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Prevalence and Polysomnographic Correlates of Insomnia Comorbid with Medical Disorders

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Study Objectives: To determine the prevalence and polysomnographic correlates of insomnia in subjects with self-reported medical disorders.
Design: Prospective cross-sectional study.
Participants: Community-based sample of 3282 men and women aged 18 to 65 years old, with a subset who underwent polysomnography.
Measurements: Self-reported measures of sleep habits and current health, and polysomnographic sleep variables.
Results: The prevalence of insomnia was 21.4%. The adjusted odds of insomnia were 2.2 times as high in persons with any medical disorders as in those without medical disorders. Specifically, odds of insomnia were higher in people with heart disease (OR = 1.6 [95% CI: 1.2-23], P = 0.004), hypertension (1.5 [12-18], P < 0.001), diabetes (1.4 [105-20], P = 0.04), stomach ulcers (2.1 [1.6-2.7], P < 0.001), arthritis (1.8 [1.5-2.2], P < 0.001), migraine (1.8 [1.5-2.1], P < 0.001), asthma (1.6 [1.3-2.0], P = 0.04), COPD (1.9 [1.5-2.5], P < 0.001), neurological problems (2.0 [1.5-2.7], P < 0.001), and menstrual problems (1.7 [1.3-2.1], P < 0.001) than in people without these disorders. Prevalence of insomnia increased with increasing number of medical disorders. However, polysomnographic sleep was not significantly different in persons with or without medical disorders for most disorders assessed.
Conclusion: This large population-based study suggests that insomnia is highly prevalent in diverse chronic medical disorders. However, polysomnographic evidence of disturbed sleep is present in only a subset of comorbid insomnia populations.
Keywords: Insomnia, comorbid, medical disorders, prevalence, hypertension, stroke, arthritis
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INTRODUCTION

Insomnia is defined as difficulty in initiating or maintaining sleep or nonrestorative sleep associated with daytime consequences such as fatigue, decreased concentration, or daytime distress.[1-3] Chronic insomnia is defined as persistence of these symptoms for more than a month. It is a common disorder in the general population with a prevalence of approximately 10% to 15%.[4-7] Insomnia is a major public health problem[8] associated with diverse consequences such as increased risk for major depression,[4] decreased productivity,[9] increased traffic accidents,[10] and reduced quality of life.[11,12]

While much of the research on insomnia and its treatment has focused on primary insomnia, insomnia is comorbid with other conditions in the majority of cases.[13] Some recent studies have assessed the relationship between insomnia and medical disorders. One study in 9,000 participants from the general population aged 65 years and older found insomnia to be associated with an increasing number of respiratory symptoms, physical disabilities, use of nonprescription medications, depressive symptoms, and generally poor health.[14] A 3-year follow-up of a subgroup of this cohort reported an increased incidence of insomnia symptoms among those with medical conditions such as heart disease, stroke, and diabetes.[15] Another study of 1506 community dwellers found a higher prevalence of insomnia among those with depression, heart disease, or bodily pain.[16] Finally, one study of 772 persons found high prevalence of insomnia in diverse medical disorders.[17]

Further evidence for this association between insomnia and medical disorders is provided by studies performed in patients with specific medical conditions. One study of 3445 patients with ≥ 1 of 5 physician-identified chronic conditions (hypertension, diabetes, congestive heart failure, myocardial infarction, or depression) found severe insomnia in 16% and mild insomnia in 34% of the patients at baseline.[13] A 2-year follow up of a subgroup from this cohort found persistence of insomnia in majority of these patients. A higher prevalence of insomnia is also seen in patients with end stage renal disease[18] and cancer.[19]

The current study investigated the association between self-reported medical disorders, a diagnosis of insomnia, and polysomnographically measured sleep in a large community sample. We hypothesized that respondents with a history of medical disorders would have a higher prevalence of chronic insomnia than those without the condition, and that this risk would vary as a function of the number of medical disorders reported.

METHODS

Participants and Definitions

Individuals participating in this study were assessed in conjunction with a larger population-based study investigating the prevalence and causes of daytime sleepiness in general population. The details of recruitment of these subjects have been

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provided in an earlier study.[20,21] Briefly, participants were drawn from the general population of the tri-county Detroit area. The tri-county area includes 84% of the population of southeastern Michigan and is similar to the United States as a whole, with the exception of a different racial/ethnic distribution. The research design was composed of 2 components: (1) a random digit dial, computer-assisted telephone survey and (2) a laboratory-based evaluation. The telephone interviews were conducted by DataStat Inc., Ann Arbor, Michigan, by trained interviewers. For eligibility, the calling address had to be a residence and the participant an adult between the ages of 18 and 65 years. A random-probability selection procedure was used to determine the sex of the target adult. If 2 or 3 adults within a target sex were present in a household, a random-probability selection procedure (oldest/second, oldest/youngest) was used to determine the target respondent. If ≥ 4 adults with the target sex were present in the household, last-birthday method was used to determine the target respondent. In order to maintain an unbiased sample, only individuals who could not answer the questionnaire due to sensory or mental impairment were excluded from the sample. From 4682 eligible participants, 3283 individuals (70.1%) aged 18-65 completed the telephone survey. The sociodemographic characteristics of this population have been described earlier[22,23] and are similar to that of the U.S. population based on the 2000 census, with the exception of higher proportion of African American and lower proportion of Hispanic participants.

