

Sleep-Related Factors and Mobility in Older Men and Women

Sari Stenholm,^{1,2} Erkki Kronholm,³ Päivi Sainio,¹ Katja Borodulin,¹ Pertti Era,⁴ Mikael Fogelholm,⁵ Timo Partonen,⁶ Tarja Porkka-Heiskanen,⁷ and Seppo Koskinen¹

¹Functional Capacity Unit, Department of Health, Functional Capacity and Welfare, National Institute for Health and Welfare, Turku/Helsinki, Finland.

²Clinical Research Branch, National Institute on Aging, Baltimore, Maryland.

³Department of Chronic Disease Prevention, National Institute for Health and Welfare, Turku, Finland.

⁴Department of Health Sciences, University of Jyväskylä, Finland.

⁵Health Research Unit, Academy of Finland, Helsinki, Finland.

⁶Department of Mental Health and Substance Abuse Services, National Institute for Health and Welfare, Helsinki, Finland.

⁷Institute of Biomedicine, University of Helsinki, Finland.

Address correspondence to Sari Stenholm, PhD, Department of Health, Functional Capacity and Welfare, Peltolantie 3, FI-20720 Turku, Finland.
Email: sari.stenholm@thl.fi

Background. To examine the association between sleep-related factors and measured and self-reported mobility in a representative sample of older adults.

Methods. This study included 2,825 men and women aged 55 years and older participating in a cross-sectional representative population-based Health 2000 Survey in Finland. Sleep duration, insomnia-related symptoms, and fatigue were inquired. Maximal walking speed was measured, and mobility limitation was defined as self-reported difficulties in walking 500 m or stair climbing.

Results. Insomnia-related symptoms and fatigue were prevalent among persons aged 65 years and older in particular. After adjusting for lifestyle factors and diseases, longer sleep (≥ 9 hours) was associated with a decreased walking speed in women aged 65 or more years ($p = .04$) and shorter sleep (≤ 6 hours) with a higher odds for mobility limitation in women aged 65 or more years (odds ratio [OR] = 1.68, 95% confidence interval [CI] = 1.02–2.75) and in men aged 55–64 years (OR = 3.62, 95% CI = 1.40–9.37) compared with those having a mid-range sleep duration. Sleeping disorders or insomnia was independently associated with both decreased walking speed and mobility limitation in men aged 55 or more years but only with mobility limitation in women aged 65 or more years. Of the sleep-related daytime consequences, “weakness or tiredness” was associated with a decreased walking speed and a higher odds for mobility limitation both in men and in women aged 55 or more years.

Conclusions. Several sleep-related factors, such as sleep duration, insomnia-related symptoms, and fatigue, are associated with measured and self-reported mobility outcomes.

Key Words: General population—Mobility—Older adults—Sleep—Walking.

Received October 20, 2009; Accepted January 19, 2010

Decision Editor: Darryl Wieland, PhD, MPH

SHORT and long sleep duration, sleep-related disturbances, and their daytime consequences are common in older adults, and they are associated with decreased health and increased mortality (1–4). Because aging is associated with decline in physical performance often leading to physical disability and loss of independence, concomitant sleep problems may exacerbate the age-related decline in physical function.

Previous studies suggest that self-reported and measured insomnia and sleep-related problems are associated with decline in psychomotor performance (5) as well as with poor balance and increased risk of falls (6–8). In addition, Goldman and coworkers (2007) (9) reported that short (< 6 hours) and long (≥ 7.5 hours) sleep, increased sleep frag-

mentation, and longer daytime sleep are all associated with decreased physical performance and increased functional limitations in older women. However, the cutpoints used in this study differ from widely used classification: short sleep (≤ 6 hours) and long sleep (≥ 9 hours) (2–4). Besides insomnia-related symptoms, daytime consequences of inadequate sleep are frequent among older adults and may have negative effect on physical function. One component of fatigue, tiredness, is associated with walking limitation and development of activities of daily living (ADL) disability in older adults (10–12).

