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THE RELATIONSHIP BETWEEN SLEEP AND PHYSICAL FUNCTION IN COMMUNITY-DWELLING ADULTS: A PILOT STUDY

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Abstract

Over 50% of community-dwelling adults have sleep complaints. Because aging is associated with decline in physical function, coexistent sleep difficulties may exacerbate functional decline. This pilot study explored the relationships between sleep, age, chronic disease burden, and physical function among 50 community-dwelling older adults. Findings revealed significant relationships between total sleep time and preclinical disability ($r = -0.33$, $P = 0.05$) and mobility difficulty ($r = -0.36$, $P = 0.05$). A regression analysis showed that total sleep time was significantly associated with mobility difficulty and preclinical disability, even after controlling for chronic disease burden. These findings suggest that total sleep time may be a catalyst for functional decline.

Keywords

Adults; Sleep; Physical Function

Disability is defined as difficulty or dependency in carrying out activities essential to independent living, including bathing and dressing, and desired activities that improve one's quality of life.¹ Nearly one person in five has some type of long-lasting disability² with the prevalence increasing with age and chronic health burden.³ The majority of adults who become disabled do so through a chronic process of gradual physiological decline,¹ which often begins during middle age.⁴

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Preclinical disability precedes disability and represents a stage of decline where people are able to complete tasks without perceived difficulty by modifying the frequency or method of task performance, such as using hands on a chair to help stand from a seating position.^{5, 6} The presence of preclinical disability is indicative of elevated risk of becoming disabled.^{7, 8} Co-occurring conditions that may accelerate decline in physical function are prevalent among community-dwelling older adults, including pain, falls, and disturbed sleep.⁹

An estimated 50% of older adults report having disturbed sleep, such as difficulty falling asleep or multiple awakenings, that inhibits daily functioning, adversely affects health and reduces quality of life.³ Older adults are particularly at risk for disturbed sleep due to the chronic diseases and other age-related medical conditions that commonly develop.^{3, 9, 10, 11, 12} Thus, disturbed sleep may represent an independent problem that may benefit from treatment¹³ with associated improvement in physical function. To our knowledge, no one has examined the relationship between sleep and preclinical disability. Examining this relationship may help health care providers identify adults in which interventions to improve sleep may reduce risk for disability. This study explored the relationship between sleep as measured by overnight polysomnography (an objective measure of sleep stages and arousals, respiration, oxygenation, and cardiac rhythm disturbances) and self-reported physical function in community-dwelling adults.

METHOD

Study Design and Participants

Nondisabled, community-dwelling adults (meaning those who are not in living in assisted living or nursing homes) participated in a prospective observational study (NIA R01AG027778, KCR PI). Inclusion criteria were age 40–89 years; cognitively intact defined as a Mini Mental State Examination (MMSE) score > 29; on stable dosages of all medications; and apnea-hypopnea index <30 either with or without continuous positive airway pressure (CPAP). Exclusion criteria included Parkinson's disease, shift work, paralysis of lower extremities, and medical record diagnosis of dementia. The Institutional Review Board (IRB) approved the study. Because the questionnaire asks if participants had altered task performance since age 40, only adults over 43 years were invited to complete the survey. Of the 212 men and women who participated in the larger study, 72 completed baseline testing prior to 2009 when the questionnaire was added, 10 were 43 years of age, one withdrew after starting the study, 53 of the eligible participants agreed to complete the questionnaire, three participants had missing polysomnography data, leaving a final sample of 50 men and women.

Data Collection

Comprehensive assessments were completed at baseline during a three-day stay at the sleep laboratory. Participants had overnight polysomnography and completed sleep, medical history, and functional performance questionnaires during their stay.

Measures

Sleep—Attended polysomnography with the Sandman Digital Polysomnography System (Natus Medical Incorporated, Ontario, Canada) was used to measure participants' sleep in the laboratory for one night. Polysomnography data were recorded, analyzed, and scored using standardized methods.¹⁴ The recording montage consisted of central (C3, C4), occipital (O1, O2), and frontal electroencephalograms (F3, F4), bilateral electrooculograms, bilateral chin electromyogram, a bipolar electrocardiogram, nasal thermistor, abdominal and respiratory inductance plethysmography, and finger pulse oximetry. The interrater reliability (IRR) between polysomnography technicians who scored the data was 90%. For this study, we examined total sleep time (minutes) and wake after sleep onset (minutes).

