Excessive Daytime Sleepiness and Risk of Occupational Injuries in Non-Shift Daytime Workers

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Study Objectives: Only a few studies have examined the possible association between excessive daytime sleepiness (EDS) and risk of occupational injuries, and most of them were based on self-reports. This study tested this association in daytime workers using injury data taken from organizational archives.

Design: A retrospective and prospective study. It covered injury occurrence during two years prior to a sleep disorder assessment/education procedure and injury occurrence in the following year. The workers were given the assessment results and, when applicable, a letter to the treating physician.

Setting: Eight industrial plants. Lectures and discussions on sleep disorders, treatment, and implications to safety and quality of life were conducted with small groups who completed the sleep assessment questionnaire beforehand. The workers completed the sleep assessment questionnaire prior to the lecture/discussion.

Participants: 532 non-shift daytime workers.

Interventions: N/A.

Measures and Results: A battery of questionnaires to assess EDS (by the Epworth Sleepiness Scale), suspected sleep disorders, sleep habits, and job and environmental conditions. Of the workers studied 22.6% had EDS. Most of those (96.3%) indicated that they had experienced this propensity for the past two years or more and 56% of them had experienced it for 10 years or more. Logistic regression analysis indicated that during the two-year period prior to the procedure, EDS was associated with an increased risk of sustaining a work injury (OR=2.23, 95% CI 1.30-3.81), even after controlling for possible confounders, including factory category, job and environmental conditions. In the year after the procedure, the injury rate decreased by one-third in the workers with EDS but remained unchanged in the workers without EDS. Consequently, the association between EDS and injury was no longer significant (OR=1.42, 95% CI 0.71-2.85).

Conclusion: EDS is a prevalent phenomenon in non-shift daytime workers. Workers with EDS had over two-fold higher risk of sustaining an occupational injury. Providing workers with the assessment results and of the implications of EDS for safety may explain the decrease in occupational injuries upon follow-up. This decrease might have occurred either because of workers taking steps to reduce EDS and/or adopting safety behaviors.

Key words: Sleep disorders; excessive daytime sleepiness; workers; work; occupational; injury; accidents; safety

INTRODUCTION

EXCESSIVE DAYTIME SLEEPINESS (EDS) DENOTES A PROPENSITY TO DOZE OFF OR FALL ASLEEP UNINTENTIONALLY DURING THE DAY, PARTICULARLY IN PASSIVE SITUATIONS.[1-3] The prevalence of EDS ranges from 4% to 31% in different studies.[2-6] Major contributory factors are insufficient nocturnal sleep and sleep disorders, such as sleep apnea, narcolepsy, idiopathic central nervous system hypersomnia, and circadian rhythm disturbances.[1,2,4]

Sleepiness/fatigue reduces performance capability induced by slow information processing, increased periods of non-responding or delayed responding during attention-based tasks, increased reaction times, reduced vigilance, reduced accuracy of short-term memory, and accelerated decrements in performance with time-on-task. This leads to human error and potentially increases the risk for accidents.[7-10]

Disclosure Statement
Nothing to disclose.

Submitted for publication September 2001
Accepted for publication February 2002

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There is cumulative evidence pointing to an association between sleepiness and probability of involvement in motor vehicle crashes.[8,11-13] Although sound epidemiological data for a causal role of sleepiness is still lacking,[14] falling asleep while driving is believed to account for a sizeable proportion of motor vehicle accidents, especially under monotonous driving conditions,[8,11] and for over 40% of fatal crashes (e.g., [15]). Many of these accidents are work-related, occurring among drivers of buses, trucks, goods vehicles, and company cars.

