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Relationships among Disordered Sleep and Cognitive and Functional Status in Nursing Home Residents

Catherine S. Cole, PhD, ACNS-BC[1,2], **Kathy C. Richards, PhD, RN**[3,4], **Cornelia C. Beck, PhD, RN**[2,5], **Paula K. Roberson, PhD**[6], **Corrine Lambert, EdD, RN**[1,2], **Allison Furnish, BSN, RN**[7], **Jon Free, BSN, RN**[7], and **Joan Tackett, BSN, RN**[7]

[1]College of Nursing, University of Arkansas for Medical Sciences, Little Rock, AR

[2]Department of Veterans' Affairs Health Services Research and Development, Arkansas Veteran's Healthcare System, Little Rock, AR

[3]Polisher Research Institute, Abramson Center for Jewish Life, Horsham, PA

[4]University of Pennsylvania School of Nursing, Philadelphia, PA

[5]Department of Geriatrics, Department of Psychiatry and Behavioral Sciences, College of Medicine, University of Arkansas for Medical Sciences, Little Rock, AR

[6]Department of Biostatistics, Colleges of Medicine and Public Health, University of Arkansas for Medical Sciences, Little Rock, AR

[7]University of Arkansas Medical Center

Abstract

This descriptive study examined relationships among disordered sleep and cognitive and functional status in nursing home residents ($N = 90$). Baseline data were used from a randomized controlled clinical trial that took place in three nursing homes. The sample included persons ≥ 55 years with disordered sleep and cognitive impairment. We measured nighttime sleep with attended polysomnography and cognitive status with the Mini Mental State Examination (MMSE) and assessed two indicators of functional status (assistance required and gait speed). Decreased total sleep time (TST), fewer respiratory awakenings, and higher SaO2 nadir were associated with better cognitive and functional status. Decreases total sleep time (TST), fewer respiratory awakenings, and higher oxygen saturation (SaO_2) nadir were associated with better cognitive and functional status. After controlling for the effect of cognitive status, the association between decreased TST and better gait speed remained significant. Although correlation does not establish causation, these findings suggest that interventions to decrease nighttime respiratory awakenings and maintain SaO_2, have the potential to support cognitive and functional status in nursing home residents.

Keywords

respiratory sleep disorder; disordered sleep; cognitive status; functional status; dementia; nursing home

A full mailing address and e-mail address for the corresponding author; Catherine S. Cole, College of Nursing, University of Arkansas for Medical Sciences, 4301 W. Markham St, Slot 529, Little Rock, AR 72205, colecatherine@uams.edu.

Introduction

In the early stages of dementia, symptoms are subtle and vary with each individual. These symptoms may include slight forgetfulness, difficulty with time relationships, impairment in solving problems, or impairment in hobbies and home activities (Morris, 1997). Casual interactions with persons who have mild cognitive impairment may not reveal any deficits, and these persons can remain in the community with minimal support. However, as cognitive impairment progresses, functional status declines (Amieva et al., 2008) and one group of investigators using The Pfeffer Functional Activities Questionnaire (FAQ) and Lawton Instrumental Activities of Daily Living (IADL) Scale found that functional deficits were higher for persons with mild cognitive impairment and significantly greater for persons who converted from mild cognitive impairment to a diagnosis of dementia even after controlling for age, education, and modified Mini-Mental State Examination scores (Tabert et al., 2002). Finally, as functional status declines the costs of care increase. One group of investigators estimated that the worldwide cost of dementia, (based on a dementia population of 29.3 million persons, was estimated to be $315.4 billion in 2005 (Wimo, Jonsson, & Winblad, 2006). In addition to financial costs, there are increasing physical and emotional costs to caregivers (McCurry, Pike, Vitiello, Logsdon, & Teri, 2008; Zhu et al., 2006a; Zhu et al., 2006b).