Preclinical disability—The Functional Performance Survey measured preclinical disability using the wording and approach of the Second Longitudinal Study on Aging¹⁵ as described initially by Fried et al.¹⁶, and later by Miller et al.¹⁷ and Wolinsky.¹⁸ The presence or absence of preclinical disability was assessed for 20 activities: three Activities of Daily Living (ADL) tasks (dressing, bathing, getting out of bed/ chairs); three Instrumental Activities of Daily Living (IADL) tasks (shopping, meal preparation, heavy housework); three lower body functional tasks (walking up/walking down 10 steps; stooping/crouching/ kneeling); three items from the Nagi physical performance measure (lifting/carrying more than 10 pounds; opening jars; using fingers to grasp); the Rosow-Breslau task (walking one-half mile); and seven items from the Functional Performance Inventory (getting up off the floor or ground; getting out of a car; driving; helping friends/family; going out with friends/family; attending religious services; distant or overnight travel). These 20 activities represent a wide range of activities necessary for independent living and are comparable to previous items used by Fried et al.,¹⁶ Miller et al.,¹⁹ and Leidy.²⁰ For each task, participants were asked if they had difficulty completing the activity (with possible answers of no, yes, activity is no longer performed for health reasons). Next question investigated whether they had changed the frequency or the method of performing the task “because of health or physical problems” since the age of 40 years. Lastly, two open-ended questions asked what main symptom and what main health condition (or disease) caused them to change the frequency or method of task completion. Preclinical disability was estimated by calculating the proportion of tasks for which a change in method or frequency was reported divided by 20 (the total number of tasks) resulting in a score between 0 and 1 with higher scores indicating higher levels of preclinical disability. The development and psychometric testing of this method has been shown to have excellent test-retest reliability (kappa 66.7 to 87.7%).¹⁷

ADL/IADL function—We measured ADL/IADL function using six functional limitation items: three ADL tasks (bathing, dressing, getting in/out of bed and chairs) and three IADL tasks (preparing meals, doing heavy housework, shopping) using a simple sum of items in the survey. Individual items were scored from 0 (no difficulty) to 5 (much difficulty). Scores were summed to provide a total score (0–30) with higher scores indicating more difficulty.

Mobility—We measured mobility using five items (walking ½ mile, walking up stairs, walking down stairs, stooping/crouching/kneeling, lifting, and carrying 10 pounds) using a simple sum of items in the survey. Individual items were scored from 0 (no difficulty) to 5

(much difficulty) with higher scores indicating more difficulty. Summing the individual item scores provided a total score (0–25) with higher scores indicating more mobility difficulty.

Covariates

Predisposing factors associated with increased risk of disability^{21–23} including demographic factors (age, gender) and chronic disease burden were included in our analysis. Chronic disease burden was estimated by aggregating the most frequently cited causes of disability²⁴ into groups according to body systems (e.g., heart disease, hypertension, and stroke as heart and circulatory conditions) or meaningfully related conditions (e.g. hearing and vision problems as sensory limitations) resulting in six groups of chronic conditions.²⁵ Each condition was scored as present (1) or absent (0) and a total score (0–6) was created by summing conditions with higher score indicating more chronic disease burden.

Statistical Analysis

Pearson's correlation coefficients were used to explore the association between total sleep time, wake after sleep onset, age, gender, chronic disease burden, mobility, ADL/IADL, and preclinical disability scores. Regression analysis estimated the relationship of sleep variables with outcomes of mobility and preclinical disability after controlling for chronic disease burden. Assumptions behind the statistical analyses were checked. Statistical tests were two-sided, and $\alpha=0.05$ was considered statistically significant. Data analysis was conducted using SPSS version 19.0 for Windows (IBM SPSS, Armonk, New York) and SAS 9.1 Statistical Package (SAS Institute, Inc., Cary, NC).

Results

Demographic and clinical characteristics of participants are listed in Table 1. Fifty community-dwelling adults (70% Female; 60% White, Mean age=69.5 years; $SD=8.76c$) participated in this study. Physical function scores indicated this group of participants had very little difficulty with daily activities. The most common physical symptom attributed to mobility limitations was pain (14%). The most common health problems were heart and circulatory diseases (68%) and sensory impairments (66%). The most common sleep complaint was nighttime awakenings (82%). Participants' sleep, as measured by PSG, was poor (see Table 2). As shown in Table 3, the most commonly reported difficulty was getting up off the floor or ground (77%).