Less investigated is the possible association of sleepiness with risk of accidents at the workplace. According to some estimates, 52.5% of work accidents might be at least partly due to sleepiness.[12] Most of the studies conducted so far focused on shiftwork or work at irregular hours.[9,16] Several authors highlighted the fact that a number of high-consequence disasters (Three-Mile Island, Chernobyl, Exxon Valdez, etc.) occurred at night (see, [9,16]). Surprisingly, there are almost no studies among non-shift daytime workers. It is also not clear whether the magnitude of the association observed between EDS and motor vehicle accidents also holds for work injuries. Workers are expected to be more physically active than drivers and thus may be more alert. Of the few investigations of the association of EDS with the risk of occupational injuries, all were based on self-reports.[17-19] On the other hand, there are some studies that demonstrated an increased risk of objectively measured occupational accidents. These studies, however, focused on workers suffering from snoring or obstructive sleep apnea for whom EDS is implied but not directly tested (see e.g., Ulfberg et al. [20]). An example of a study that measured EDS but relied on self-reported data on accidents is Lavie et al.,[17] which showed that workers complaining of EDS reported 1.5 times more accidents than workers with no complaints. This difference was statistically significant. Subjective reports, however, are considered to be less reliable than objective data, as they depend on the person's willingness to disclose accident involvement and are prone to recall bias.[21]

The present investigation sought to test the association between EDS and occupational injuries (including minor ones) in non-shift daytime workers, and to examine whether precursors of EDS (namely insufficient sleep and sleep disorders) can predict occupational injuries. The findings were based on objective data taken from the registries of the respective companies. In addition, the same workers were studied both retrospectively and prospectively.

METHODS

Subjects

A total of 740 non-shift daytime workers from eight industrial plants (two power plants, three metal fabrication plants, two composite material production and fabrication, one heavy machinery maintenance and repair workshop) were invited to participate in the study. Their clock hours ranged from 06:30 - 15:30 hours and 07:15 to 16:15 hours. Some worked overtime but none of them worked on two jobs that required some shift work. Working time ranged from 42-55 hours/week. To ensure a potential statistical power for testing our study hypothesis, we selected plants in which at least 6% of the workers had sustained lost-workday injuries in the year preceding the study. Six hundred and thirty-three workers (80.1%) responded. Of these, 101 subjects (from two factories) were excluded for lack of injury data. Thus, the final sample consisted of 532 workers. Mean age was 44.5±8.89 years; 91.7% were men; 34.2% had more than 12 years of education. Those not included in the sample were of similar age, 46.3±7.6 years; 73.6% were men; and 36.4% had more than 12 years of education.

Procedure

All participants underwent a sleep disorders assessment/education procedure conducted from November 1988 to February 1999. The sleep assessment was based on a sleep questionnaire, the Epworth Sleepiness Scale, and the Mini Sleep Questionnaire (see below). The education component consisted of a 90-minute lecture and discussion on sleep disorders, sleepiness, effects of EDS on performance and quality of life, sleep hygiene, and possible treatments for EDS. The lectures were conducted at the worksite with small groups. The workers completed the sleep assessment questionnaires prior to the lecture.

The study participants received their assessment results and a letter (confidential) to the treating physician. For workers who manifested moderate or severe sleep disorders and/or EDS, the letter included a recommendation to continue the diagnostic process in a sleep disorders unit. However, we have no information on the number of workers who actually followed up this recommendation.

Data Collection

Demographic, occupational, and health data. Data were collected on gender, age, level of physical work (ranked from 1—none at all, to 4—heavy physical work), number of work hours per week, and exposure to high noise levels (yes/no). Participants were also asked if they suffered from one or more of 22 chronic diseases (cardiovascular disease, asthma, diabetes, back pain, prostate problems, etc.).

Sleep questionnaire. This questionnaire provided data on sleep habits (average amount of sleep, typical time of retiring and waking, naps, etc.), sleep quality (ranked from 1—bad, to 4—excellent), and signs and symptoms of sleep apnea (snoring, awakening with dry mouth, witness of sleep apnea events), and tiredness upon awakening.

Epworth Sleepiness Scale (ESS). The eight-item ESS[22] was designed to determine a subject's likelihood to doze off or fall asleep in different situations. All questions are rated on a scale of 0 to 3; a score above 10 is considered positive for EDS.[3] The reliability and validity of the ESS has been demonstrated in a number of studies (see for example, Johns[23]). Recently, the ESS was reported to best discriminate between the EDS of narcolepsy and the daytime sleepiness of normal subjects.[23] Participants were also asked to indicate the length of time (in years) during which they had been experiencing a tendency to EDS, if applicable.