Maintaining functional status in persons with cognitive impairment could help them maintain their independence, quality of life, reduce the costs of care, and caregiver burden. Therefore, it is important to identify factors amenable to intervention that could help maintain independent functional status. One potentially modifiable factor in persons with cognitive impairment is disordered sleep. In healthy persons, a good night's sleep contributes to optimal cognitive and functional status (Schneider, Fulda, & Schulz, 2004) and disordered sleep has significant adverse effects on cognitive and functional status (Fischer, Hallschmid, Elsner, & Born, 2002; Stickgold, James, & Hobson, 2000). Not all persons with cognitive impairment have disordered sleep, but investigators have found increased disordered sleep in persons with many types of dementia.(Fuh, Wang, & Cummings, 2005; Yesavage, 2003) Disordered sleep in persons with cognitive impairment is associated with worse outcomes for both the persons with cognitive impairment and their caregivers (Foley et al., 2001; Frenchman, Capo, & Kass, 2000). Indeed, disordered sleep is often the reason for moving a person with cognitive impairment to a nursing home (Phillips & Diwan, 2003). We do not know whether disordered sleep is an unfortunate symptom experienced by persons with cognitive impairment or if disordered sleep in persons with cognitive impairment actually hastens functional and cognitive decline.

Overall, sleep becomes more disturbed with age and many of the parameters used to describe sleep change. Sleep consists of periods of rapid eye movement (REM) sleep and non-REM sleep. Non-REM sleep is further categorized into three stages: light sleep (stage 1) and progressively deeper levels of sleep (stages 2 and 3). The term "sleep architecture" is used to describe the process of sleep and the way in which an episode of sleep alternate between periods of non-REM and REM sleep in about 90-minute cycles. As a person ages, the proportion of time spent in deep sleep decreases, while awakenings and time spent in light sleep increases. Sleep efficiency is the ratio of time spent in bed to time spent asleep and this ratio decreases with age. Healthy young adults have an average sleep efficiency of about 95%. In addition to decreased sleep efficiency, other parameters used to describe sleep and to distinguish good and bad sleep include; total sleep time (TST), sleep onset latency (SOL), total awakenings and wake after sleep onset (WASO). TST is the total minutes of nighttime sleep. SOL is the number of minutes from the time one enters bed until the onset of sleep and usual SOL ranges from 15 – 25 minutes. In this study awakenings were measured with electroencephalogram as a return to alpha/and or low voltage, mixed frequency activity rhythm that lasts over half of one-30 second epoch (Bliwise, Willians, Irbe, Ansari, & Rye, 2000; Rechtschaffen A & Kales,

1968; Silber et al., 2007). WASO is defined as the number of minutes spent awake after first episode of sleep. Generally a good night's sleep begins with a SOL of 15 – 25 minutes, it may include five or fewer brief awakenings, is at least 90% efficient and lasts about 7 – 9 hours (Kryger, Roth, & Dement, 2005). This study examined relationships among disordered sleep (described with sleep efficiency, TST, SOL, total awakenings, and WASO), cognitive and functional status in nursing home residents. We hypothesized that disordered sleep would be associated with worse cognitive impairment and worse functional status.

Methods

This descriptive correlational study used baseline data (collected over a period of seven days) from a larger study funded by the National Institute of Nursing Research (NINR) and the National Institute of Aging. The primary aim of the larger study was to determine the effects of individualized social activity (ISA), progressive resistance training (PRT), combined ISA and PRT, or a usual care control condition on total nocturnal sleep time and amplitude of sleep-wake rhythm in nursing home residents with cognitive impairment. The study reported in this article was conducted in three not-for-profit nursing homes located in the southeastern United States. These nursing homes were typical of other nursing homes in the area, and capacity ranged from 60 – 176 beds. We obtained approval for the study from The University of Arkansas for Medical Sciences institutional review board. The participants, if they were able or their legally authorized representatives provided informed consent. The research staff obtained assent from the participants each time they participated in the study.

Data Collection and Measurement

The study reported here used baseline data from the larger study to examine the relationships among disordered sleep, cognitive status, and functional status. Inclusion criteria (also from the larger study) were 1) age 55 years or older, 2) chart review that documented cognitive impairment, 3) ≤ 7 hours of sleep at night and 30 minutes or more daytime sleep as determined by actigraphy, 4) at least 2 weeks residency in the nursing home, and 5) ability to stand with assistance. Residents with documented near terminal medical disorder (including advanced heart, lung, kidney, or liver failure resistant to medical management), unresolved malignancy (except non-metastatic skin cancer), undergoing treatment with chemotherapy, or a pharmacologic dose of steroids or with unstable cardiovascular disease were excluded.