Pearson's correlation coefficients in Table 4 show statistically significant associations between total sleep time and mobility ($r=-.36$; $p=0.011$) and total sleep time and preclinical disability ($r=-.33$; $p=0.018$). Regression analysis indicated that total sleep time explained 12.7% of the variance in mobility ($p=0.010$) after controlling for chronic disease burden (see Table 5), with a one minute increase in total sleep time, there was a 0.02 unit decrease in mobility difficulty score. In a final regression model ($R^2=20.2\%$; $p=0.010$) adjusted for chronic disease burden, total sleep time was the strongest predictor of preclinical disability, such that less sleep was associated with more difficulty completing daily tasks (see Table 6).

Discussion

This study is one of the first to examine the relationship between sleep and preclinical disability in community-dwelling adults. Preclinical disability represents an early stage of functional decline where adults have an intermediate level of physical function but are at risk of disability within one to two years.^{5, 18} Consistent with this stage of functional decline, participants in this study had a high level of physical function with very few reporting difficulty with ADLs, such as dressing or bathing, and the most commonly reported difficulty was getting up off the floor or ground and doing heavy housework. In this study, short total sleep time was associated with higher levels of preclinical disability. This is an important finding because interventions, such as cognitive behavioral training for insomnia (CBT-I) or exercise to improve sleep, may reduce the risk of disability.^{1, 17}

In this study, the prevalence of preclinical functional disability was substantial, ranging from a low of 13% for dressing to a high of 77% for getting up off the floor or ground. These percentages are slightly higher than those reported by Wolinsky et al.²⁶ in a sample of African American men and women (age 49–65 years). Two years later, these researchers found that the level of preclinical disability were the main predictors of the development of difficulty in all tasks.¹⁸ In a three-year follow up study of the same participants, Wolinsky et al. (2007) found that the level of preclinical disability independently predicted adverse outcomes, such as hospitalization. These researchers suggested that clinicians routinely assess for preclinical disability and provide interventions promptly when identified to reduce disability.²⁷

Participants with short total sleep time also had more difficulty with mobility. These findings are comparable with results by other researchers who examined the relationship between sleep and physical function in older adult men and women.^{28–30} Goldman and colleagues²⁸ found a curvilinear relationship between sleep duration and mobility, with those sleeping less than 6.0 hours or more than 7.5 hours at increased odds for mobility difficulty compared with mid-range sleepers. In this study, however, short total sleep time was linearly associated with decreased mobility, with a one-minute increase in total sleep time being associated with 0.02 unit decrease in mobility difficulty score. However, the comparisons between these two studies are impeded by differences in measures used for sleep and for function. Goldman et al.²⁸ used performance-based measures of physical function and sleep as measured by actigraphy. One strength of our study is the use of PSG to assess sleep because there is evidence that actigraphy underestimates sleep disturbances.³¹

The relationship between sleep and mobility is consistent with other researchers' findings.^{28, 32} Other previously identified factors related to mobility difficulty include fatigue and exhaustion.²⁹ It is possible that participants with mobility difficulty were more sedentary, which has been shown to lead to reduced functional ability and poorer sleep.³³ Future longitudinal studies with larger sample sizes will be needed to explore relationship and trajectory of functional decline among adults with disturbed sleep and preclinical disability.

This study has several limitations. The cross-sectional design eliminates the possibility to determine causality and observe changes over time. The sample size was small. Sleep of these community-dwelling older adults was poor, as measured by polysomnography. Total sleep time was short and sleep efficiency of the sample was less than the usual 79% efficiency for a 70 year old,³⁴ possibly related to the “first night effect” of sleeping in a different environment. Use of self-reported physical function may have introduced some inaccuracies; however, this approach is entirely consistent with traditional conceptualization of the disablement process^{35, 36} and reflects what Verbrugge and Jette³⁷ describe as activity accommodations. Furthermore, this approach has been demonstrated to reliably identify preclinical disability in adult populations by other researchers.^{5, 6, 16, 16, 19, 38, 39}

Conclusions

This study is the first to suggest that short total sleep time may be associated with preclinical disability. The presence of preclinical disability indicates elevated risk of disability within the next two years. Given the prevalence of disturbed sleep in older adults, our findings suggest that interventions to improve sleep, such as exercise, may reduce functional decline and disability among the rising population of older adults. Future research with larger sample sizes should test the effect of interventions to improve sleep on physical function to determine whether increasing total sleep time reduces preclinical disability and mobility difficulty among community-dwelling older adults.

