Sleep-disordered Breathing and Self-reported General Health Status in the Wisconsin Sleep Cohort Study

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Objective: To determine the relationship between sleep-disordered breathing and self-reported general health status.
Design: Cross sectional, population-based study of general health status, satisfaction with life, and sleep-disordered breathing status assessed by overnight in-laboratory polysomnography.
Setting: General Community
Subjects: Employed men (n=421) and women (n=316), ages 30-60 years, enrolled in the Wisconsin Sleep Cohort Study
Interventions: None
Outcome Measure: Self-reported general health profile and life satisfaction measured by the Medical Outcomes Survey Short Form-36 and obtained by interview.
Results: Sleep-disordered breathing was associated with lower general health status before and after adjustment for age, sex, body mass index, smoking status, alcohol usage, and a history of cardiovascular conditions. Even mild sleep-disordered breathing (apnea-hypopnea index = 5) was associated with decrements in the Medical Outcomes Short Form 36 Survey health constructs comparable to the magnitude of decrements linked to other chronic conditions such as arthritis, angina, hypertension, diabetes, and back problems.
Conclusions: Sleep-disordered breathing is independently related to lower general health status, and this relationship is of clinical significance. Given the growing emphasis of the importance of patients' perceptions of health, these findings are relevant to estimating the overall impact of sleep-disordered breathing.
Key Words: Sleep-disordered breathing; quality of life; body habitus measures

THE NEED TO ASSESS the healthcare burden of sleep-disordered breathing (SDB), a major sleep disorder, has been widely recognized.[1] Recently, the benefit of medical attention to this disorder was questioned, including both the efficacy of and the necessity for treatment.[2] Sleep-disordered breathing is a prevalent but largely undiagnosed condition with repeated episodes of apnea and hypopnea during sleep. These episodes fragment sleep, decrease arterial O_2 saturation, and cause hemodynamic fluctuations.[3,4] Although consequences of sleep-disordered breathing are not fully understood, behavioral and cardiovascular morbidity are consistent features of clinical cases.[5-7] Furthermore, recent population-based studies have linked sleep-disordered breathing with hypertension, motor vehicle accidents, increased medical care utilization, and neuropsychological impairment.[8-12] However, the effect of sleep-disordered breathing on self-assessed health has not been adequately addressed. The impact of chronic conditions on self-assessments of health is being recognized increasingly by the healthcare system.[13] In addition, the healthcare system is expanding utilization of such outcome measures to policy decision-making.[14,15] The goal of our investigation is to ascertain the relationship between sleep-disordered breathing and self-reported health status,

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using a widely employed health profile instrument.

Limited studies of sleep clinic patients have shown reductions in general health status with sleep-disordered breathing,[16,17] and treatment with nasal continuous positive air pressure has been associated with increases in quality-adjusted life years.[18] Self-reported loud snoring and a history of observed apneas[19] and sleepiness—one well-established outcome of sleep-disordered breathing[20,21]—have been associated with reduced self-rated general health.[22,23] In sleep apnea patients, hypoxemia has been associated with impaired neuropsychological and cognitive functioning independent of other consequences of sleep-disordered breathing.[24,25]

Although these studies imply that sleep-disordered breathing may be related to general health status, the evidence is not conclusive. In clinic-based studies, patients have sought help based on their own perception of problems with their health. Such self-selection may bias findings toward stronger associations than exist in the population as a whole. Furthermore, most clinic-based studies were limited by unrepresentative control groups, small sample sizes, or predominance of male patients. Other studies were limited by the use of self-report as a surrogate for objectively measured sleep-disordered breathing. Our study quantifies the association between sleep-disordered breathing and self-reported health status in a general population, using participants in the Wisconsin Sleep Cohort Study. The distinctive strengths of this study are these: (1) a large, population-based sample of employed adults; (2) assessment of sleep-disordered breathing by overnight in-laboratory polysomnography, the clinical standard of diagnosis[26,27]; and (3) measurement of health status by the Medical Outcomes Short Form-36 Survey, a widely used, generic health profile.[28,29,30]

METHODS

Sample

The Wisconsin Sleep Cohort Study is an ongoing prospective study of the natural history of sleep-disordered breathing. A two-stage sampling procedure, previously described,[31] was used to construct the cohort. All men and women, aged 30-60 years, employed in a range of occupational categories at one of five state agencies in south-central Wisconsin, were surveyed on sleep characteristics and sociodemographic factors. A probability sample was drawn from survey respondents and recruited for the Sleep Cohort Study. To increase study efficiency, individuals with self-reported snoring and breathing pauses were oversampled. With ongoing recruitment since 1989, the response rate averages 50%.

