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Incidence of Sleep Apnea in a Presumably Healthy Working Population: A Significant Relationship with Excessive Daytime Sleepiness

P. Lavie

Sleep Laboratory, Faculty of Medicine, Technion–Israel Institute of Technology, Haifa, Israel

Summary: Seventy-eight workers, drawn from a population of 1502 presumably healthy working men who were interviewed about sleep habits and sleep disorders, underwent polygraphic recordings for at least 1 night. A significant association was found between the complaint of excessive daytime sleepiness and the incidence of sleep apnea. Workers with more than 10 apneas per hour of sleep complained significantly more about loud snoring, hypermotility in sleep, and frequent headaches. They had significantly more ENT findings and hypertension. **Key Words:** Sleep apnea—Excessive daytime sleepiness—Nonpatient population—Hypertension.

Sleep apnea syndrome (SAS) is a sleep disorder with potentially fatal consequences that mostly affects men in midlife (1). The incidence of sleep apnea syndrome has never been formally investigated, but it was recently shown that it is the most common diagnosis among patients referred to diagnostic sleep laboratories in the United States, and that it may be especially prevalent among the aged (2,3). More recently it was shown that about 1% of an unselected inpatient population admitted to a general hospital in Italy during a 1-year period had SAS (4). Any attempt to determine the prevalence of SAS in the general population is complicated by the fact that there is no definition of the syndrome upon which there is general agreement. Although it has been suggested that SAS be defined by the occurrence of at least 30 apneas, of at least 10 s duration, in 7 h of sleep or by the occurrence of at least 5 apneas in each hour of sleep (5), there are data suggesting that these criteria are too permissive, since multiple sleep apneas can occur in normal individuals who are completely asymptomatic (6). Much more information about the incidence of sleep apnea among normal individuals is needed before an adequate definition of SAS can be provided.

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Address correspondence and reprint requests to P. Lavie, Sleep Laboratory, Department of Behavioral Biology, Gutwirth Building, Technion, Haifa 32000, Israel.

In recent years we have investigated the prevalence of sleep disturbances in industrial workers and their effects on safety at work. The study consists of a field survey of sleep habits and sleep disturbances among a large group of industrial workers, followed by all-night polyhypnographic recordings of a large sample of these workers. The present paper describes the incidence of sleep apneas among these presumably healthy working men, and demonstrates a significant relationship between the incidence of sleep apneas and the subjective complaint of excessive daytime sleepiness (EDS).

METHODS

Population

The population investigated in this field study consists of 1,502 industrial workers, 84% male and 16% female. All are permanent day workers, sampled from a wide geographic area, including the largest industrial cities in Israel. Population distributions regarding age and country of origin are identical to the corresponding distribution obtained from the Israeli National Statistical Bureau for civilian industrial workers for 1979. The distributions are also similar in regard to years of education and family status. The sleep questionnaire used in the field survey consists of 72 questions, grouped as demographic data, sleep habits, nocturnal sleep disturbances, EDS, life style, work accidents, health, and medications. Most questions are of the multiple-choice type, requiring the worker to choose one of four possible alternatives: "never," "many times," or "always," or "yes" or "no".

The results of the field study, describing the incidence of the various sleep complaints and their relationship to work-related factors, have already been published (7).

Three hundred male workers, in proportions equal to the percentages of the different sleep complaint groups, were contacted by telephone and asked to participate in the sleep laboratory recordings. The reason for investigating only males was that we were particularly interested in sleep apnea, which is overwhelmingly a disease of males. Seventy-eight workers agreed to participate for at least 1 night. The laboratory sample includes 20 workers (25.6%) who complained about EDS, which was defined as falling asleep "always" or "many times" in two out of five passive and undemanding activities. Workers complaining about EDS accounted for 8.1% of the total male population; 17 workers, or 21.7% of the laboratory sample, were from the insomniac groups. These groups included workers who reported sleep latencies of at least 45 min "always" or "many times," and workers who reported at least two midsleep awakenings "always" or "many times." This percentage was close to their percentages in the population (20.1%); 41 workers, or 52.6%, were from the control group without complaints about sleep. These workers accounted for 71.8% of the 1502 workers. The confidentiality of the results was assured before the recordings.

Sleep recordings

All-night polyhypnographic recordings were obtained in the conventional way (8). Respiration was monitored by a nostril thermistor and a respiratory belt. Since we were particularly interested in the preponderance of sleep apnea, most workers were recorded for 1 night only. To assess the reliability of the recordings, however, 11 workers were studied for a 2nd night, at least 1 week after the first recording. The

Pearson product moment correlation coefficient between the apnea index (AI) in the 1st and 2nd night in the laboratory was 0.91 ($p < 0.01$).

Sleep records were scored in 30-s epochs by a trained scorer, who was unaware of the source of the record. The 10-s criterion was utilized for the scoring of apneic episodes, and then the AI (total number of apneas divided by hours of sleep) was calculated and the predominant type of apnea was determined for each worker. The present paper focuses on the prevalence and characteristics of apneic workers; findings regarding nonapneic workers will be published at a later date.