Thirty-seven percent of the total interview sample (n = 1198) was randomly selected to participate in a laboratory study. In order to enrich the laboratory sample for individuals with excessive sleepiness, all remaining individuals from the overall interview sample who scored high on a validated self-report measure of sleepiness (Epworth Sleepiness Scale) were also asked to participate in the laboratory study (N = 668). Participation rate was 33% for the laboratory study. However, there were no differences between those electing to participate in the laboratory study and those who declined participation for age, gender, race, income, employment, marital status, or reported total sleep time. The laboratory study included 399 random individuals and 222 individuals selected based on the Daytime Sleepiness Scale (total N = 621). There were no demographic differences between the 2 samples. The institutional review board approved all procedures, and informed consent was obtained from all participants.

Insomnia

All respondents were asked about their sleep. Insomnia was assessed using DSM-IV criteria for insomnia.[2] Specifically, respondents had to have presence of chronic sleep complaints with daytime impairment. In order to meet insomnia criteria, individuals must have reported difficulty falling asleep, staying asleep, or non-restorative sleep at least "sometimes" or "often" for one month or more. Finally, respondents were asked (a) how many days in the last 3 months had they missed work or school because of sleep problems or had productivity at work or school reduced by half or more because of sleep problems (b) how many days in the last 3 months did they not do any household work because of sleep problems or had productivity in household work reduced by half or more because of sleep problems (c) how many days in the last 3 months did they miss social or leisure activities because of sleep problems? If the answer to any of these questions was > 26 (roughly more than twice per week), or their Epworth Sleepiness score was > 10, they were considered to have daytime impairment. Three-month duration was used to ensure that daytime impairment from sleep problems had significant chronicity.

Medical disorders

The respondents were asked whether they ever had any of the following 14 medical disorders: heart disease, hypertension or high blood pressure, diabetes, thyroid problems, cancer, stomach ulcers, colitis, arthritis, migraines, asthma, emphysema or chronic bronchitis, stroke, epilepsy, or other neurological problems. Women were also asked if they currently have menstrual or gynecological problems. "No" and "don't know" responses were collapsed together for analyses. The menstrual or gynecological problems are hereafter referred to as menstrual problems; stomach ulcers as ulcers; stroke, epilepsy or other neurological conditions as neurological problems; and emphysema or chronic bronchitis as COPD (chronic obstructive pulmonary disease).

Polysomnography

The polysomnograms were conducted in the sleep laboratory. The montage of the diagnostic polysomnography included recordings of electroencephalograms (C3, C4, and OZ referenced to mastoid), electrooculogram, submental and leg electromyograms, and electrocardiogram. Airflow was measured by a nasal thermistor. All studies were scored using previously published criteria.[24] Subjects were given a scheduled bedtime consistent with their average 2-week sleep diary bedtime. Time in bed was set at 8.5 h. Sleep efficiency was calculated as the total sleep time divided by the time in bed multiplied by 100. Sleep latency was defined as time from lights off to the first epoch of any stage of sleep.

Analyses

Statistical analyses were conducted using SPSS 10.0 for Windows (SSPS Inc, Chicago, IL).We compared the demographic variables in respondents with or without insomnia; in those with or without medical disorders; and in those undergoing polysomnography using Student's *t*-test or χ^2 test where appropriate. The respondents were dichotomized. The prevalence of insomnia was compared in those with a specific medical disorder (e.g., hypertension) and those without that particular disorder using χ^2 test. This process was repeated for each disorder. The odds ratios for insomnia in the presence of each medical disorder, while controlling for age and gender, were calculated using binary logistic regression with insomnia as the dependent variable and each disorder serially used as an independent variable (Table 2). The entire study population of 3,282 respondents was utilized for these analyses. Thereafter, the mean sleep efficiency in the subset of subjects who underwent PSG (n = 621) was calculated. Analysis of covariance (ANCOVA) was used to compare the proportion of different sleep stages in persons with any medical disorder to those with no medical disorder, controlling for the effects of gender and age (Table 3). The χ^2 test was used to compare proportion of respondents with sleep efficiency ≤ 82% in presence or absence of specific disorders

Table 1—Population characteristics and prevalence of diverse disorders in all subjects and in those who underwent polysomnography

	All subjects (N = 3282) N (%)	Polysomnography sample (N = 621) N (%)
Sex		
Female	1668 (50.8)	320 (51.5)
Male	1614 (49.2)	301 (48.5)
Age (y)	41.7 ± 12.7	41.6 ± 12.8
Heart disease	211/3276 (6.4)	43/618 (7.0)
Hypertension	846/3281 (25.8)	172/621 (27.7)
Diabetes	207/3278 (6.3)	47/620 (7.6)
Thyroid disorders	256/3275 (7.8)	51/620 (8.2)
Cancer	153/3279 (4.7)	30/621 (4.8)
Ulcer	314/3273 (9.6)	48/620 (7.7)
Colitis	98/3263 (3.0)	19/617 (3.1)
Arthritis	817/3277 (24.9)	171/618 (27.7)
Migraines	778/3275 (23.8)	149/621 (24.0)
Asthma	420/3279 (12.8)	100/621 (16.1)
COPD	286/3273 (8.7)	54/616 (8.8)
Neurological problems	229/3270 (7.0)	60/621 (9.7)
Menstrual problems	393/1273 (23.6)	83/320 (25.9)

