79 (1.23, 6.32)**	**2.43 (1.0001, 5.92)**
Increase in # of mobility difficulties		*N* = 299	*N* = 287
AHI <5 (reference)	27 (38.0)	(ref)	(ref)
AHI ≥5 to <15	52 (42.6)	1.24 (0.68, 2.28)	1.14 (0.59, 2.18)
AHI ≥15	48 (45.3)	1.41 (0.75, 2.62)	1.16 (0.59, 2.28)
Incident mobility difficulty		*N* = 200	*N* = 196
AHI <5 (reference)	17 (34.7)	(ref)	(ref)
AHI ≥5 to <15	38 (46.9)	1.66 (0.80, 3.46)	1.52 (0.68, 3.40)
AHI ≥15	34 (48.6)	1.78 (0.84, 3.77)	1.46 (0.64, 3.32)

Note: Model 1 is unadjusted for analyses with incident difficulty as the outcome and adjusted for baseline number of IADL or mobility difficulties for analyses with increases in these variables as the outcome. Model 2 is further adjusted for baseline age, BMI ≥30, MMSE score, GDS score, and history of hypertension and chronic obstructive pulmonary disease. CI = confidence interval; OR = odds ratio.

Table 4

Association of Hypoxemia, Sleep Fragmentation, and Sleep Duration with IADL difficulty.

Outcome	Tertile	*n* (%) with outcome	Model 1 OR (95% CI)	Model 2 OR (95% CI)
Increase in # of IADL difficulties			*N* = 292 to 295	*N* = 280 to 283
Hypoxemia				
Oxygen desaturation index	Low	28 (29.2)	(ref)	(ref)
	Mid	52 (53.6)	**2.82 (1.55, 5.11)**	**2.64 (1.38, 5.04)**
	High	49 (49.5)	**2.46 (1.35, 4.46)**	**2.17 (1.13, 4.17)**
% sleep in apnea/hypopnea	Low	31 (32.3)	(ref)	(ref)
	Mid	53 (53.0)	**2.38 (1.33, 4.26)**	**2.14 (1.14, 4.01)**
	High	47 (47.5)	**1.95 (1.09, 3.50)**	1.65 (0.87, 3.14)
Fragmentation & duration				
Arousal index	Low	46 (46.5)	(ref)	(ref)
	Mid	45 (45.9)	0.96 (0.55, 1.69)	0.97 (0.52, 1.78)
	High	39 (40.2)	0.78 (0.44, 1.37)	0.62 (0.33, 1.17)
# of sleep-to-wake transitions/hr	Low	49 (49.0)	(ref)	(ref)
	Mid	45 (45.5)	0.88 (0.51, 1.55)	1.23 (0.66, 2.30)
	High	37 (38.5)	0.66 (0.37, 1.16)	0.68 (0.37, 1.28)
Sleep duration (min)	Low	45 (44.6)	(ref)	(ref)
	Mid	48 (49.0)	1.19 (0.68, 2.08)	1.30 (0.70, 2.40)
	High	38 (39.6)	0.80 (0.45, 1.41)	1.20 (0.64, 2.26)
Incident IADL difficulty			*N* = 175 to 177	*N* = 170 to 172
Hypoxemia				
Oxygen desaturation index	Low	19 (30.2)	(ref)	(ref)
	Mid	33 (54.1)	**2.73 (1.31, 5.70)**	**2.84 (1.27, 6.36)**
	High	30 (58.8)	**3.31 (1.52, 7.18)**	**3.07 (1.31, 7.18)**
% sleep in apnea/hypopnea	Low	20 (31.8)	(ref)	(ref)
	Mid	37 (57.8)	**2.95 (1.43, 6.09)**	**2.59 (1.18, 5.66)**
	High	26 (52.0)	**2.33 (1.08, 5.02)**	2.28 (0.99, 5.27)
Fragmentation & duration		N = 176		
Arousal index	Low	23 (40.4)	(ref)	(ref)
	Mid	29 (44.6)	1.19 (0.58, 2.45)	1.08 (0.49, 2.36)
	High	30 (55.6)	1.85 (0.87, 3.93)	1.32 (0.58, 3.01)
# of sleep-to-wake transitions/hr	Low	30 (48.4)	(ref)	(ref)
	Mid	27 (47.4)	0.96 (0.47, 1.97)	1.02 (0.46, 2.27)
	High	26 (44.8)	0.87 (0.42, 1.78)	0.85 (0.38, 1.87)

Outcome	Tertile	*n* (%) with outcome	Model 1 OR (95% CI)	Model 2 OR (95% CI)
Sleep duration (min)	Low	25 (44.6)	(ref)	(ref)
	Mid	30 (51.7)	1.33 (0.64, 2.78)	1.29 (0.57, 2.92)
	High	28 (44.4)	0.99 (0.48, 2.05)	1.38 (0.62, 3.10)

Note: Model 1 is unadjusted for analyses with incident IADL difficulty as the outcome and adjusted for baseline number of IADL difficulties for analyses with increase in IADL difficulties as the outcome. Model 2 is further adjusted for baseline age, BMI ≥30, MMSE score, GDS score, and history of hypertension and chronic obstructive pulmonary disease. CI = confidence interval; OR = odds ratio.