The actigraph is a small device, very similar in appearance to a wrist watch. The actigraph contains a pizoelectric cell that records participant movements, which are averaged over a predetermined period of time or epoch. The actigraph can be worn and data continually collected for as long as 22 days. The recordings can be downloaded to a computer where numerous parameters describing sleep/wake continuity can be calculated from an algorithm. Therefore, the actigraph provides objective proxy measures for TST, total wake time, sleep efficiency, and other sleep continuity parameters.

Sleep

We measured nighttime sleep with attended polysomnography (PSG), the standard objective measure of sleep that allows observation of numerous physiological variables during sleep. Specific physiological variables that can be recorded include the electrical impulses generated from brain (electroencephalogram or EEG), heart rate and arrythmias (electrocardiogram or ECG), eye movements (electrooculogram or EOG), muscle tension in the chin (electromyography or EMG) and leg muscles (EMG of the anterior tibialis), we also measured thoracoabdominal movements associated with breathing, air flow through the pharynx, and arterial oxygen saturation via continuous pulse oximetry. Periodic limb movements of sleep, apnea hypopnea index, and oxygen saturation data were only collected during the first night

of sleep. Therefore, for this analysis all variables, except periodic limb movements of sleep, apnea hypopnea index, and oxygen saturation data were the average of measurements obtained during two nights of sleep.

Sleep technologists conducted attended polysomnography on participants in the nursing home environment. We used the nursing home because when people sleep in unfamiliar surroundings, like a sleep laboratory, their sleep patterns may not be typical during the first night of change and revert to more usual patterns on subsequent nights. This atypical sleep pattern is referred to as first-night effect. In this study, participants did not change their sleep environments therefore we believe this practice lessened first-night effect (Tamaki, Nittono, Hayashi, & Hori, 2005).

Sleep technicians collected descriptive sleep variables with the Grass Portable Polysomnography Data Acquisition System (Astro-Med Inc, West Warwick, RI). The technicians used 2 electroencephalogram leads, right and left electrooculograms, and submental electromyogram. Other recordings included oral and nasal airflow with a thermistor, snore vibrations with a microphone, thoracic and abdominal respiratory movements were recorded with belts, and ear or finger pulse oximetry using a Palco 340 (Palco Laboratory Inc., Santa Cruz, CA) or Nonin 8600 (Nonin Medical Inc., Minneapolis, MN). To record leg movements during sleep, surface electromyogram electrodes were placed 3 to 4 cm apart on the right anterior tibialis muscle. Attended polysomnography was carried out during the participants' usual hours of sleep.

We analyzed and scored continuous polysomnography data using standardized methods for recording and scoring.(Rechtschaffen A & Kales, 1968). Although, in April 2007, the American Academy of Sleep Medicine published "The AASM Manual for the Scoring of Sleep and Associated Events," meant to replace the R & K (1968) standard of sleep staging and unifying it with scoring roles for the most important events associated with sleep, at the time these data were collected the new criteria had not been published. All data were scored by one Registered Polysomnographic Sleep Technologist (RPSGT) who was blinded to the other study measures. In addition, because persons with cognitive impairment may have diffuse electroencephalogram slowing, we used some exceptions to standard scoring criteria for persons with cognitive impairment (Bliwise et al., 2000). We collapsed all non-rapid eye movement sleep into one-indeterminate category of non-rapid eye movement sleep, because people with cognitive impairment often have diffuse delta and theta activity in the electroencephalograms and landmarks used to categorize sleep stages such as sleep spindles disappear. We also disregarded conventional scoring criteria for rapid eye movement sleep muscle atonia because some persons with cognitive impairment may not have it.

Cognitive status

We used the Mini Mental State Examination (MMSE) to measure Cognitive status. The MMSE, a 30-point questionnaire, tests orientation, registration, attention, calculation, recall, and language (Folstein, Folstein, & McHugh, 1975). Scores can range from 0–30, with higher numbers indicating better cognitive status. The MMSE provides a global assessment of cognitive status and includes an attention subscale calculated using a mathematical task (serially subtracting 7s from 100) or a spelling task (spelling the word "world" backwards). Test-retest reliability is 0.83 and validity with similar measures ranges from 0.66 – 0.88 for the entire scale (Crum, Anthony, Bassett, & Folstein, 1993).