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Table 1**Demographic and Clinical Characteristics of Participants (N=50)**

Demographic variables	
Age, mean (SD), [range]	69.5 (8.76), [55 – 88]
Gender, (female), n (%)	35 (70)
Race (Caucasian), n (%)	30 (60)
Body Mass Index, mean, (SD), [range]	27.9 (5.44), [19.7–47.1]
Education, n (%)	
<12 years	7 (14)
High school	4 (8)
Partial college	13 (26)
College graduate	8 (16)
Advanced degree	18 (36)
Physical Function Measures, mean (SD)	
Mobility	4.2 (4.35)
Activities of Daily Living/Instrumental Activities of Daily Living	4.1 (4.08)
Physical symptoms attributed to motility limitations, n (%)	
Pain	7 (14)
Fatigue	5 (10)
Chronic Disease Burden, n (%)	
Heart and circulatory disease*	34 (68)
Lung disease	4 (8)
Mental distress	13 (26)
Metabolic conditions	21 (42)
Musculoskeletal conditions**	11 (22)
Sensory impairments	33 (66)
Sleep Complaints, n (%)	
Nighttime awakenings	41 (82)
Excessive daytime sleepiness	12 (24)
Snoring	13 (26)
Difficulty falling asleep	25 (50)

Table 2

Descriptive Statistics for Sleep from Polysomnography (N=50)

Variable	Mean (SD)	Median	Range
Sleep efficiency (%)	70.5 (16)	74	30 – 95
Total sleep time (minutes)	298.5 (78.73)	298.8	112.5 – 476.8
Sleep onset latency (minutes)	26.7 (27.74)	16.1	0 – 101.9
Wake after sleep onset (minutes)	101.2 (66.51)	84.2	16.1 – 305.4

Table 3

Participants Reporting Mobility Difficulty or Preclinical Disability in Tasks related to Mobility, ADLs and IADLs (N=50)

	Mobility Difficulty		Preclinical Disability	
	N	Percent	N	Percent
Mobility Tasks				
Walking ½ mile	20	40	33	63
Walking up Stairs	26	52	26	49
Walking down Stairs	14	28	20	38
Stooping/couching/ kneeling	37	74	38	72
Lifting and carrying 10 pounds	19	38	19	36
Getting up off of floor or ground	38	76	41	77
ADLs				
Bathing	15	30	16	30
Dressing	8	14	7	13
Getting in and out of bed and chairs	11	22	15	28
IADLs				
Preparing meals	10	2	14	26
Doing heavy housework	34	68	33	62
Shopping	12	24	17	32

Table 4

Pearson's correlation coefficients between sleep variables, mobility difficulty, difficulty with ADL/IADL and preclinical disability (N=50)

Sleep Variable	Mobility difficulty	Difficulty with ADL/IADL	Preclinical disability
Total sleep time	-.36*	-.23	-.33*
Sleep efficiency	-.22	-.01	-.11
Sleep onset latency	.22	-.01	.06
Wake after sleep onset	.08	-.08	-.01
Age	.06	-.18	-.07
Gender [†]	.04	.02	-.05
Chronic disease burden	.11	.15	0.28*

Note: ADL/IADL = activities of daily living / instrumental activities of daily living

*
p<0.05,

[†]
=point-biserial correlation coefficient

Table 5

Regression of mobility on total sleep time ($R^2=12.7\%$, residual $df=48$)

Term	β	S.E. $(\hat{\beta})$	t	P	95% CI for β
Constant	9.599	2.159	4.45	<.001	5.258 – 13.94
Total sleep time	-.018	.007	-2.64	.01	-.033 – -.004

Abbreviations: df =degrees of freedom, $\hat{\beta}$ =estimate of partial regression coefficient β , S.E. $(\hat{\beta})$ =standard error of the estimated coefficient, CI=confidence interval

Table 6

Relationship of preclinical disability with total sleep time after controlling for chronic disease burden ($R^2=20.2\%$, residual $df=47$)

Term	$\hat{\beta}$	S.E. ($\hat{\beta}$)	t	P	95% CI for β
Constant	.616	.155	3.98	<.001	.305 – .927
Total sleep time	-.001	<.0005	-2.70	.01	-.002 – .000
Chronic disease burden	.069	.030	2.31	.02	.009 – .129

Abbreviations: df =degrees of freedom, $\hat{\beta}$ =estimate of partial regression coefficient β , S.E. ($\hat{\beta}$)=standard error of the estimated coefficient, CI=confidence interval