Despite the previously described studies concerning sleep-related factors and physical function, several important questions still remain open, such as what is the association of

Table 1. Characteristics of the Study Population ($N = 2,825$)

	Men ($n = 1,132$)	Women ($n = 1,693$)	p^*
Age, mean (SD), y	66.3 (8.4)	68.6 (9.0)	<.001
Education, %			.89
Basic	32.5	32.8	
Intermediate	47.6	48.0	
Higher	20.0	19.2	
Waist circumference, mean (SD), cm	100.1 (11.3)	92.5 (12.1)	<.001
Leisure-time physical activity, %			<.001
Inactive	24.7	33.2	
Regular lifestyle activity	56.9	57.7	
Exercise training	18.5	9.1	
Smoking, %			<.001
Current	20.9	9.8	
Former	46.1	11.2	
Never	33.0	79.0	
Alcohol consumption, %			<.001
None	33.4	58.8	
Moderate	58.5	38.7	
Heavy use	8.0	2.5	
Chronic diseases, %			
Heart disease	21.6	17.1	.005
Diabetes	9.2	7.6	.16
Lung disease	11.3	10.2	.37
Depression	4.9	9.1	<.001
Use of medication [†] , %	20.3	29.8	<.001
Maximal walking speed (SD), m/s	1.6 (0.5)	1.3 (0.5)	<.001
Mobility limitation, %	20.6	32.9	<.001

Notes: SD = standard deviation.

*Differences between men and women are examined with t test and chi-square test.

[†]Medication for sleep problems, vertigo, depression, anxiety, and neurological symptoms.

sleep-related factors and mobility. Furthermore, it is not known whether the association between sleep-related factors and measured and self-reported mobility varies across sex or age groups. Examining these questions may help us to recognize persons with an increased risk for mobility limitation. Thus, the aim of this representative population-based study was to examine whether self-reported sleep duration, insomnia-related symptoms, and fatigue are associated with walking speed and self-reported mobility limitation in men and women aged 55–64 and 65 or more years.

METHODS

Study Design and Participants

The study is based on the Health 2000 Survey, a comprehensive nationwide health interview and examination survey carried out in Finland in 2000–2001 (13). The two-stage stratified cluster sample comprised 8,028 persons aged 30 years or older living in Finland either in the community or in the institutions. Participants aged 80 years or older were oversampled (2:1) in relation to their proportion in the population. Details of the study design and data collection have been described elsewhere (13,14).

The sample for the present study was limited to participants aged 55 years or older ($n = 3,392$, 0.25% of the Finnish population), and of these, 2,825 (1,132 men and 1,693 women) had complete information on walking speed and mobility limitation (participation rate 83%). The exact number of participants according to each sleep-related variable is presented in Table 2. All participants signed a written informed consent approved by the Ethical Committee for Epidemiology and Public Health in the Hospital District of Helsinki and Uusimaa in Finland.

Sleep-Related Factors

Sleep duration. Self-reported 24-hour sleep duration was determined by the question: “How many hours do you sleep in 24 hours?” Participants were divided into three groups according to their sleep duration: “short sleepers” (≤ 6 hours), “mid-range sleepers” (7–8 hours), and “long sleepers” (≥ 9 hours) (2–4).

Insomnia-related symptoms. The following questions were used: (a) sleeping disorders or insomnia (“Have you had some of the following usual symptoms and troubles within the last month (30 days): . . . sleeping disorders or insomnia . . .?”; source: Symptom Checklist [SCL]-90) (15), (b) difficulties in getting sleep without sleeping medicine (“Do you have difficulties in getting sleep without sleeping medicine?”), and (c) awaking in the small hours or very early (“Do you wake up during small hours/after midnight or very early morning hours?”) (14).

Fatigue. The following questions were used: (a) weakness or tiredness (“Have you had some of the following usual symptoms and troubles within the last month (30 days): . . . weakness or tiredness . . .?”; source: SCL-90) (15), (b) overstrained or exhaustion (“Have you had some of the following usual symptoms and troubles within the last month (30 days): . . . overstrained or exhaustion . . .?”; source: SCL-90) (15), and (c) exceptional tiredness (“Are you usually more tired during the daytime than other people of your age?”) (14).

To clarify the terminology, in the present study, we use the term “sleep-related factors” when referring to sleep duration, insomnia-related symptoms, and fatigue.

Measures of Mobility

Maximal walking speed was measured over a distance of 6.1 m (16) using a stopwatch. The participant was instructed to “walk to the end of the course as fast as you can,” starting from a standstill. Walking aids were allowed if the person normally used them when walking. The reliability of the walking speed test, measured with intraclass correlation coefficient (ICC), was moderately good (ICC = 0.77, $n = 153$) (17). As a part of the interview, participants were asked: “Can you walk 0.5 km without resting?” and “Can you climb up one flight of stairs without resting?” Participants were considered to have mobility limitation if

Table 2. Prevalence of Sleep-Related Factors in Men and Women Aged 55–64 and 65 or More Years