Data Collection

The overnight study protocol, including polysomnography and other tests and measurements, was conducted at a dedicated sleep research laboratory equipped with comfortable bedrooms.

Polysomnography included recording of sleep-state parameters (EEG, EOG, EMG), breathing (oral airflow, nasal airflow, and ribcage and abdominal excursions), heart rate (ECG), and oximetry. (See ref. 31 for details.) All records were manually scored by trained technicians using conventional criteria,[27] and reviewed by one of two sleep clinicians. Abnormal breathing events with no airflow for 10 seconds or more were scored as apneas, and events with a 40% or more reduction in respiratory effort accompanied by a 4% or more desaturation were scored as hypopneas. A polysomnographic study of acceptable quality was defined by adequate sleep and breathing signals throughout the night, at least 4 hours of objectively measured sleep, and at least one period of REM sleep. To date, 97.8% of the sleep studies have had acceptable polysomnographic data.

The total number of scored apneas and hypopneas, divided by the number of hours of sleep (apnea-hypopnea index, AHI), was determined for each participant as the summary measure of sleep-disordered breathing.

Height and weight without shoes, and waist, neck, and hip girths were measured using standard procedures.[32] Body mass index (BMI) was calculated from height and weight (kg/m^2).

Cardiovascular disease history (coronary artery disease, angina, congestive heart failure, or report of previous myocardial infarction), age, lifestyle, and other sociodemographic factors were obtained by interview on the night of the polysomnography. Smoking status was defined as current smoker vs not, and alcohol usage was the total number of alcoholic drinks (beer, wine, and hard liquor) consumed during a typical week. The interview also questioned (1) general life satisfaction (completely, mostly, moderately, or not very satisfied), and (2) evaluation of health (excellent, very good, good, fair or poor). The sample sizes are smaller (n_1=588, n_2=681) for the analyses of data from these questions, as these were added to the overnight interview after the study began.

General health status was measured using a self-administered Medical Outcomes Short Form-36 Survey (SF-36).[28-30] The SF-36 comprises 36 questions measuring eight health constructs: (1) limitations in physical activities; (2) limitations in social activities; (3) limitations in usual role activities because of physical health problems; (4) bodily pain; (5) general mental health (psychological distress and well-being); (6) limitations in usual role activities because of emotional problems; (7) vitality (energy and fatigue); and (8) general health perceptions. Scores range from 0 to 100, with 100 the best score.

Table 1.—Selected characteristic of the sample (n=737)

Apnea-hypopnea index, median	0.98 (0 - 97.5)
Age (years), mean ± sd	48.4 ± 7.7
Body mass index (kg/m^2), mean ± sd	29.1 ± 6.0
Male, %	57.1
Excessive daytime sleepiness (more than one day per week), %	20
Excellent evaluation of health*,%	24.9
Completely satisfied with life*,%	11.6
Cardiovascular condition**, %	3.7

* Obtained on the night of the overnight sleep study
**History of coronary artery disease, angina, congestive heart failure or myocardial infarction

Table 2.—Medical Outcome Survey Short Form-36 (SF-36) mean scores for the Wisconsin Sleep Cohort Study

Wisconsin Sleep Cohort (n=737)	
SF-36 Variable	**Mean ± SD**
Mental health	75.5 ± 16.9
Role, emotional	82.6 ± 32.5
Social	83.5 ± 22.8
Role, physical	81.8 ± 32.0
Vitality	59.1 ± 20.0
Pain	72.8 ± 21.8
Physical functioning	87.0 ± 18.0
General health perception	72.5 ± 19.7

The SF-36 was sent to all current cohort participants in the winter of 1995-96 (n=1 027), and was returned by 760 individuals (74% response rate). Of these individuals, 23 had insufficient polysomnography data and were not included in the analysis. On average, the SF-36 was completed 3.1 years after the polysomnography. To assess the generalizability of our results, participants in the current analysis were compared to nonparticipants (ie, those who refused participation in the Sleep Cohort Study or did not complete the SF-36). No difference was found between the two groups with respect to age, self-reported BMI, sex, or race; however, participants were slightly more educated than nonparticipants.