(Table 4). This cutoff (82%) was chosen since this represented the 25th percentile of sleep efficiency values in persons without any medical disorders. ANCOVA was then used to test the effect of presence or absence of a particular medical disorder on sleep efficiency and sleep latency, controlling for the effects of gender and age. Sleep efficiency and sleep latency were dependent variables for these analyses. The process was repeated for each disorder (Table 5). Next, we chose only respondents in whom one of the medical disorders (such as hypertension) was present and compared sleep between those with and without insomnia to assess whether presence of insomnia is associated with polysomnographically determined sleep disruption in those with a given medical disorder (Table 6). The process was repeated for each disorder. In a similar manner, we assessed the proportion of different stages in each disorder and compared sleep stages in presence or absence of insomnia within that disorder. Again, the process was repeated for each disorder (Table 7). Finally, we compared sleep only in insomniacs in presence or absence of each disorder to assess whether insomnia comorbid with medical disorders was associated with more polysomnographically determined sleep disruption than insomnia without the comorbid disorder (Table 8). Data are expressed as mean ± standard deviation unless otherwise stated. For all tests, 2-tailed statistical significance was set at $P < 0.05$.

RESULTS

Table 1 shows the demographic characteristics and the prevalence of the various disorders in the entire sample and the persons who underwent PSG. Of the 3282 respondents, 3247 responded to the survey questions needed to make the diagnosis of insomnia. Of these, 21.4% (N = 695) met criteria for insomnia disorder. The insomnia subjects were slightly younger than the non-insomniacs (40.2 ± 11.5 y vs. 42.1 ± 12.9 y, $P = 0.001$) and were more likely to be female (58.6% vs. 48.7%, $P < 0.001$). The prevalence of insomnia was 24.7% in women and 18.0% in men ($P < 0.001$).

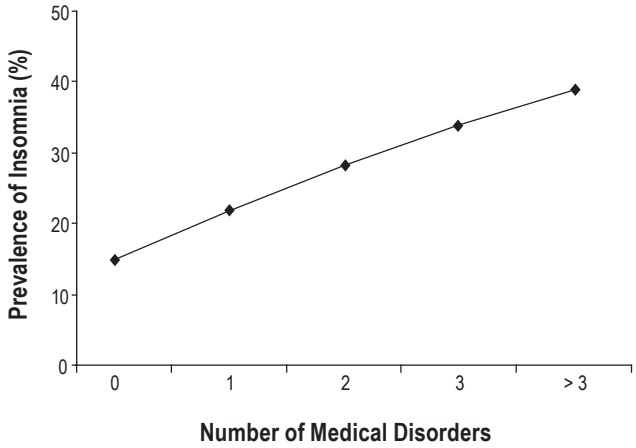

Figure 1—Prevalence of insomnia increased with increasing number of medical disorders: The prevalence in those with no medical disorder (n = 1395) was 14.8%, with 1 medical disorder (n = 904) was 21.9%; with 2 disorders (n = 459) was 28.3%; with 3 disorders (n = 207) was 33.8%; and with > 3 disorders (n = 113) was 38.9%.

At least one medical disorder was reported by 54.9% of the respondents. Participants reporting medical disorders were older than those with no medical disorders (43.2 ± 12.4 y vs. 37.1 ± 12.5 y, $P < 0.001$). The prevalence of insomnia in those with any medical disorder was significantly higher than in those with no medical disorders (26.3% vs. 14.8%, $P < 0.001$). Logistic regression revealed that participants with any medical disorders (OR = 2.2 [95% CI 1.8-2.7], $P < 0.001$) and women (OR = 1.6 [95% CI 1.2-2.2], $P < 0.001$) had higher odds of insomnia, while older respondents had slightly lower odds of insomnia (OR = 0.93 [95% CI 0.88-0.98], $P = 0.04$).

Of all persons, 45.3% had no medical disorders, 29.4% had 1 medical disorder, 14.9% had 2 medical disorders, 6.7% had 3 medical disorders, and 3.7% had > 3 medical disorders. Prevalence of insomnia increased with increasing number of medical disorders ($P < 0.001$, Figure 1).

Prevalence of Insomnia in Specific Medical Disorders

Table 2 shows the prevalence of insomnia in subjects with each disorder as compared with those without that particular disorder. We calculated the odds of presence of insomnia in each disorder using logistic regression, adjusting for gender and age. People with heart disease, hypertension, diabetes, stomach ulcers, arthritis, migraine, asthma, COPD, neurological, and menstrual problems had significantly higher odds of having insomnia than those without the conditions (Table 2).