	Men			Women			Gender difference <i>p</i>
	55–64 y	≥65 y	<i>p</i>	55–64 y	≥65 y	<i>p</i>	
	<i>N</i> (%)	<i>N</i> (%)		<i>N</i> (%)	<i>N</i> (%)		
Sleep duration, h			<.001			<.001	.62
≤6	63 (13.4)	106 (22.0)		83 (15.3)	179 (21.0)		
7–8	365 (77.3)	283 (58.3)		388 (70.9)	516 (62.5)		
≥9	45 (9.4)	100 (19.7)		76 (13.9)	159 (16.5)		
Insomnia-related symptoms							
Sleeping disorders or insomnia			.01			.24	<.001
No	343 (67.5)	337 (59.3)		324 (54.5)	495 (50.3)		
Somewhat	115 (23.1)	158 (26.9)		151 (25.3)	288 (28.7)		
Much or very much	48 (9.4)	85 (13.8)		120 (20.2)	215 (21.0)		
Difficulties in getting sleep without sleeping medicine			<.001			<.001	<.001
No	335 (70.8)	296 (60.6)		325 (59.4)	413 (48.6)		
Sometimes	109 (22.9)	125 (25.5)		160 (29.1)	249 (30.0)		
Often or always	30 (6.3)	76 (13.9)		63 (11.5)	196 (21.4)		
Awaking in the small hours or very early			.003			.07	.63
No	30 (6.5)	18 (3.6)		36 (6.5)	40 (4.3)		
Sometimes	263 (55.6)	237 (48.7)		287 (51.7)	420 (49.0)		
Often or always	180 (38.0)	242 (47.8)		232 (41.8)	408 (46.7)		
Fatigue							
Weakness or tiredness			.004			<.001	<.001
No	354 (70.4)	345 (60.9)		356 (59.9)	457 (48.3)		
Somewhat	100 (19.9)	152 (26.5)		165 (27.7)	326 (33.0)		
Much or very much	49 (9.7)	83 (12.6)		73 (12.5)	212 (18.7)		
Overstrained or exhaustion			.09			.45	<.001
No	393 (78.2)	424 (74.1)		393 (66.6)	638 (66.4)		
Somewhat	82 (16.4)	99 (17.3)		142 (24.4)	227 (22.8)		
Much or very much	27 (5.4)	54 (8.6)		52 (9.0)	114 (10.9)		
Exceptional tiredness			.22			.14	.63
No	278 (78.7)	270 (74.9)		297 (78.2)	429 (73.9)		
Often or always	75 (21.3)	94 (25.1)		82 (21.8)	154 (26.1)		

Note: Differences between groups were examined with chi-square test. *P* values showing statistically significant difference between age groups ($p < 0.05$) are bolded.

they reported any difficulties in walking 500 m or stair climbing (18).

Covariates

Educational level, smoking status, alcohol consumption, physical activity, waist circumference, chronic condition, and medication to sleep problems were all considered as possible confounders of the association between sleep-related factors and mobility. Based on the interview, the level of education was classified as basic education (0–9 years), intermediate education (10–12 years), and higher education (13 years or more). For smoking status, participants were categorized into never-smokers, former smokers, and current smokers. Alcohol use was measured with a questionnaire as average weekly consumption (in grams per week) based on the consumption of different drink types during the past month and classified as no alcohol use, moderate use, and heavy use (≥ 280 g/wk in men and ≥ 140 g/wk in women) (19). Leisure-time physical activity was determined based on a questionnaire and was categorized as sedentary (eg, reading and watching television), regular lifestyle activity at least 4 h/wk (eg, walking, biking, gardening, and

outdoor recreations), and exercise training at least 3 h/wk (eg, running, biking, and gymnastics).

Waist circumference was measured on naked skin at the end of a light expiration with the participant standing from a half way between the iliac crest and the lowest rib. The physician ascertained medical conditions by using structured, uniform diagnostic criteria based on current clinical practice. Disease categories used in this study were hypertension, heart disease (congestive heart failure, angina pectoris, or myocardial infarction), diabetes mellitus, lung disease (asthma or chronic obstructive pulmonary disease), depression, and knee and hip osteoarthritis. In addition, the use of medication for sleep problems, vertigo, depression, anxiety, and neurological symptoms during the preceding 7 days was determined by checking the drug names from the package or prescription. Use of any previously mentioned medication was considered as a potential confounding factor.