Functional Status

We used The Nursing Home Physical Performance Test (NHPPT), a performance-based instrument, to measure functional status.(Binder, Miller, & Ball, 2001) According to Binder (2001):

> Test-retest reliability for the NHPPT ranges between 0.73 and 0.93. Factor analysis and correlations between Nursing Home Physical Performance Test (NHPPT) items and other scales with measures of activities of daily living (ADL) suggest that the NHPPT taps aspects of gross motor function and fine motor coordination and task sequencing required for ADL function and mobility. The NHPPT may also tap aspects of ADL function and mobility not measured by the Minimum Data Set (r = −.72−.75), Multidimensional Observational Scale for Elderly Subjects (MOSES) (r = −.82 −.84), or Katz (r = −.75−.77) scales (Binder et al., 2001). Effect sizes based on mean change scores were larger for the NHPPT scales (.38–.53) than for the other functional scales (.27–.33) (p.671).

We believe this tool is superior to other measures of functional status for our target population because it is designed specifically for nursing home residents and reflects the range of function commonly present in this population.

The NHPPT evaluates six activities that are timed with a stopwatch and rated according to the level of assistance required to complete the activity. The six activities are sit to stand, scoop 3 tablespoons of applesauce, simulate face washing, dial a telephone, put on/take off a sweater, and walk 6 meters. We collected data on five of the six items in the resident's room. We tested the sixth item (walking six meters) in a pre-designated low-traffic hallway. The research assistant (RA) administered the test while instructing, prompting, or assisting the participant. Because gait speed is a standard measure of functional status in other populations, (Fitzpatrick et al., 2007) we will report data here on gait speed during the 6 meter walk and level of assistance required for the six activities.

Scores for level of assistance required for the activities range from 0–4; a rating of 4 indicates that the participant correctly completes the task after instruction is given once. If the participant completes the task after repeated step–by-step instruction, a rating of 3 is given. When a participant requires step–by-step instruction as well as minimal physical assistance, a rating of 2 is given, and if full physical assistance is required, a rating of 1 is given. If the participant is unable to complete the task even with step–by-step instruction and maximal physical assistance, the rating is 0. We report here a scale constructed of the level of assistance scores for each activity, with scores from 0 – 24. Because the NHPPT measures both ability to understand verbal instruction and ability to do the activity, the NHPPT captures both cognitive and physical aspects of functional capacity necessary for actual performance.

To ensure the validity and reliability of the level of assistance measure, the NHPPT is closely scripted. In this study, the research assistants (RA) practiced the scripted NHPPT with the first author until they achieved 100% accuracy. After the initial training, RAs were observed during three follow–up assessments to verify their adherence to the scoring guide and completeness of documentation.

Results

The sample of 90 included 55 females (61.1%) and 35 males (38.9%). Their average age was 81.2 (SD 8.56), with range from 58 to 95. Seventy-seven participants were Caucasian, 12 were African-American, and one was a Pacific Islander. Twenty-five percent of the sample had less than a high school education.

Measures of sleep continuity showed a mean sleep efficiency (ratio of time in bed to time asleep) of 64.46% (SD 15.38) with a range from 23% to 89.5%. Total sleep time (TST) ranged from 62.5 minutes to 493.25 minutes, with a mean TST of 300.82 minutes (SD 95.54). Although cut-off for study inclusion was seven hours of sleep or less measured with actigraphy, seven of ninety participants slept more than seven hours during PSG nights, indicating that TST can vary from night to night. Average sleep onset latency (minutes from lying down in bed to beginning of sleep) was 29.48 minutes (SD 34.48) with a range from 0.25 – to 194.25. Usual sleep onset latency is 15 – 25 minutes. Number of awakenings ranged from one to 173 with an average of 36.89 (SD 27.31). Minutes of wake after sleep onset averaged 130.04 (SD 64.31) and ranged from 15.75 – 333.00. The average time in bed for participants was 460.61 (SD 92.47) and ranged from 193.5 to 654.75.