Sleep in Persons who Underwent Polysomnography

The mean sleep efficiency in subjects who underwent in-laboratory PSG (n = 621) was 83.9% ± 12.4%. Sleep efficiency correlated inversely with age ($r = -0.44$, $P < 0.001$). Women (n = 320) had a higher mean sleep efficiency than men (n = 301) (84.9% vs. 82.8%, $P = 0.04$). There was a negative correlation between sleep efficiency and the apnea hypopnea index ($r = -0.12$, $P = 0.003$). However, the apnea hypopnea index was

not significantly different in individuals with or without insomnia (1.0 ± 0.7 vs. 1.9 ± 0.2, P = 0.26). Sleep efficiency expectedly correlated inversely with sleep latency (r = −0.48, P < 0.001) and latency to persistent sleep (r = −0.61, P < 0.001).

Table 2—Prevalence of DSM-IV insomnia in presence or absence of specific medical disorders.

Medical condition (number with disease/total n, % with disease)	Unadjusted prevalence of insomnia if disease present (%)	Unadjusted prevalence of insomnia if disease absent (%)	Adjusted odds ratio (95% CI)	P
Ulcer (307/2919)	33.0	20.1	2.1 (1.6-2.7)	< 0.001
Neurological problem (691/2532)	33.3	20.6	2.0 (1.5-2.7)	< 0.001
COPD (282/2944)	32.9	20.3	1.9 (1.5-2.5)	< 0.001
Migraines (767/2461)	30.5	18.5	1.8 (1.5-2.1)	< 0.001
Arthritis (800/2430)	27.1	19.5	1.8 (1.5-2.2)	< 0.001
Menstrual (388/1252)	32.2	22.3	1.7 (1.3-2.1)	< 0.001
Asthma (409/2824)	29.9	20.1	1.6 (1.3-2.0)	< 0.001
Heart disease (202/3027)	26.8	21.0	1.6 (1.2-2.3)	0.004
Hypertension (829/2045)	24.7	20.2	1.5 (1.2-1.8)	< 0.001
Diabetes (202/3030)	25.6	21.1	1.4 (1.05-2.0)	0.047
Colitis (93/3125)	27.4	21.2	1.4 (0.9-2.3)	0.13
Cancer (152/3081)	23.0	21.3	1.2 (0.8-1.8)	0.32
Thyroid disorders (251/2979)	23.8	21.2	1.1 (0.8-1.6)	0.41

Adjusted odds ratio refers to the odds of developing insomnia in presence of that particular disorder, adjusted for age and gender. P values denote significance for adjusted odds ratios.

Table 3—Comparison of sleep stages in respondents with any medical disorders compared with respondents with no medical disorders

Sleep stage	Respondents with any medical disorder (n = 341) (mean ± SE)	Respondents with no medical disorders (n = 242) (mean ± SE)	P
Stage N1 (%)	10.9 ± 0.4	9.9 ± 0.4	0.13
Stage N2 (%)	56.7 ± 0.5	58.7 ± 2.0	0.34
Stage N3 (%)	14.6 ± 0.5	14.5 ± 0.6	0.95
Stage REM (%)	17.6 ± 0.3	19.0 ± 0.4	0.02

Table 4—Percentage of respondents with sleep efficiency ≤ 82% in presence or absence of specific disorders

Medical disorder (number with disorder/ number without disorder)	Percentage of respondents with sleep efficiency ≤ 82%		
	Disease present	Disease absent	P
Heart disease (43/575)	62.8	29.9	0.001
Hypertension (172/449)	42.4	28.5	0.001
Diabetes (47/573)	51.1	30.9	0.006
Thyroid disorders (51/569)	47.1	31.1	0.028
Cancer (30/591)	30.0	32.5	0.84
Ulcer (48/572)	33.3	32.2	0.87
Colitis (19/598)	42.1	31.9	0.45
Arthritis (171/447)	41.5	28.6	0.003
Migraines (149/472)	30.9	32.8	0.69
Asthma (100/521)	31.0	32.6	0.82
COPD (54/562)	44.4	31.0	0.04
Neurological problem (60/561)	31.2	44.6	0.06
Menstrual (83/237)	27.7	29.1	0.88

Polysomnographic Sleep in Medical Disorders

Respondents with any medical disorder had lower proportion of REM sleep than those without any medical disorders (Table 3). We compared the percentage of respondents with disorders who had sleep efficiency of ≤ 82% compared to the percentage in those who did not have that medical disorder. The percentage was significantly higher in those with heart disease, hypertension, diabetes, thyroid disorders, arthritis, and COPD compared to those without these disorders (Table 4). This cutoff (82%) represented the 25th percentile of sleep efficiency values in persons without any medical disorders. However, when adjusted for age, gender, and AHI, mean sleep efficiency and latency in most disorders were similar to that in absence of those disorders (Table 5). We compared sleep in persons with or without insomnia within each specific medical disorder. Presence of insomnia was not associated with significantly different sleep efficiency or sleep latency in most disorders (Table 6). Distribution of different sleep stages was similar in persons with medical disorders in presence or absence of insomnia when adjusted for age, gender, and apnea hypopnea index (Table 7).