Statistical Analysis

The characteristics of men and women participating in the study are reported as mean values and standard deviations (*SDs*) for continuous variables and proportions for categorical variables. Differences between men and women were examined with *t* test and chi-square test. The interaction

Table 3. Maximal Walking Speed (in meters per second) by Sleep-Related Factors in Men

	55–64 y				≥65 y			
	Unadjusted		Adjusted*		Unadjusted		Adjusted*	
	Mean (SE)	<i>p</i>	Mean (SE)	<i>p</i>	Mean (SE)	<i>p</i>	Mean (SE)	<i>p</i>
Sleep duration, h								
≤6	1.69 (0.05)	.09 [†]	1.58 (0.07)	.08 [†]	1.42 (0.04)	.06 [†]	1.32 (0.07)	.28 [†]
7–8	1.81 (0.02)		1.70 (0.06)		1.54 (0.03)		1.39 (0.07)	
≥9	1.55 (0.06)	<.001[†]	1.56 (0.08)	.07 [†]	1.26 (0.05)	<.001[†]	1.34 (0.07)	.53 [†]
Insomnia-related symptoms								
Sleeping disorders or insomnia								
No	1.77 (0.02)	.06 [‡]	1.68 (0.06)	.01[‡]	1.46 (0.03)	<.001[‡]	1.40 (0.06)	.02[‡]
Somewhat	1.79 (0.04)		1.67 (0.06)		1.37 (0.04)		1.36 (0.06)	
Much or very much	1.60 (0.06)		1.47 (0.07)		1.20 (0.06)		1.26 (0.07)	
Difficulties in getting sleep without sleeping medicine								
No	1.77 (0.02)	.30 [‡]	1.67 (0.06)	.36 [‡]	1.48 (0.03)	.02[‡]	1.34 (0.07)	.48 [‡]
Sometimes	1.81 (0.04)		1.70 (0.07)		1.48 (0.04)		1.33 (0.07)	
Often or always	1.61 (0.08)		1.52 (0.09)		1.30 (0.06)		1.41 (0.08)	
Awaking in the small hours or very early								
No or sometimes	1.82 (0.40)	.12 [‡]	1.56 (0.09)	.18 [‡]	1.69 (0.06)	.02[‡]	1.39 (0.07)	.20 [‡]
Often or always	1.76 (0.40)		1.44 (0.06)		1.64 (0.06)		1.34 (0.06)	
Fatigue								
Weakness or tiredness								
No	1.83 (0.02)	<.001[‡]	1.74 (0.06)	<.001[‡]	1.55 (0.02)	<.001[‡]	1.44 (0.06)	<.001[‡]
Somewhat	1.67 (0.04)		1.63 (0.06)		1.28 (0.04)		1.34 (0.06)	
Much or very much	1.49 (0.06)		1.51 (0.07)		0.93 (0.06)		1.21 (0.07)	
Overstrained or exhaustion								
No	1.79 (0.02)	.01[‡]	1.68 (0.06)	.34 [‡]	1.49 (0.02)	<.001[‡]	1.41 (0.06)	<.001[‡]
Somewhat	1.67 (0.05)		1.56 (0.07)		1.25 (0.05)		1.29 (0.07)	
Much or very much	1.65 (0.08)		1.74 (0.09)		1.01 (0.07)		1.19 (0.08)	
Exceptional tiredness								
No	1.83 (0.02)	.001[‡]	1.77 (0.08)	.003[‡]	1.53 (0.03)	<.001[‡]	1.43 (0.10)	.11 [‡]
Often or always	1.66 (0.05)		1.62 (0.08)		1.26 (0.05)		1.34 (0.09)	

Notes: *Adjusted for education, leisure-time physical activity, smoking, alcohol consumption, waist circumference, use of medication (for sleep problems, vertigo, depression, anxiety, and neurological symptoms), and diseases (heart, lung, diabetes, depression, and osteoarthritis). *P* values showing statistically significant difference between subgroups ($p < 0.05$) are bolded.

[†]Univariate testing, 7–8 h is the reference group.

[‡]Trend test for linearity.

of Sex × Sleep-Related Factors and Sex × Age × Sleep-Related Factors on walking speed and mobility limitation was tested with generalized linear models (GLM). Because we found a significant interaction of sex, age, and multiple sleep factors on the outcome variables, the analyses were carried out in two age groups (55–64 and ≥65 years) for men and women.

To compare walking speed across groups of sleep duration, insomnia-related symptoms, and fatigue, analysis of covariance and GLM with Tukey post hoc test were used. In addition, the linear trend across categories was examined by entering categorical variables in the model as ordinal variables. Finally, the associations between sleep-related factors and mobility limitation were examined with logistic regression analysis using the same covariates. All the models were adjusted for potential confounding factors but also crude estimates are presented.

Statistical analyses were completed using the SAS 9.1 Statistical Package (SAS Institute, Inc., Cary, NC). The data were weighted to reduce bias due to nonresponse and to correct the oversampling in the age group of 80 years and older in order to

represent the Finnish population. The complex sampling design was taken into account by using SAS survey procedures.