Data Analysis

Data were analyzed with SAS[33] software modules for descriptive statistics, contingency tables, correlations and multiple linear and polychotomous logistic regression. AHI was used either as a continuous variable or categorized using cutpoints of 5, 15, or 30. Although the clinical significance of any AHI cutpoint has not been adequately established, cutpoints of 5 and 15 are often used to indicate physiologic evidence of at least mild sleep-disordered breathing and clinically significant sleep-disordered breathing, respectively.

Multiple polychotomous logistic regression was used to estimate odds ratios for associations of sleep-disordered breathing (defined as AHI ≥5), with life satisfaction and evaluation of health ascertained by interview on the night of the sleep study. Models were adjusted for the potential confounders of age, sex, BMI, smoking status, alcohol usage, and a history of cardiovascular conditions. Due to the small number of individuals who evaluated their health as *poor* (n=3), the *fair* and *poor* responses were combined.

The SF-36 constructs were used as the continuous dependent variables in multiple linear regressions with AHI as the predictor variable transformed to the natural log scale to meet linearity assumptions. Age, sex, a history of cardiovascular conditions, smoking status, alcohol usage, and BMI were included as covariates in all models. Interactions between the covariates and AHI were tested for each SF-36 construct.

Statistical significance of linear and logistic regression coefficients was assessed by *t* tests and Wald chi-square tests, respectively. Two-tailed p values less than 0.05 were considered to indicate statistical significance.

RESULTS

Selected characteristics of the sample are given in Table 1. Sample mean scores for SF-36 constructs are given in Table 2. These means are similar to normative data reported on other working adult populations.[34,35]

Table 3 gives unadjusted percentages by AHI severity for in-laboratory life satisfaction and evaluation of health responses from the interview. A negative trend can be seen with increasing AHI severity for both “completely satisfied with life” and “excellent evaluation of health.” Odds ratios (95% confidence intervals) associated with an AHI ≥5 compared to AHI <5, controlling for the effect of age, sex, BMI, smoking status, alcohol usage, and a history of cardiovascular conditions, were (1) 1.6 (0.7,3.3), 1.4 (0.6,3.3), and 6.6 (1.8,23.4) ($p<0.05$) for *mostly*, *moderately*, and *not very satisfied with life* compared to *completely satisfied*, respectively; and (2) 2.0 (1.1,3.8), 3.0 (1.5,6.2), and 4.9 (1.7,14.3) for *very good*, *good* and *fair/poor* evaluation of health compared to *excellent*, respectively (all $p<0.05$).

Multiple linear regression adjusting for the covariates showed that sleep-disordered breathing, measured by AHI, was significantly related in a dose-response fashion to six of the eight health status scores profiled by the SF-36 (Table 4). Mental health, social roles, role functioning due to physical problems, physical functioning, vitality, and general health perceptions all decreased with increasing sleep-disordered breathing. Pain and role limitations due to

Table 3.—Life satisfaction and general health data collected on the night of the polysomnography by sleep-disordered breathing severity, Wisconsin Sleep Cohort Study

	Apnea Hypopnea Index			
	0-2	2-5	5-15	≥15
Life Satisfaction:	(n=365)	(n=101)	(n=72)	(n=50)
Completely, %	12	12	10	8
Mostly/Moderately,	85	87	86	82
Not Very, %	3	1	4	10
General Health*:	(n=420)	(n=117)	(n=87)	(n=57)
Excellent, %	29	27	13	7
Very Good/Good, %	68	70	82	82
Fair/Poor, %	3	3	5	11

Questions on life satisfaction and general health were added to the protocol; thus the different sample sizes.
*Overall chi square p<0.05

Table 4.—Relationship between the MOS Short Form-36 Health Survey constructs and sleep-disordered breathing adjusted for age, sex, body mass index and cardiovascular conditions (Wisconsin Sleep Cohort)