Sleep in Insomniacs with or without Specific Medical Disorders

We compared sleep in subjects with insomnia comorbid with specific medical disorders and in insomniacs without those disorders. Hence, for these analyses, only respondents with insomnia were included. Persons with hypertension, migraines, or neurological problems had sig-

Table 5—Mean sleep latency and sleep efficiency in presence or absence of specific disorders (adjusted for age, gender, and apnea hypopnea index)

Disorder (number with disease/number without disease)	Sleep latency (min)			Sleep efficiency (%)		
	Disease Present	Disease absent	P	Disease present	Disease absent	P
Heart disease (41/552)	12.7 ± 3.7	15.9 ± 1.0	0.41	82.3 ± 1.7	84.0 ± 0.46	0.34
Hypertension (165/431)	19.6 ± 1.8	14.1 ± 1.1	0.01	82.4 ± 0.87	84.9 ± 0.53	0.04
Diabetes (46/549)	11.2 ± 3.4	16.0 ± 1.0	0.17	83.2 ± 1.6	83.9 ± 0.46	0.66
Thyroid disorders (50/545)	12.9 ± 3.3	15.9 ± 1.0	0.40	84.2 ± 1.6	83.9 ± 0.47	0.87
Cancer (30/566)	13.5 ± 4.2	15.8 ± 1.0	0.61	86.1 ± 2.0	83.8 ± 0.46	0.26
Ulcer (46/549)	14.0 ± 3.4	15.8 ± 1.0	0.60	84.0 ± 1.6	83.9 ± 0.46	0.94
Colitis (17/575)	9.1 ± 5.5	15.8 ± 1.0	0.23	85.4 ± 2.6	83.9 ± 0.45	0.58
Arthritis (167/426)	12.8 ± 1.8	16.9 ± 1.1	0.07	84.5 ± 0.88	83.8 ± 0.53	0.50
Migraines (142/454)	17.9 ± 1.9	14.9 ± 1.1	0.18	83.4 ± 0.92	84.1 ± 0.51	0.51
Asthma (97/499)	17.5 ± 2.3	15.3 ± 1.0	0.38	83.8 ± 1.1	83.9 ± 0.49	0.92
COPD (53/538)	13.9 ± 3.1	15.7 ± 1.0	0.60	83.4 ± 1.5	84.0 ± 0.46	0.72
Neurological problem (58/538)	19.8 ± 3.0	15.2 ± 1.0	0.14	81.3 ± 1.4	84.2 ± 0.47	0.06
Menstrual (82/228)	13.0 ± 2.2	17.2 ± 1.3	0.14	85.0 ± 1.1	84.8 ± 0.64	0.86

Data are expressed as mean ± standard error.

Table 6—Mean sleep latency and sleep efficiency in persons with medical disorders in presence or absence of insomnia (adjusted for age, gender, and apnea hypopnea index)

Disorder (Number with insomnia/number without insomnia)	Sleep Latency			Sleep Efficiency		
	Insomnia	No Insomnia	P	Insomnia	No Insomnia	P
Heart disease (21/18)	16.8 ± 3.7	13.2 ± 4.0	0.53	76.9 ± 2.7	78.1 ± 2.9	0.78
Hypertension (54/109)	21.8 ± 4.4	20.1 ± 3.1	0.75	80.8 ± 1.7	79.6 ± 1.2	0.58
Diabetes (19/27)	14.8 ± 2.6	12.1 ± 3.1	0.52	86.1 ± 2.4	74.7 ± 2.0	0.001
Thyroid disorders (11/39)	16.1 ± 2.1	14.4 ± 4.0	0.69	83.4 ± 3.1	80.7 ± 1.6	0.45
Cancer (13/16)	12.2 ± 5.2	18.6 ± 5.8	0.43	83.0 ± 2.3	84.0 ± 2.1	0.75
Ulcer (17/29)	14.7 ± 3.7	15.4 ± 4.8	0.92	80.4 ± 3.0	83.5 ± 2.3	0.43
Colitis (7/10)	12.1 ± 2.4	9.7 ± 2.0	0.47	78.8 ± 2.5	84.6 ± 2.1	0.12
Arthritis (60/107)	18.3 ± 2.4	13.2 ± 1.8	0.09	81.3 ± 1.5	81.9 ± 1.1	0.77
Migraines (58/84)	20.5 ± 2.9	15.4 ± 2.4	0.18	83.4 ± 1.5	85.0 ± 1.2	0.38
Asthma (42/53)	17.1 ± 3.1	16.6 ± 2.8	0.89	84.9 ± 1.4	85.8 ± 1.2	0.65
COPD (23/30)	16.4 ± 4.3	13.8 ± 3.8	0.65	80.5 ± 2.2	83.8 ± 1.9	0.28
Neurological problem (21/37)	27.7 ± 5.4	17.1 ± 4.0	0.12	80.7 ± 2.8	78.8 ± 2.1	0.61
Menstrual (37/45)	12.4 ± 2.1	13.9 ± 1.9	0.61	85.8 ± 1.6	84.6 ± 1.4	0.56

Data are expressed as mean ± standard error.

nificantly higher sleep latency (adjusted for age, gender, and AHI) than those without these disorders (Table 8). The adjusted sleep efficiency was higher in persons with diabetes than those without diabetes (Table 8).