RESULTS

Table 1 shows the main characteristics of the study population for men ($n = 1,132$) and women ($n = 1,693$). As shown in Table 2, short and long sleep duration was more common in participants aged 65 years and older ($p < .001$). “Sleeping disorders or insomnia” as well as “overstrained or exhaustion” were more common in women than in men ($p < .001$). “Difficulties in getting sleep without sleeping medicine” and “weakness or tiredness” were also more prevalent in older persons, and the prevalence was higher in women than in men ($p < .001$). There were no differences between men and women in “awakening in the small hours or very early” and “exceptional tiredness.”

The unadjusted maximal walking speed was highest among men and women sleeping 7–8 hours daily. After adjusting for confounding factors, only long sleep (≥9 hours) was associated with decreased walking speed in women aged 65 years and older compared with mid-range

Table 4. Maximal Walking Speed (in meters per second) by Sleep-Related Factors in Women

	55–64 y				≥65 y			
	Unadjusted		Adjusted*		Unadjusted		Adjusted*	
	Mean (SE)	<i>p</i>	Mean (SE)	<i>p</i>	Mean (SE)	<i>p</i>	Mean (SE)	<i>p</i>
Sleep duration, h								
≤6	1.51 (0.03)	.32 [†]	1.45 (0.06)	.77 [†]	1.15 (0.03)	.02 [†]	1.26 (0.05)	.46 [†]
7–8	1.57 (0.02)		1.48 (0.05)		1.25 (0.02)		1.30 (0.04)	
≥9	1.56 (0.04)	.94 [†]	1.47 (0.06)	.93 [†]	0.95 (0.04)	<.001[†]	1.20 (0.05)	.04[†]
Insomnia-related symptoms								
Sleeping disorders or insomnia								
No	1.57 (0.02)	.05[‡]	1.49 (0.05)	.39 [‡]	1.17 (0.02)	.05[‡]	1.27 (0.04)	.28 [‡]
Somewhat	1.58 (0.03)		1.52 (0.05)		1.13 (0.03)		1.23 (0.04)	
Much or very much	1.48 (0.03)		1.45 (0.05)		1.09 (0.03)		1.24 (0.05)	
Difficulties in getting sleep without sleeping medicine								
No	1.57 (0.02)	.12 [‡]	1.46 (0.05)	.86 [‡]	1.20 (0.02)	.01[‡]	1.30 (0.05)	.33 [‡]
Sometimes	1.59 (0.02)		1.50 (0.05)		1.19 (0.03)		1.25 (0.05)	
Often or always	1.47 (0.04)		1.42 (0.06)		1.09 (0.03)		1.27 (0.05)	
Awaking in the small hours or very early								
No or sometimes	1.58 (0.3)	.06 [‡]	1.49 (0.05)	.23 [‡]	1.29 (0.38)	.31 [‡]	1.28 (0.04)	.33 [‡]
Often or always	1.53 (0.3)		1.46 (0.05)		1.27 (0.37)		1.25 (0.05)	
Fatigue								
Weakness or tiredness								
No	1.61 (0.02)	<.001[‡]	1.54 (0.05)	.01[‡]	1.28 (0.02)	<.001[‡]	1.35 (0.04)	<.001[‡]
Somewhat	1.51 (0.03)		1.46 (0.05)		1.12 (0.03)		1.28 (0.04)	
Much or very much	1.41 (0.04)		1.46 (0.06)		0.82 (0.03)		1.14 (0.05)	
Overstrained or exhaustion								
No	1.58 (0.02)	.06 [‡]	1.50 (0.05)	.36 [‡]	1.19 (0.02)	<.001[‡]	1.29 (0.04)	.07 [‡]
Somewhat	1.51 (0.03)		1.45 (0.06)		1.09 (0.03)		1.23 (0.05)	
Much or very much	1.52 (0.05)		1.48 (0.06)		0.96 (0.05)		1.23 (0.05)	
Exceptional tiredness								
No	1.62 (0.02)	<.001[‡]	1.54 (0.06)	.06 [‡]	1.24 (0.02)	<.001[‡]	1.34 (0.06)	.55 [‡]
Often or always	1.48 (0.03)		1.46 (0.06)		1.01 (0.04)		1.31 (0.05)	

Notes: *Adjusted for education, leisure-time physical activity, smoking, alcohol consumption, waist circumference, use of medication (for sleep problems, vertigo, depression, anxiety, and neurological symptoms), and diseases (heart, lung, diabetes, depression, and osteoarthritis). *P* values showing statistically significant difference between subgroups ($p < 0.05$) are bolded.

[†] Univariate testing, 7–8 h is the reference group.