The mean MMSE score was 20.54 (SD 7.33), with scores ranging from 4 – 28 indicating mild to severe cognitive impairment. Of the 90 participants, 9 were diagnosed with Alzheimer's disease and had a mean MMSE score of 15.11 (SD 6.53); 6 had multi-infarct dementia with a mean MMSE score of 18.67 (SD 8.04); 19 had other types of dementia (alcoholic, Pick's, Lewy body) and a mean MMSE score of 23.53 (SD 4.8); 26 had unspecified dementia (mean MMSE 16.31 [SD 7.27]), and 26 were diagnosed with mild cognitive impairment (mean MMSE 26.23 [SD 2.54]).

The mean level of assistance score was 20.68 (SD 4.41): scores ranged from 7 to 24 indicating that a majority of participants were unable to follow multi-step instructions. All participants were ambulatory and took an average of 33.47 (SD 48.16) seconds to walk 6 meters. Gait speed ranged from a surprisingly brisk 3.49 seconds to 282 seconds. Table 1 presents the means and standard deviations for sleep, cognitive status, and functional status variables for the 90 participants.

To describe the relationships among disordered sleep, cognitive status, and functional status, we conducted Pearson product-moment correlations. Table 2 summarizes these correlations. Because of skewed data we also conducted Spearman's rho correlations; however no change in statistical significance was observed. The non-parametric procedure was explored because of concern regarding violation of assumptions underlying *r*.

Decreased total sleep time (TST) ($r = -0.21$, $p = 0.04$) and fewer awakenings ($r = -0.25$, $p = 0.02$) were associated with better cognitive status. Decreased TST was also associated with better functional status measured as level of assistance required ($r = -0.30$, $p = 0.01$) and functional status measured as gait speed ($r = 0.32$, $p=0.01$). Better cognitive status was strongly associated with functional status measured as level of assistance required ($r = 0.68$, $p=0.01$) and with better functional status measured as gait speed. ($r = -0.40$, $p= 0.01$). After controlling for the effect of cognitive status, only the association between better gait speed and decreased TST remained significant ($r = 0.24$, $p=0.03$) (Table 3 summarizes partial correlations controlling for cognitive status).

To provide additional description of the relationships among sleep and cognition we created three MMSE categories (0 – 10 [severe cognitive impairment], 11 – 20 [moderate cognitive impairment], and 21 – 29 [mild cognitive impairment]). We calculated the mean sleep parameters for each group (Table 4) and compared means using a one way analysis of variance. We found no statistically significant differences, although the differences in mean TST among groups showed a trend toward significance (F (2, 87) = 2.87, $p < 0.06$).

Finally, awakenings were categorized by type (respiratory [55%], spontaneous [39%], bathroom [5%], and periodic limb movements [1%]). Further analysis determined that fewer respiratory awakenings and higher SaO_2 nadir were significantly associated with better cognition ($r = -0.24$, $p < 0.03$; $r = 0.23$, $p< 0.04$). In this sample, 60.8% had an apnea-hypopnea

index (apneas and O_2 desaturations ≥4% per hour) greater than 5, indicating a diagnosis of obstructive sleep apnea.

Discussion

This study examined the relationships between disordered sleep, cognitive status, and functional status in nursing home residents, with attended polysomnography in the nursing home. Not surprisingly, functional status was strongly associated with cognitive status ($p < 0.01$). McConnell and colleagues (2003) reported comparable findings (McConnell, Branch, Sloane, & Pieper, 2003; McConnell, Pieper, Sloane, & Branch, 2003). However, the direction of the association between total sleep time (TST), cognitive status, and functional status was not as anticipated. Increased TST was associated with worse cognitive status, and worse functional status. Although short sleep is a risk factor for numerous health problems, recent epidemiological studies describe associations between negative outcomes in both short and long sleepers (Cappuccio et al., 2007). One group of investigators note that persons reporting 6 to 7 hours of sleep at night have the best health outcomes.(Kripke, Garfinkel, Wingard, Klauber, & Marler, 2002). Further, it has been suggested that increased time in bed may not only lead to increased total sleep time but may also lead to sleep fragmentation and poorer quality sleep (Youngstedt & Kripke, 2004). The consequences such poor quality nighttime sleep could be increased daytime sleepiness.