Mini Sleep Questionnaire (MSQ). The MSQ[25] is a 10-item sleep disorders screening scale measuring sleep difficulties, early awakening, fatigue upon awakening, frequent awakenings during the night, etc. The response scale ranges from 1—never to 7—always. A score of 10-24 is considered representative of good sleep; 25-27, a possible mild sleep disorder; 28-30, a possible moderate sleep disorder; and >30, a possible severe sleep disorder.

Injury Data

Data were collected on all injuries registered at the participating factories in 1997, 1998, and 1999. A broad range of injuries was included, even minor ones that did not lead to absence from work. Zohar[26] listed three methodological advantages of collecting minor injuries (or micro-accidents): 1) they occur much more frequently than lost-workday accidents, resulting in a homogeneous distribution as a function of time, as opposed to the highly skewed distribution characteristics of accident data in a single organization; 2) they provide an objective measure of behavioral safety unaffected by sources of bias associated with self-reported or other forms of rating; and 3) they are strongly associated with lost-workday accidents. We divided the data into two types: retrospective—injury occurrence during the two years (1997,1998) prior to the sleep disorders assessment/education procedure; and prospective—injury occurrence in the following year (1999). Also included in these data were injuries that occurred during the period of November 1998 through February 1999 when the assessment/education procedure took place.

Statistical Analysis

Univariate analyses. Chi-square tests to analyze frequency data, and t-tests or one-way analysis of variance (ANOVA) to compare differences between means, were conducted.

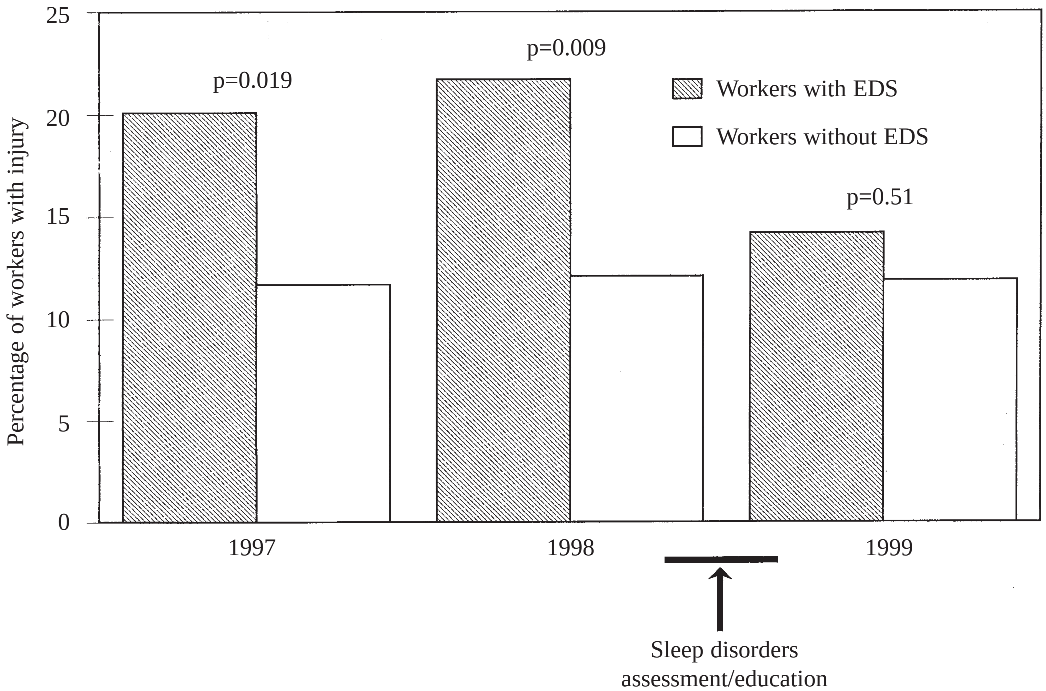

Figure 1—Percentages of non-shift daytime workers with EDS (n=120) sustaining occupational injuries in 1997, 1998, and 1999, and the corresponding percentages among workers without EDS (n=412), and the time of the sleep disorders assessment/education procedure.