[‡] Trend test for linearity.

sleepers (7–8 hours; Tables 3 and 4). Of the insomnia-related symptoms, sleeping disorders or insomnia was independently associated with decreased walking speed among men in both age groups ($p \leq .02$) but not in women after adjusting for confounding factors. Of the fatigue indicators, weakness or tiredness was associated with lower walking speed in both men and women and in younger and older age groups ($p \leq .01$). Overstrained or exhaustion was independently associated with lower walking speed in older men ($p < .001$) and suggestively in women ($p = .07$). Exceptional tiredness was associated with decreased walking speed in younger men ($p = .003$) and suggestively in women ($p = .06$) after controlling for confounding factors.

The unadjusted prevalence of mobility limitation was lowest in men and women sleeping 7–8 hours a day. After adjusting for confounding factors, the odds for mobility limitation were increased only for short sleep (≤ 6 hours) in men aged 55–64 years (odds ratio [OR] = 3.62, 95% confidence interval [CI] = 1.40–9.37) and in women aged 65 or more years (OR = 1.68, 95% CI = 1.02–2.75; Tables 5 and 6). Sleeping disorders or insomnia was independently associated with increased odds for mobility limitation in

younger and older men as well as in older women. “Difficulties in getting sleep without sleeping medicine” “often or always” was associated with increased odds for mobility limitation in women but not in men after adjusting for confounding factors. All the fatigue indicators were significantly associated with increased odds for having mobility limitation in men and women and in both age groups, except for exceptional tiredness in older men after controlling for confounding factors.

DISCUSSION

In a nationally representative population-based study of older Caucasians, insomnia-related symptoms and fatigue were prevalent especially among persons aged 65 years and older. Several sleep-related factors were associated with decreased walking speed and higher odds for self-reported mobility limitation in men and women aged 55–64 and 65 or more years.

Sleep duration. We found that only long sleep (≥ 9 hours) was associated with lower walking speed in women aged 65 or more years compared with mid-range sleepers (7–8

Table 5. Odds Ratios (ORs) and 95% Confidence Intervals (CIs) for Multivariable Associations Between Sleep-Related Factors and Mobility Limitation* in Men

	55–64 y		≥65 y	
	Unadjusted	Adjusted†	Unadjusted	Adjusted†
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sleep duration, h				
≤6	2.38 (1.12–5.08)	3.62 (1.40–9.37)	1.74 (1.04–2.94)	1.60 (0.78–3.31)
7–8	1.00	1.00	1.00	1.00
≥9	2.74 (1.19–6.34)	1.15 (0.30–4.45)	2.50 (1.49–4.20)	1.00 (0.48–2.07)
Insomnia-related symptoms				
Sleeping disorders or insomnia				
No	1.00	1.00	1.00	1.00
Somewhat	1.55 (0.82–2.95)	1.73 (0.77–3.90)	1.55 (1.01–2.37)	1.30 (0.71–2.39)
Much or very much	2.85 (1.33–6.11)	3.88 (1.28–11.81)	2.93 (1.75–4.89)	2.42 (1.06–5.52)
Difficulties in getting sleep without sleeping medicine				
No	1.00	1.00	1.00	1.00
Sometimes	1.84 (0.96–3.53)	2.41 (1.06–5.47)	1.41 (0.85–2.32)	1.26 (0.63–2.55)
Often or always	1.29 (0.38–4.54)	0.58 (0.09–3.65)	3.31 (1.89–5.81)	1.68 (0.68–4.16)
Awaking in the small hours or very early				
No or sometimes	1.00	1.00	1.00	1.00
Often or always	1.87 (1.00–3.49)	1.85 (0.87–3.95)	1.45 (0.92–2.28)	1.07 (0.59–1.92)
Fatigue				
Weakness or tiredness				
No	1.00	1.00	1.00	1.00
Somewhat	6.29 (3.19–12.39)	4.83 (2.06–11.31)	4.20 (2.69–6.54)	1.92 (1.05–3.50)
Much or very much	10.92 (5.08–23.46)	8.54 (2.79–26.17)	12.55 (7.00–22.48)	3.94 (1.76–8.84)
Overstrained or exhaustion				
No	1.00	1.00	1.00	1.00
Somewhat	3.15 (1.67–5.95)	3.51 (1.57–7.87)	3.19 (2.00–5.10)	2.13 (1.11–4.07)
Much or very much	3.57 (1.38–9.22)	2.12 (0.43–10.48)	6.60 (3.52–12.39)	2.97 (1.28–6.89)
Exceptional tiredness				
No	1.00	1.00	1.00	1.00
Often or always	3.10 (1.47–6.50)	3.13 (1.07–9.12)	2.10 (1.22–3.62)	0.71 (0.31–1.64)

Notes: *Defined as self-reported difficulties in walking 500 m or stair climbing. ORs showing statistically significant difference from reference group ($p < 0.05$) are bolded.