DISCUSSION

The current study evaluated the effect of several disorders on self-report and PSG-determined sleep parameters. The study findings suggest that a history of heart disease, hypertension, diabetes, stomach ulcers, arthritis, migraine, asthma, COPD, neurological problems (including epilepsy or stroke), or menstrual problems is associated with a higher prevalence of insomnia. Prevalence of insomnia increased with increasing number of medical disorders suggesting an additive adverse effect of medical disorders on insomnia.

Virtually all of the disorders studied were associated with higher odds of having insomnia. The odds were especially high in conditions associated with significant somatic discomfort. For example, arthritis and COPD, where pain and dyspnea, respectively, may contribute to sleep disturbances,[25] were associated with adjusted odds of insomnia of 1.8 and 1.9, respectively. Other conditions with chronic pain or discomfort such as ulcer and migraines also had a higher prevalence of insomnia. The association between stomach ulcers and insomnia is consistent with prior findings of sleep disturbances in persons with GERD.[26] While determining the specific etiologies of the insomnia disorder in these diverse disorders is beyond the scope of the current study, one may speculate that insomnia, in some cases, results not only from the health condition itself, but from the treatment thereof, e.g., β-blockers for hyperten-

Table 7—Distribution of different sleep stages (as percentage of total sleep) in persons with medical disorders in absence or presence of insomnia (adjusted for age, gender, and apnea hypopnea index)

Disorder (N with insomnia/ N without insomnia)	Stage N1 (%)	P	Stage N2 (%)	P	Stage N3 (%)	P	Stage REM (%)	P
Heart disease (21/18)		0.60		0.50		0.28		0.32
Insomnia	12.3 ± 1.5		57.6 ± 3.0		16.1 ± 2.5		13.9 ± 1.6	
No insomnia	11.1 ± 1.4		60.4 ± 2.8		12.3 ± 2.3		16.1 ± 1.5	
All respondents	11.8 ± 1.0		59.0 ± 2.0		16.8 ± 1.1		15.0 ± 1.1	
Hypertension (54/109)		0.78		0.75		0.48		0.91
Insomnia	11.9 ± 0.8		55.5 ± 1.1		15.2 ± 1.1		17.5 ± 6.4	
No insomnia	12.3 ± 1.2		56.1 ± 1.6		13.9 ± 1.5		17.6 ± 9.1	
All respondents	12.1 ± 0.7		55.9 ± 1.0		14.5 ± 1.0		17.6 ± 0.5	
Diabetes (19/27)		0.17		0.39		0.31		0.06
Insomnia	13.8 ± 1.7		58.8 ± 2.1		13.6 ± 1.9		13.8 ± 1.2	
No insomnia	9.8 ± 2.1		55.8 ± 2.5		16.8 ± 2.3		17.5 ± 1.4	
All respondents	11.8 ± 1.3		57.3 ± 1.5		15.2 ± 1.4		15.6 ± 0.9	
Thyroid disorders (11/39)		0.10		0.054		0.006		0.88
Insomnia	9.5 ± 0.8		60.6 ± 1.5		13.2 ± 1.3		17.1 ± 1.1	
No insomnia	6.4 ± 1.6		54.4 ± 2.8		21.7 ± 2.6		17.4 ± 2.0	
All respondents	9.8 ± 1.0		57.5 ± 1.5		17.5 ± 1.5		17.2 ± 1.1	
Cancer (13/16)		0.26		0.39		0.29		0.44
Insomnia	11.8 ± 1.3		56.2 ± 2.4		13.0 ± 2.5		19.0 ± 1.1	
No insomnia	9.5 ± 1.4		52.9 ± 2.8		17.2 ± 2.8		20.3 ± 1.3	
All respondents	10.6 ± 0.9		54.5 ± 1.8		15.1 ± 1.8		19.6 ± 0.8	
Ulcer (17/29)		0.50		0.53		0.75		0.05
Insomnia	10.6 ± 1.1		57.9 ± 2.0		12.6 ± 1.8		18.9 ± 1.3	
No insomnia	11.8 ± 1.4		60.0 ± 2.6		13.5 ± 2.3		14.6 ± 1.6	
All respondents	11.2 ± 0.9		58.9 ± 1.6		13.0 ± 1.4		16.7 ± 1.0	
Colitis (7/10)		0.95		0.58		0.44		0.91
Insomnia	10.7 ± 2.0		55.9 ± 3.4		14.2 ± 2.7		19.1 ± 3.5	
No insomnia	10.5 ± 2.5		59.1 ± 4.2		10.6 ± 3.4		19.7 ± 4.3	
All respondents	10.6 ± 1.6		57.5 ± 2.6		12.4 ± 2.0		19.4 ± 2.6	
Arthritis (60/107)		0.39		0.63		0.44		0.11
Insomnia	12.4 ± 0.8		56.1 ± 1.0		14.7 ± 1.0		16.8 ± 6.1	
No insomnia	11.2 ± 1.0		56.9 ± 1.4		13.3 ± 1.4		18.5 ± 0.8	
All respondents	11.6 ± 0.6		56.5 ± 0.8		14.0 ± 0.9		17.7 ± 0.5	
Migraines (58/84)		0.50		0.13		0.71		0.02
Insomnia	10.6 ± 0.8		55.6 ± 1.2		14.1 ± 1.2		19.5 ± 0.7	
No insomnia	9.8 ± 1.0		58.5 ± 1.5		14.8 ± 1.4		16.9 ± 0.9	
All respondents	10.2 ± 0.7		57.1 ± 0.9		14.5 ± 9.1		18.2 ± 0.6	
Asthma (42/53)		0.16		0.62		0.42		0.70
Insomnia	8.9 ± 0.7		56.1 ± 1.2		15.7 ± 1.5		19.2 ± 0.9	
No insomnia	10.5 ± 0.8		57.0 ± 1.3		13.8 ± 1.6		18.6 ± 1.9	
All respondents	9.7 ± 0.5		56.5 ± 0.8		14.7 ± 1.1		18.9 ± 0.6	
COPD (23/30)		0.71		0.29		0.53		0.98
Insomnia	12.5 ± 2.0		56.8 ± 1.9		13.2 ± 2.0		17.3 ± 1.5	
No insomnia	11.4 ± 2.3		59.9 ± 2.1		11.3 ± 2.3		17.4 ± 1.7	
All respondents	12.0 ± 1.5		58.4 ± 1.4		12.3 ± 1.6		17.4 ± 1.1	
Neurological problem (21/37)		0.55		0.09		0.35		0.38
Insomnia	13.0 ± 1.8		55.0 ± 2.0		13.5 ± 1.4		18.4 ± 1.2	
No insomnia	11.1 ± 2.4		60.8 ± 2.7		11.4 ± 1.9		16.6 ± 1.6	
All respondents	12.1 ± 1.5		57.9 ± 1.7		12.5 ± 1.2		17.5 ± 1.9	
Menstrual (37/45)		0.57		0.25		0.6		0.2
Insomnia	10.0 ± 0.8		58.2 ± 1.3		15.2 ± 1.5		16.4 ± 1.0	
No insomnia	9.2 ± 0.9		55.9 ± 1.5		16.5 ± 1.6		18.4 ± 1.1	
All respondents	9.6 ± 0.6		57.1 ± 1.0		15.9 ± 1.1		17.4 ± 0.7	