RESULTS

Figure 1 presents the accumulated frequency distributions of AI in each of the three groups. Sixteen of the 78 workers (20.5%) had AI $\geq$ 5, 8 from the EDS group (8/20 = 40%), 2 from the insomnia group (2/17 = 11.7%), and 6 from the control group (6/41 = 14.6%). Eleven workers had AI $\geq$ 10, 7 from the EDS group (35%), 1 from the insomnia group (5.8%), and 3 from the control group (7.3%). Five of the workers had AI $\geq$ 15, 4 from the EDS group (20%) and 1 from the control group (2.4%); 3 workers, all from the EDS group, had AI $\geq$ 20. The nonparametric Kolmogorov-Smirnov Test revealed a highly significant difference between the cumulative frequency distributions of AI of the EDS group and the combined group of controls and insomniacs (χ^2 = 17.84, df = 2, $p < 0.001$).

An AI $\geq$ 10 was chosen for further comparisons between apneic and nonapneic workers. Table 1 presents relevant data for all workers with AI $\geq$ 10 (n = 11). The average age of workers with AI $\geq$ 10 was significantly higher than the average age of the nonapneic workers (52.8 $\pm$ 11.36 versus 41.9 $\pm$ 11.5, t = 2.81, df = 76, $p < 0.01$). Six of the apneic workers (5 from the EDS group and 1 from the insomnia group) had obstructive or mixed apnea, and 5 (2 from the EDS group and the 3 controls) had central apnea. None of the workers with AI $\geq$ 10 was obese, and there was no significant difference between the average deviation of body weight from ideal body weight of the apneic and nonapneic workers. Similarly, there were no significant differences

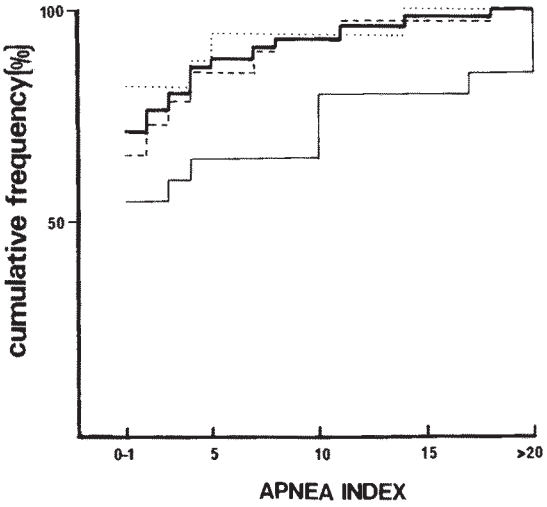

FIG. 1. Cumulative frequency of apnea indices for the insomniacs (dotted line), normals (broken line), and EDS group (continuous line). The mean of the insomniacs and normals is shown by a continuous heavy line.

TABLE 1. *Summary of data for workers with AI ≥ 10*

Subject	Age	Weight (kg)	Height (cm)	% Overweight	AI	Type of apnea	ENT finding	SN	NHM	HA	HT
EDS group											
1	67	67	166	0	27	Obstructive	DNS, allergic rhinitis	+	+	+	+
2	64	74	16[illegible]	+11	41	Mixed	Allergic rhinitis	+	+	+	+
3	61	65	170	−14	31	Mixed	Sinusitis	+	+	+	−
4	37	75	170	+4	11	Central	—	+	+	−	−
5	32	70	175	−7	19	Central	—	−	−	−	−
6	59	72	168	−3	10	Mixed	DNS, allergic rhinitis	+	+	+	+
7	52	74	176	−11	11	Obstructive	DSN, allergic rhinitis	+	+	+	+
Insomnia											
8	63	78	158	+19	15	Mixed	—	−	+	+	−
Control											
9	45	80	174	+3	11	Central	DNS due to accident	+	+	+	−
10	50	90	176	+11	12	Central	—	−	+	−	−
11	51	82	176	+1	19	Central	DNS, polyp on vocal cord	+	+	−	−
$\bar{x}$	52.8	75.2	170.6	0.3	18.8		7/11	8/11	10/11	7/11	4/11
SD	11.36	7.1	5.59	9.9	10.1						

SN = Snoring; NHM = nocturnal hypermotility; HA = headaches; HT = hypertension.
DNS = Deviated nasal septum.

TABLE 2. *Significant differences between apneic (AI ≥ 10) and nonapneic (AI < 10) workers*

Symptom	AI ≥ 10	AI < 10	p
Heavy snoring	8/11 (72.3%)	26/67 (40.3%)	0.05
Excessive motility in sleep	10/11 (90.9%)	27/67 (40.3%)	0.005
Frequent headaches	7/11 (63.6%)	17/67 (25.4%)	0.01
Ear and throat findings	7/11 (63.6%)	18/67 (26.8%)	0.025
Hypertension	4/11 (36.3%)	5/67 (7.4%)	0.017

between the apneic and nonapneic workers with respect to smoking habits, alcohol intake, hypnotic usage, or underlying lung disease.