†Adjusted for education, leisure-time physical activity, smoking, alcohol consumption, waist circumference, use of medication (for sleep problems, vertigo, depression, anxiety, and neurological symptoms), and diseases (heart, lung, diabetes, depression, and arthritis).

hours). This is comparable with the results by Goldman and coworkers (9), where women with mid-range sleep had higher walking speed and faster chair rise time compared with persons who had shorter or longer sleep. Furthermore, short sleep (≤ 6 hours) was found to be associated more often with mobility limitation in women aged 65 or more years and men aged 55–64 years compared with mid-range sleepers (7–8 hours). Interestingly, Goldman and coworkers (9) found that sleeping *more* than 7.5 hours was associated with an increased odds of functional limitation in older women compared with mid-range sleepers, but sleeping less than 6.8 hours *was not* associated with functional limitation. Study populations in our study and Goldman's study consist of older Caucasians, but in their study, subjects were older and the measures for functional limitation included difficulties in ADLs, thus hampering the direct comparison with our results. In addition, in their study, short sleep was defined as less than 6 hours and long sleep as 7.5 or more hours sleep per night and it was based on wrist actigraphy measurement. However, our findings that short sleep is associated with self-perceived difficulties in mobility tasks, whereas long sleep is associated with impaired

physical performance are interesting and need further exploration.

Insomnia-related symptoms. Sleeping disorders or insomnia was independently associated with both measured and self-reported mobility outcomes in men across age groups, and it was associated only with self-reported mobility limitation in women after controlling for potential confounders. Our results partly confirm results from Goldman's study, in which fragmented sleep was more associated with functional limitations and slower walking speed among older women (9). Previous studies based on data from wrist actigraphs, nocturnal arterial oxygen saturation, and self-reports have also reported an association between insomnia and sleep disturbances and poor balance, increased risk of fall (6–8), and difficulties in ADLs (20,21).

The explanation for the relationship between sleeping disorders or insomnia and decreased mobility may stem from excessive daytime sleepiness and fatigue (22). This pathway will need to be confirmed in a longitudinal study, but our additional analysis provides tentative support for this hypothesis. Both insomnia-related symptoms and fatigue are independently related to mobility limitation.

Table 6. Odds Ratios (ORs) and 95% Confidence Intervals (CIs) for Multivariable Associations Between Sleep-Related Factors and Mobility Limitation* in Women

	55–64 y		≥65 y	
	Unadjusted	Adjusted [†]	Unadjusted	Adjusted [†]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sleep duration, h				
≤6	1.83 (0.97–3.54)	1.23 (0.58–2.62)	1.95 (1.35–2.81)	1.68 (1.02–2.75)
7–8	1.00	1.00	1.00	1.00
≥9	1.47 (0.73–2.96)	1.91 (0.87–4.16)	2.04 (1.37–3.06)	1.20 (0.66–2.16)
Insomnia-related symptoms				
Sleeping disorders or insomnia				
No	1.00	1.00	1.00	1.00
Somewhat	1.73 (0.95–3.15)	1.88 (0.95–3.69)	1.49 (1.08–2.04)	1.37 (0.87–2.16)
Much or very much	3.06 (1.72–5.34)	1.98 (0.97–4.03)	2.46 (1.72–3.51)	2.15 (1.27–3.66)
Difficulties in getting sleep without sleeping medicine				
No	1.00	1.00	1.00	1.00
Sometimes	1.53 (0.85–2.75)	1.64 (0.81–3.31)	1.18 (0.83–1.66)	1.56 (0.96–2.54)
Often or always	3.80 (1.97–7.35)	3.39 (1.45–7.94)	2.85 (1.94–4.19)	2.67 (1.46–4.88)
Awaking in the small hours or very early				
No or sometimes	1.00	1.00	1.00	1.00
Often or always	1.77 (1.05–2.98)	1.47 (0.82–2.65)	1.77 (1.27–2.47)	1.42 (0.95–2.12)
Fatigue				
Weakness or tiredness				
No	1.00	1.00	1.00	1.00
Somewhat	2.81 (1.57–5.01)	2.27 (1.16–4.47)	2.68 (1.95–3.68)	2.08 (1.34–3.23)
Much or very much	6.33 (3.34–11.98)	3.45 (1.57–7.59)	11.33 (7.22–17.78)	4.70 (2.56–8.61)
Overstrained or exhaustion				
No	1.00	1.00	1.00	1.00
Somewhat	2.27 (1.33–3.89)	2.07 (1.09–3.94)	2.15 (1.55–3.01)	1.84 (1.18–2.88)
Much or very much	2.08 (0.95–4.54)	1.73 (0.70–4.31)	5.35 (3.23–8.85)	2.97 (1.50–5.86)
Exceptional tiredness				
No	1.00	1.00	1.00	1.00
Often or always	5.99 (3.08–11.63)	4.11 (1.79–9.42)	4.60 (3.01–7.03)	2.11 (1.14–3.93)

Notes: *Defined as self-reported difficulties in walking 500 m or stair climbing. ORs showing statistically significant difference from reference group ($p < 0.05$) are bolded.