Multivariate analyses. Logistic regression models were fitted to the data to test the association between injury occurrence (none vs. one or more in a given period of time) and EDS while controlling for several possible confounders. Significance level was set at $p<.05$.

RESULTS

Work Injury Data

The plant registries showed that 24.3% of the 532 workers in the sample sustained at least one injury during the two-year period of 1997-1998. This rate was similar to the 23.8% found in the large-scale Israeli CORDIS study[27] for workers employed under adverse work and environmental conditions. Exposure to high noise levels was reported by 52.7% of the workers and was significantly associated with occurrence of injuries: 37% of the workers exposed to high noise levels sustained one occupational injury or more in 1997-1998, compared to 26.9% of non-exposed workers [$\chi^2(1)=6.1, p=0.013$]. There was also a positive association of physical work (moderate or heavy) with occupational injury: workers who performed physical work sustained twice as many occupational injuries (66.7%) as workers who did not [33.3%, $\chi^2(1)=6.31$, $p=0.012$]. Finally, there was a significant and wide difference in injury rate across the eight industrial plants, ranging from 7% to 52% [$\chi^2(7)=46.59, p=0.001$]. In the CORDIS study[27] we found that the work and environmental conditions markedly differed across various industrial plants and this was positively associated with injury rate (data not reported). Thus, it is very likely that this also holds for the factories sampled in the present study and that this accounted for the above large variation in injury rate across the plants.

Frequency of EDS

The average ESS score in the study sample was 9.22±4.65. Of the workers, 22.6% (n=120) had a score above 10, and they were considered to have EDS. Most of the responders with EDS (96.3%) indicated that they had experienced an EDS propensity for the past two years or more; 56.6% of them had experienced this propensity for 10 years or more.

EDS and Work Conditions

No association was found between working hours and ESS ($r=.01$, $p=0.78$). There was no difference in mean ESS score between the workers who were exposed to high noise levels and those who were not [9.21 vs. 9.25; $t(530) = 0.08$, $p=0.93$]. This was also true when workers performing moderate to heavy physical work were compared to the other workers (9.05 vs. 9.43; $t(530)=0.35$, $p=0.35$). Furthermore, there was no difference in the mean ESS score across the 8 participating factories. It ranged from 8.99 to 9.59 [$F(7,522)=0.50, p=0.83$]. Thus, the ESS scores were not associated with the work conditions (including the work hours) in the factories sampled.

EDS and Occupational Injuries

The results of the univariate analysis testing the association between EDS and rate of occupational injuries in 1997, 1998, and 1999, and the timing of the sleep disorders assessment/education procedure, are depicted in Figure 1.

The analysis yielded three major findings that can be observed in the figure.

1. Prior to the sleep disorders assessment/education procedure, workers with EDS had nearly double the injury rate of

Table 1—Logistic regression results for predicting occupational injury occurrence in 1997 and 1998 by excessive daytime sleepiness (EDS) and several control variables

Variable	Odds ratio	95% CI	p-value
EDS (no, yes)	2.23	1.30-3.81	0.003
Age (years)	1.02	0.98-1.05	0.37
Sex (men, women)	0.98	0.47-2.71	0.98
BMI (units)	1.01	0.99-1.02	0.25
Tenure (years)	1.00	0.97-1.04	0.66
Factory category[1]	3.21	1.44-5.31	0.0001
Hard physical work (no, yes)	1.54	0.93-2.57	0.10
Noise exposure (no/yes)	1.42	0.87-2.32	0.13

BMI—body mass index, CI—confidence interval
[1]Of low or high injury rate

Table 2—Logistic regression results for predicting occupational injury occurrence in 1999 by excessive daytime sleepiness (EDS) and several control variables

Variable	Odds ratio	95% CI	p-value
EDS (no, yes)	1.42	0.71-2.85	0.32
Age (years)	0.98	0.94-1.02	0.24
Sex (men, women)	2.97	1.11-7.96	0.0029
BMI (units)	0.95	0.89-1.03	0.29
Tenure (years)	1.06	0.97-1.05	0.78
Factory category[1]	3.27	1.67-6.42	0.0006
Physical work (no, yes)	0.81	0.42-1.54	0.51
Noise exposure (no, yes)	1.22	0.87-3.13	0.12

BMI—body mass index, CI—confidence interval
[1]Of low or high injury rate

workers without EDS both in 1997, [$\chi^2(1)=5.54$, p=0.0019] and in 1998 [$\chi^2(1)=6.89$, p=0.009].