P values denote significance for comparison between respondents without insomnia and those with insomnia within the disorder. Data are expressed as mean ± standard error.

sion or β-agonists for COPD; or from nonspecific psychological factors associated with chronic disease. Another possibility is that the symptoms of disorders per se, such as nocturnal chest pain and dyspnea in some patients with hypertension and heart disease, may predispose to sleep disturbances. These data are consistent with prior studies reporting a relationship between higher reported sleep disturbances and hypertension or heart complaints.[27-29] However, in contrast to previous studies,[30-32] we did not find higher prevalence of insomnia in persons with self-reported cancer. However, the small number of persons with cancer in the current study and a poor characterization of the type or stage of cancer limit conclusions from our data.

Table 8—Mean sleep latency and sleep efficiency within insomniacs in presence or absence of specific disorders (adjusted for age, gender, and apnea hypopnea index)

	Sleep latency (min)			Sleep efficiency (%)		
Disorder (number with disease/ number without disease)	**Disease present**	**Disease absent**	**P**	**Disease present**	**Disease absent**	**P**
Heart disease (21/162)	14.3 ± 4.5	15.9 ± 1.6	0.74	81.5 ± 2.4	84.5 ± 0.8	0.23
Hypertension (54/129)	21.5 ± 2.8	13.3 ± 1.8	0.02	82.9 ± 1.5	84.7 ± 0.9	0.33
Diabetes (19/164)	10.8 ± 4.6	16.3 ± 1.6	0.27	89.7 ± 2.4	83.5 ± 8.0	0.02
Thyroid disorders (11/172)	10.0 ± 6.3	16.1 ± 1.5	0.35	86.0 ± 3.2	84.1 ± 0.8	0.57
Cancer (13/170)	16.2 ± 5.6	15.7 ± 1.5	0.92	86.5 ± 2.9	84.0 ± 0.8	0.41
Ulcer (17/166)	15.3 ± 4.9	15.7 ± 1.5	0.93	81.4 ± 3.2	84.4 ± 0.8	0.26
Colitis (7/174)	9.4 ± 7.6	15.8 ± 1.5	0.43	82.1 ± 3.9	84.5 ± 0.8	0.56
Arthritis (60/123)	16.4 ± 2.7	15.3 ± 1.8	0.74	84.2 ± 1.4	84.2 ± 0.9	0.99
Migraines (58/125)	21.5 ± 2.6	13.0 ± 1.8	0.008	82.4 ± 1.4	85.1 ± 0.9	0.12
Asthma (42/151)	17.3 ± 3.2	15.2 ± 1.7	0.57	83.8 ± 1.6	84.2 ± 0.9	0.81
COPD (23/157)	13.8 ± 4.3	15.9 ± 1.6	0.65	82.0 ± 2.2	84.3 ± 0.8	0.39
Neurological problems (21/162)	25.6 ± 4.2	14.4 ± 1.5	0.01	83.4 ± 2.3	84.2 ± 0.8	0.80
Menstrual problems (37/77)	12.2 ± 3.5	19.9 ± 2.4	0.08	86.2 ± 1.7	83.8 ± 1.1	0.24

Data are expressed as mean ± standard error.