In this sample, better cognitive and functional status was associated with decreased TST and fewer awakenings. When mean sleep parameters were categorized by cognitive status we found that TST was slightly greater in persons with more severe cognitive impairment (354.52 SD 108.76) vs. mild impairment (284.77 SD 85.38). Although this difference was not statistically significant it is plausible to suggest that a difference of 69.75 minutes of sleep is clinically significant.

When awakenings were categorized by type we found that respiratory awakenings and SaO2 nadir were significantly associated with cognitive status. We posit that frequent awakenings are evidence of poor quality nighttime sleep that may be more deleterious to cognitive and functional status than short sleep. Although correlation does not establish causation, these findings do suggest the possibility that interventions to decrease nighttime respiratory awakenings and maintain SaO2, have the potential to support cognitive and functional status in nursing home residents.

Obstructive sleep apnea increases with age in both sexes and other studies report prevalence rates that range from 11% (mean age 65 ± 3) to 62% (mean age 72.4 ± 6.4) (Janssens, Pautex, Hilleret, & Michel, 2000). We found that 60.8% of our sample of nursing home residents had five or more respiratory events per hour, indicating a diagnosis of obstructive sleep apnea. However, none of these residents were being treated for obstructive sleep apnea. Other investigators estimate that obstructive sleep apnea is improperly diagnosed or undiagnosed more than 90% of the time (Young, Evans, Finn, & Palta, 1997).

Moreover, according to Borbely's two process model of sleep regulation, (Borbely, 1982) the drive to sleep and the ability to stay awake are regulated through the interaction of time of day and duration of prior wakefulness. Saper et al.(2001) expanded our understanding of the rapid transition between wakefulness and sleep with their "sleep flip-flop switch" model in which wake- and sleep-promoting neurons inhibit each other. In healthy adults, this mutual inhibition results in a stable behavioral state of alert daytime wakefulness and sound nighttime sleep. However, in persons with cognitive impairment, neuronal degeneration may affect these mechanisms such that the flip/flop switch becomes unbalanced. The result of this imbalance is daytime sleepiness and light, fragmented sleep at night. Frequent brief nighttime arousals

and awakenings could reduce the benefits of sleep without reducing total minutes of sleep. Future research should examine the effects of brief nighttime arousals and awakenings as well as decreased total minutes of nighttime sleep from all causes including obstructive sleep apnea.

Our study provides important insights into the relationships among disordered sleep, cognitive, and functional status. However, the sample included only those who sleep 7 or fewer hours per night and 30 minutes or more during the day per actigraphy, and therefore they do not represent the general population. The findings may not be applicable to good sleepers or long sleepers with frequent nighttime arousals and awakenings. Further, descriptions of participants' sleep in this study were based on two nights of polysomnography and may not reflect the participants' usual sleep patterns, which may be more significant for the relationships among disordered sleep, cognitive status, and functional status.

During polysomnography, when people sleep in unfamiliar surroundings with extensive instrumentation, their sleep patterns may not be typical. This is called, "first night effect." Although our participants were in familiar surroundings the instrumentation required for polysomnography may have caused their sleep to be atypical and therefore must be considered a limitation of this study.

The cross sectional design precludes attribution of causality. Although our data may imply that disordered sleep has a negative impact on cognitive and functional status, this is only one possible scenario. It may also be the case that the aging process or other factors lead to both worse cognitive status and disordered sleep, thus producing spurious correlations. The Mini Mental State Examination was used as an indication of cognitive status in this study; while this is a well-accepted global measure of cognitive status, it may not be sensitive to the effects of disordered sleep. Finally, although all participants in this study met the inclusion criteria and had documentation of cognitive impairment in their chart, 22 participants had an MMSE score of 27 or above, which the authors of the MMSE report indicates normal cognitive function. (Folstein, 2001)

Despite these limitations, the study produced interesting data. Decreased total sleep time and fewer respiratory awakenings were associated with better cognitive and functional status. Disordered sleep, particularly obstructive sleep apnea, are potentially modifiable, and this study suggests that better sleep, not necessarily longer sleep, could improve functional performance through its effect on cognitive status.