	Log (AHI + 1) Coefficient (SE)	Difference in SF-36 Variable from AHI=0:		
		At an AHI of 5	At an AHI of 15	At an AHI of 30
Pain	-0.58 (0.89)	*	*	*
Mental health	-1.50 (0.69)	-2.7 ± 1.2	-4.2 ± 1.9	-5.2 ± 2.4
Vitality	-2.22 (0.81)	-4.0 ± 1.5	-6.2 ± 2.2	-7.6 ± 2.8
Physical functioning	-1.57 (0.70)	-2.8 ± 1.3	-4.4 ± 1.9	-5.4 ± 2.4
Role, emotional	-2.04 (1.33)	*	*	*
Social	-2.32 (0.93)	-4.2 ± 1.7	-6.4 ± 2.6	-8.0 ± 3.2
Role, physical	-2.71 (1.31)	-4.9 ± 2.3	-7.5 ± 3.6	-9.3 ± 4.5
General health perception	-2.03 (0.80)	-3.6 ± 1.4	-5.6 ± 2.2	-7.0 ± 2.7

*Not significant

emotional problems were not associated with sleep-disordered breathing. The coefficient of Log(AHI+1) and the predicted reduction of the SF-36 constructs at different severity levels of AHI are given in Table 4.

DISCUSSION

This investigation shows that sleep-disordered breathing is associated with lower general health status, and that a significant decrement exists for even mild sleep-disordered breathing (AHI=5). These results are especially important because they come from a population-based sample with occult, untreated sleep-disordered breathing and are thus free of clinical selection bias. Furthermore, the reported associations were observed controlling for the major confounding variables of age, sex, BMI, smoking status, alcohol usage, and a history of cardiovascular conditions.

An important strength of this study is that general health measures were obtained at two points in time, and measurements at both timepoints were related to sleep-disordered breathing. The evaluation of general health and life satisfaction were obtained the night of the polysomnography (Table 3), and the SF-36 was collected some time after the polysomnography (Table 4). Collection of self-reported general health only on the night of the polysomnography or some time after the polysomnography would lead to concerns about potential bias due to incorrect temporal relationships or misclassification error. The consistent finding of a relationship between sleep-disordered breathing and the measures of self-reported general health at both timepoints adds strength to the results.

Potential study limitations are not likely to explain our findings. Because one of the health assessment tools (SF-36) was administered after the overnight polysomnography, it is possible that those with unrecognized sleep-disordered breathing might report lower health status once informed of the results of their sleep study, thus creating a spurious relationship between sleep-disordered breathing and the SF-36. However, this is unlikely because participants were never told that they had sleep-disordered breathing or any other disorder. They were only sent a brief summary of their sleep and breathing characteristics from the overnight study, with the recommendation to see their doctor if they had any problems with their sleep, regardless of their report. Furthermore, the distribution of change in the evaluation of general health from the time of the overnight sleep study to the time of the SF-36 did not differ by category of sleep-disordered breathing (chi-square p=0.87). For example, 29% of those with an AHI<5 versus 28% of those with an AH≥5 reported decreases in their evaluation of general health.

Adjustment of the relationship between sleep-disordered breathing and general health status for cardiovascular conditions possibly underestimates the association between sleep-disordered breathing and general health status. A high prevalence of cardiovascular conditions exists among sleep-disordered breathing patients, although a causal pathway has not been established,[5-7] and cardiovascular morbidity is likely to be related to decreased general health status. If a portion of the cardiovascular morbidity is due to sleep-disordered breathing, as hypothesized,[5-7] adjustment for this will reduce the relationship between sleep-disordered breathing and general health status.

Selection bias for less-impaired individuals with sleep-disordered breathing in our sample may also have led to underestimation of the association between sleep-disordered breathing and general health status. Individuals in

Table 5.—Comparison of SF-36 heath decrements for sleep disordered breathing in the Wisconsin Sleep Cohort Study and SF-36 health decrements for other chronic conditions reported by Stewart*