Table 2 lists some of the variables for which there is a statistically significant difference between the apneic and nonapneic workers (pooled together, χ^2 test). Apneic workers complained significantly more of heavy and disturbing snoring (72.3% versus 25.4%, $\chi^2 = 6.54$, $p < 0.01$), excessive motility in sleep (90.9% versus 40.3%, $\chi^2 = 7.78$, $p < 0.005$), and frequent headaches (63.6% versus 25.4%, $\chi^2 = 6.54$, $p < 0.01$). They had significantly more ear and throat findings (63.6% versus 26.8%, $\chi^2 = 4.29$, $p < 0.025$), and more of them suffered from hypertension (36.3% versus 7.4%, $p < 0.017$, Fisher Exact Probability Test). Hypertension is defined as blood pressure values exceeding 160 mm Hg systolic and 95 mm Hg diastolic.

DISCUSSION

The present results demonstrate for the first time a significant relationship between subjective complaints of EDS and sleep apnea incidence in a large, presumably healthy working male population. Seven workers, or 35% of the workers in the EDS group recorded in the laboratory, had an AI ≥ 10, as compared with 3 of the 41 controls and 1 of the 17 insomniacs.

It can be safely concluded that all the workers with AI ≥ 10 from the EDS group and the one worker from the insomnia groups (n = 8) indeed suffer from full-blown SAS. All had at least some of the complaints typical of the syndrome, e.g., heavy snoring, hypermotility in sleep, and frequent headaches, and in some there were typical ENT findings.

It is more difficult, however, to reach a conclusion regarding the three control workers who had predominantly central apneas, with AI ≥ 10. One plausible explanation is that more than 10 apneas per hour of sleep, particularly of central origin, can occur in normal individuals and represent an extreme of a normal physiological phenomenon. On the other hand, two of the three control workers (nos. 9 and 11 in Table 1) had some complaints consistent with the SAS: heavy snoring and nocturnal hypermotility, in addition to typical ENT findings. Therefore, it is highly likely that they suffered from a milder form of SAS. Possibly, measurements of oxygen saturation level could help to subdivide further the control workers with apneas in accordance with their degree of desaturation.

One should be cautious when attempting to generalize the present findings to the general adult male population. The field survey was conducted on a presumably healthy working population required to be alert throughout the working hours. This eliminates

the most severe sleep apnea patients, whose excessive sleepiness prevents them from working in the industry. Furthermore, none of the workers interviewed in the field study could be defined as obese. Since obesity is a risk factor for sleep apnea, selecting a population which excludes obese individuals should lead to an underestimation of the true prevalence of sleep apnea in the total population. On the other hand, the sample of 78 workers recorded in the laboratory was not a representative sample of the total population investigated in the field study. The reason is that many workers, particularly those without complaints about sleep, refused to participate in the sleep laboratory study. Only 78 of the 300 workers who were contacted agreed to participate in the sleep recordings. It is possible, therefore, that the sleep laboratory sample included a disproportionate number of workers with more severe sleep disorders, who expected some benefit from the sleep recordings.

However, even if the laboratory sample was grossly disproportionate and included all the apneic workers in the initial population of 1236 male workers, the incidence of workers with a definite diagnosis of SAS is still remarkably high (11/1236). Since it is not reasonable to assume that we succeeded in selecting all the apneic workers in the population, it can be safely concluded that the true incidence of sleep apnea in that population is much higher. I suggest that the prevalence of 0.89% should be considered as the lower limit of the true prevalence in the adult male population.

Another point of interest was the significant difference between the apneic and nonapneic workers with regard to the prevalence of hypertension. There were almost five times as many hypertensive apneic workers as nonapneic workers (36.1% versus 7.4%). The incidence of hypertension among the nonapneic workers was identical to the incidence in the total population of industrial workers, which was 7.3%. Although it is premature at this stage to conclude that sleep apnea is causally related to hypertension, it should be mentioned that heavy snoring has been suggested as a risk in the development of hypertension (9), and that about two-thirds of SAS patients have hypertension (1). Moreover, we have recently shown that 11 out of a sample of 50 unselected patients with essential hypertension had AI $\geq$ 10. All had at least some of the characteristic complaints of SAS (10). Taken together, these results indicate that the possibility of SAS should be seriously considered in the clinical evaluation of patients with essential hypertension.

Even accepting the very conservative estimate of sleep apnea to be in the neighborhood of 1% of the male population older than 21, the number of afflicted individuals is enormous. This brings up some unavoidable questions regarding diagnostic strategies, as well as treatment procedures. There is no doubt that proper diagnosis and treatment of all sleep apnea patients requires changes in the prevailing views regarding the role of polyhypnographic sleep recordings. The present data suggest that for a rather large segment of the adult male population diagnostic polyhypnographic recordings are an essential diagnostic procedure.

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