While medical disorders may result in sleep disturbances, sleep disturbances themselves may contribute to the severity of many of the disorders that give rise to insomnia. Immune function is altered in patients with insomnia. Insomniacs have lower levels of CD3+, CD4+, and CD8+ cells.[33] Insomniac men have a lower IFN-γ than non-insomniac men.[34] One study showed a reduction in natural killer cell activity, interleukin-2 production, and lymphocyte enumeration in participants with insomnia.[35] Such alteration in immune function may be one of the factors mediating this reciprocal relation between insomnia and medical disorders. Furthermore, inflammation is believed to be an important pathogenetic component of disorders such as hypertension and cardiovascular disease.[36-39] Inflammation has been demonstrated in patients with insomnia and sleep deprivation, and may be another factor underlying the association between sleep problems and other medical disorders. Finally, it is plausible that the psychosocial stress from poor sleep may affect the health conditions. Emerging data suggest a role for poor sleep in causing or worsening health conditions. Indeed, short sleep duration, often found among patients with insomnia, has been shown to increase the risk of hypertension.[40]

The prevalence of insomnia in the current study was higher than that reported in some prior population studies utilizing DSM-IV criteria (6% to 10%).[5,41,42] However, many of these studies based their diagnoses primarily on the Sleep-EVAL,[43] which may underestimate the prevalence of insomnia.[44] Our insomnia estimate is close to that reported in a recent study (22.1%) in 10,094 US commercial health plan subscribers,[44] as well as a large (n = 12,778) French study that reported a 19.0% prevalence estimate.[45] We also found lower prevalence of DSM-IV insomnia in elderly. This is similar to that reported in the aforementioned study by Roth et al.[44] This might be because elderly may report less daytime impairment compared to younger people, plausibly because of less demanding daytime social and/or professional responsibilities many elderly people may have.

In addition to relating medical disorders to insomnia diagnoses, the current study also assessed objective sleep parameters in medical disorders in a large sample. We did not find significant polysomnographic differences in sleep efficiency or sleep latency in presence of most disorders or insomnia. The absence of significant impairment in polysomnographic sleep architecture in individuals with COPD is similar to what has been noted in analysis of Sleep Heart Health Study data.[46] Similarly, paucity of PSG findings has been demonstrated in patients with rheumatoid arthritis.[47] Notably, frequency analysis of EEG in this study by Drewes et al. showed an increase in alpha activity in NREM sleep in most sleep cycles despite minimal PSG changes. Another study in gastroesophageal reflux disease patients has shown that EEG spectral power during sleep is shifted towards higher frequencies despite no difference in PSG sleep architecture when compared to controls.[48] We did find that hypertension was associated with a more pronounced polysomnographically defined sleep disruption, a finding similar to that noted by Redline et al. in an analysis of Sleep Heart Health Study data.[49] However, while assessment of PSG variables yielded significant differences at P values less than 0.05 for some disorders, the clinical significance of these differences is unclear, especially since no correction was made for multiple comparisons.

This study has several limitations. First, self-reporting may have limited the reliability of the presence of various disorders. While prevalence of disorders such as COPD, asthma, hypertension, and thyroid disorders is close to what has been shown in prior population studies, prevalence of migraines was very high in the current study. This may have been because of reporting of any significant headaches by respondents as migraines. The lower numbers of subjects in less prevalent disorders also limits conclusions regarding sleep in those disorders. Studies with larger samples are required to better elucidate the sleep patterns in specific disorders. Second, while the study demonstrated a higher prevalence of insomnia in several medical dis-

orders, it is not clear whether the insomnia predated the medical disorder, started concurrently, or followed the medical disorder; and whether it worsened with progression of the medical disorder. Prospective longitudinal studies in specific conditions are needed to determine the temporal concordance of medical complaints with sleep problems and to elucidate whether a given condition is a cause of insomnia. Third, the study was designed with the aim of broadly encompassing different systems of the body to include widely prevalent and important conditions.[50] Still, patients may have had other medical problems which were not identified.

In conclusion, this study demonstrates a significantly increased prevalence of insomnia in most medical disorders in a community-based sample. The results provide a platform for more focused research aimed at determining the causes and consequences of insomnia in specific disorders. Studies analyzing adverse effects of insomnia on daily functioning and healthcare use over and above those conferred by medical disorders will provide an estimate of the individual and public health burden of these sleep abnormalities. Furthermore, studies need to be designed to assess the effects of various therapies for insomnia on the comorbid disorders. The recognition and therapy of insomnia may have the potential of improving the symptoms and severity of the medical disorders themselves, as has been shown recently for multiple sclerosis,[51] osteoarthritis,[52] and depression.[53]

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