	Difference in SF-36 Variable ± Standard Error				
Chronic Condition	**Mental Health**	**Physical Functioning**	**Social**	**Pain**	**General Health Perceptions**
Wisconsin Sleep Cohort Study:					
Sleep Disordered Breathing: AHI = 5 vs AHI = 0	-2.7 ± 1.2	-2.8 ± 1.3	-4.2 ± 1.7	**	-3.6 ± 1.4
AHI = 15 vs AHI = 0	-4.2 ± 1.9	-4.4 ± 1.9	-6.4 ± 2.6	**	-5.6 ± 2.2
Chronic conditions reported by Stewart et al					
Diabetes	0.1 ± 0.8	-7.6 ± 1.3	-5.3 ± 0.9	-0.6 ± 1.1	12.8 ± 1.0
Arthritis	-3.0 ± 0.6	-9.3 ± 0.9	-3.9 ± 0.7	-16.6 ± 0.8	-7.3 ± 0.7
Angina	-3.4 ± 1.0	-15.7 ± 1.7	-5.4 ± 1.3	-7.3 ± 1.6	-13.2 ± 1.4
Hypertension	-1.1 ± 0.5	0 ± 0.9	1.1 ± 0.7	3.1 ± 0.8	-3.5 ± 0.7
Back Problems	-1.0 ± 0.9	-9.5 ± 1.5	-2.1 ± 1.1	-10.4 ± 1.4	-4.4 ± 1.2

*Stewart A, Greenfield S, Hays R, Wells K, Rogers W, Berry S, Mc Glynn E, Ware J. Functional status and well-being of patients with chronic conditions. JAMA 1989;262(7):907-13.
**Not significant

this study were employed at the time of their recruitment, and most were still employed when they completed their overnight studies. It is possible that the people most functionally impaired with sleep-disordered breathing would be unable to work and would have been missed in our sample.

An important question raised by our results is whether changes in general health status associated with sleep-disordered breathing are clinically relevant. Stewart et al compared health status, measured by the SF-36, of patients with chronic conditions to those with no chronic conditions, using data gathered by the Medical Outcomes Study.[36] Comparisons of our estimates of SF-36 decrements for an AHI of 5 and 15 with estimates from Stewart et al of SF-36 decrements for hypertension, arthritis, angina, back problems, and diabetes, are given in Table 5. All estimates are adjusted for age, sex, and comorbid conditions; our estimates are also adjusted for BMI, smoking status, and alcohol usage. The mental health and social function decrements are similar for an AHI of 5, arthritis, diabetes, hypertension, angina, and back problems. The mental health and social function decrements associated with an AHI of 15 are greater than the decrements for any of the conditions in Table 5. The general health perception reduction associated with an AHI of 5 is comparable to that of hypertension and back problems, and that of an AHI of 15 is comparable to the reduction associated with arthritis. The reductions found in physical functioning and pain associated with sleep-disordered breathing were smaller than reductions for the other chronic conditions, as might be expected. Stewart et al did not report vitality scores, and role limitations due to emotional and physical functioning were combined into one construct, so comparison with these health constructs cannot be made. The similarities in health decrements between sleep-disordered breathing and other chronic conditions emphasize the clinical relevance of the decrement magnitude associated with even mild sleep-disordered breathing.

These results demonstrate that sleep-disordered breathing as measured by the apnea-hypopnea index is related to lower general health status. Although the apnea-hypopnea index is the most commonly used measure of sleep-disordered breathing, it has not been determined to be the best measure of severity. As a frequency measure, the apnea-hypopnea index does not take into account the acute consequences of apneas and hypopneas, such as the degree of desaturation or the presence of arousal. Thus, separate event characteristics may differentially explain the impact of sleep-disordered breathing on general health status.

We conclude that sleep-disordered breathing is associated with lower general health status in a dose-response fashion after controlling for BMI, age, sex, smoking status, alcohol usage, and a history of cardiovascular conditions, and that the decrement is of clinical significance. Even modest sleep-disordered breathing (AHI=5) is related to SF-36 health construct decrements comparable to those associated with other chronic conditions such as diabetes, arthritis, angina, back problems and hypertension. Our results, from the first population-based study to address the impact of sleep-disordered breathing on health perception, are particularly important in light of current controversy concerning the relevance of sleep-disordered breathing to public health. In addition, considering the high prevalence of unrecognized mild-to-severe sleep-disordered breathing in both men and women (24% and 9% respectively),[31] our findings underscore the importance of understanding the total burden, including decrements in general health status, of the entire severity spectrum of untreated sleep-disordered breathing.

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