[†]Adjusted for education, leisure-time physical activity, smoking, alcohol consumption, waist circumference, use of medication (for sleep problems, vertigo, depression, anxiety, and neurological symptoms), and diseases (heart, lung, diabetes, depression, and arthritis).

However, when added in the same model without confounding factors, we found that weakness or tiredness fully explained the association between sleeping disorders or insomnia and mobility limitation. Other factors that may lead to decreased physical performance and thus mobility limitation among persons with poor sleep are cognitive dysfunction and decreased psychomotor performance (5,23,24).

Fatigue. Several fatigue indicators were associated with negative mobility outcomes in both men and women across the age groups. Weakness or tiredness was consistently associated with decreased walking speed independently of several confounding factors. Our findings are consistent with earlier studies, in which the effects of tiredness on current walking limitation and future disability have been examined (10,11). However, it must be emphasized that term “fatigue,” used in this study, is very wide. When interpreting these findings, we cannot be certain that all the reported fatigue were sleep-related. Fatigue, weakness or tiredness, is a multidimensional concept and can accompany other physiological and psychological conditions than sleep disturbances, such as cardiopulmonary diseases, cancer, depression, and pain

(25). We tried to partly overcome this problem by controlling for several diseases and were still able to see a strong independent association between weakness and tiredness and mobility outcomes.

Mechanisms leading to functional limitation. According to the theoretical pathway from disease to disability described by Verbrugge and Jette (26), decline in walking performance or self-reported mobility limitation is often a consequence of physical impairments, such as decreased muscle strength or impaired balance (27,28), which on the other hand are affected by diseases or changes in body homeostasis. Observational studies have confirmed an association between short sleep and sleep apnea and increased inflammation, insulin resistance, diabetes, metabolic syndrome, and hypertension (3,29–33). Changes in previously mentioned immunology, metabolic, and endocrinologic systems may predispose to functional decline in older people, either directly or through chronic conditions and muscle strength loss (28,34–36). Finally, an important prerequisite for maintaining physical function, namely physical activity, may be affected by sleep-related disturbances (9,37,38).

This study has some limitations that warrant discussion. First, self-reported measures of sleep duration, insomnia-related symptoms, and fatigue were used, thus predisposing to over- or underreporting (39). In addition, we cannot be sure that participants reporting short sleep are actually suffering from sleep deprivation because there are wide inter-individual differences in sleep quality and sleep duration preferences. Thus, future studies are needed to confirm the associations of sleep-related factors with physical function using objective instruments, such as wrist actigraph measurements. Second, despite the high participation rate (83%), there were some significant differences between participants and nonparticipants. The nonparticipants were older (72.8 vs 67.6 years), had lower education, were physically less active, and used more drugs (p for all $< .05$). Based on the self-reported mobility limitation data, 54% of the nonparticipants were considered to have mobility limitation, whereas only 27% of the participants had mobility limitation ($p < .001$). Thus, it is possible that our findings underestimate the association between sleep-related factors and measured and self-reported mobility outcomes. Finally, due to the cross-sectional nature of this study, we are unable to make any causal inferences between sleep-related factors and decline in mobility as well as about the mediating factors. As discussed earlier, there are factors related to biological processes and medical conditions that support the hypothesis that sleep-related problems would lead to decline in mobility. Further prospective studies are greatly needed to clarify the causal pathway between these entities.

In conclusion, sleep duration, insomnia-related symptoms, and fatigue are associated with the measured and self-reported mobility outcomes independently of lifestyle factors and diseases, in men and women. Sleep problems may exacerbate the age-related decline in physical functioning, thus the assessment of sleep-related factors in the clinical examination may be beneficial in recognizing persons with an increased risk of mobility problems. In addition, among persons with decreased mobility, sleep-related problems may reveal underlying health issues. Further longitudinal prospective studies are needed to confirm the causality between sleep-related problems and physical functioning.

FUNDING

This study was supported by grant from the Finnish Academy (125494 SS) and in part by the Intramural Research Program of the National Institutes of Health, National Institute on Aging.

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