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Table 1

Descriptive Statistics for Sleep, Cognitive status and Functional Status

	Mean(SD)	Median	Range
Sleep Efficiency	64.46 (15.38)	66.50	23–89.5
Total Sleep Time	300.82 (95.54)	305.00	62.5 – 493.25
Sleep Onset Latency	29.48 (34.48)	17.75	0.25 – 194.25
Total Awakenings	36.89 (27.31)	31.00	1 – 173
Wake after Sleep Onset	130.04 (64.31)	120.50	15.75 – 333.00
MMSE[a]	20.54 (7.33)	22.00	4 – 28
Level of Assistance[b]	20.68 (4.41)	22.00	7 – 24
Gait Speed[c]	33.47 (48.16)	16.70	3.49 – 282

N = 90

MMSE[a] = Mini Mental State Exam.

Level of Assistance[b] = Level of Assistance required to complete tasks. Lower score indicates more assistance required.

Gait Speed[c] = Speed in seconds to ambulate six meters.

Table 2

Correlations among sleep, cognitive status, and functional status variables.

	1	2	3	4	5	6	7	8
1. Sleep Efficiency[a]	1	0.79**	−0.31**	−0.03	−0.74**	−0.01	−0.17	0.10
2. TST[b]		1	−0.13	0.11	−0.38**	−0.21*	−0.30**	0.32**
3. SOL[c]			1	−0.15	−0.08	0.17	0.12	−0.08
4. Awakenings				1	0.20	−0.25*	−0.14	0.17
5. WASO[d]					1	−0.16	−0.00	0.13
6. MMSE[e]						1	0.68**	−0.40**
7. LOA[f]							1	−0.30**
8. Gait Speed[g]								1

(N = 90)

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Sleep Efficiency[a] = ratio of time in bed to time asleep in minutes.

TST [b] = total sleep time in minutes per polysomnography.

SOL[c] = minutes until onset of sleep.

WASO [d] = minutes of wake after sleep onset.

MMSE [e] = Mini Mental State Exam.

LOA [f] = Level of assistance required. Lower scores indicate more assistance required.

Gait Speed [g] = speed in seconds to walk six meters.

Table 3

Partial correlations controlling for cognitive status

	1	2	3	4	5	6	7
1. Sleep Efficiency[a]	1	0.78	-0.36	-0.05	-0.74	-0.14	0.07
2. TST[b]		1	-0.14	0.05	-0.39	-0.13	0.24*
3. SOL[c]			1	-0.11	-0.04	0.05	-0.03
4. Awakenings				1	0.17	0.01	0.07
5. WASO[d]					1	0.08	0.10
6. LOA[e]						1	0.09
7. Gait Speed[f]							1

(N = 90)

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Sleep Efficiency[a]= ratio of time in bed to time asleep in minutes.

TST [b]= total sleep time in minutes per polysomnography.

SOL[c]= minutes until onset of sleep.

WASO [d]= minutes of wake after sleep onset.

LOA [f]= Level of assistance required. Lower scores indicate more assistance required.

Gait Speed [g]= speed in seconds to walk six meters.

Table 4

Mean sleep parameters by MMSE category

MMSE Category	Minimum	Maximum	Mean	Std. Deviation
Severe Cognitive Impairment (n = 11)				
Sleep Efficiency	31.00	87.50	67.95	18.46
TST	158.50	493.25	354.52	108.76
SOL	2.25	24.50	11.98	8.29
Awakening	18.00	173.00	54.10	43.77
WASO	32.50	333.00	140.41	87.71
Moderate Cognitive Impairment (n = 23)				
Sleep Efficiency	24.00	83.50	61.87	16.62
TST	106.75	492.00	314.22	105.03
SOL	.50	145.50	34.63	41.00
Awakening	6.00	85.00	37.09	20.36
WASO	52.75	310.00	151.13	68.16
Mild Cognitive Impairment (n = 56)				
Sleep Efficiency	23.00	89.50	64.84	14.32
TST	62.50	445.75	284.77	85.39
SOL	.25	194.25	30.80	34.13
Awakening	1.00	119.00	33.68	25.34
WASO	15.75	294.00	119.35	55.78