2. In 1999, the year after the above procedure, there was no significant difference between those with and without EDS [$\chi^2(1)=0.44$, p=0.51].
3. The injury rate in the workers without EDS remained constant throughout the three years (1997 to 1999), whereas the rate in the workers with EDS declined in 1999 to almost one-third the rates recorded in 1997 and 1998.

Multivariate (logistic regression) analysis was conducted to explore the association between EDS (yes/no) and occurrence of at least one occupational injury (yes/no), while controlling for possible confounders (namely, age, sex, body mass index, tenure, and the factory category with respect to injury rate). Factories were classified into two categories: 0—with low injury rates (<25%) in 1997-98, or 1—with high injury rates (≥25%). These two categories, rather than the full eight factories, were used to increase statistical power and model stability. In a separate exploratory run, eight dummy variables were included in the model ensuring that the same results were obtained. Also included were physical work and exposure to high noise levels. These last two variables were found here to be significantly associated with injury rate. In accordance with the study of Melamed et al.,[27] we combined the injury rates for the years 1997 and 1998 to increase the reliability of the data. The results are presented in Table 1.

EDS was found to be associated with more than a twofold increased risk of sustaining a work injury during 1997-1998 (OR=2.23, 95% CI 1.30-3.81). Of the possible confounding variables only the factory category proved to be significant beyond EDS.

The same analysis was replicated for injuries sustained in 1999 (see Table 2). EDS was not a significant predictor of injuries in this analysis (OR=1.42, 95% CI 0.71-2.85). Again the factory category remained a significant predictor. Interestingly, in this analysis sex also proved to be significant, with women being at higher risk for injuries (OR=2.97). A similar trend has been reported in previous studies (see e.g., Liao et al.[28]).

Sleep Disorders/Habits, EDS and Injury Risk

The next step in the data analysis was to explore the association of sleep disorders and sleep habits with EDS and injury risk on the basis of the injury data for 1997-1998. The results are summarized in Table 3. Participants were divided into two groups by score on the MSQ: suspected of having a moderate or severe sleep disorder and no sleep disorder. We found that the first group had a significantly higher rate of EDS than the second. However, there was no difference between the two groups in the percentage of workers sustaining an occupational injury.

A similar analysis was conducted for workers reporting/not reporting signs and symptoms of sleep apnea: snoring, dry mouth on awakening, and witness of sleep apnea events. The workers who reported meeting both criteria had the highest prevalence of EDS compared with those reporting only one or none. Again, no difference was noted among the three groups in injury rate.

Somewhat different results were obtained when workers were classified into two groups by sleep quality. Poor sleep quality was defined as a score of 1 or 2 on the relevant question, and good sleep quality as a score of 3 or 4. A significantly higher percentage of workers with poor sleep quality had EDS, but this had no impact on injury rate.

The last section of Table 3 shows the association between the average hours of sleep and the outcomes studied. Workers who habitually slept less than six hours had a higher rate of EDS than workers who got six to eight hours of sleep. A few workers reported sleeping for nine hours or more; they not only had the highest rate of EDS, they also had more than 2.5 times the number of occupational injuries compared to the other workers.

Thus, the data presented in Table 3 reveal no difference in injury rate between workers with different sleep disorders/habits and controls, despite the significant difference in EDS. This finding, coupled with the positive association of EDS with injury risk uncovered in the earlier analyses, suggests that it is the presence of EDS, and not sleep disorders per se, that is predictive of injury risk. To directly test this suggestion, we analyzed the difference in injury rate between workers with and without EDS and sleep disorder. The results are presented in Table 4. To attain sufficient subgroup sizes, workers who reported snoring and dry mouth and witness of sleep apnea events were combined with those reporting snoring or dry mouth or witness of sleep apnea events (see Table 3). Likewise, the workers reporting more than nine hours' sleep were combined with those reporting six to eight hours. The results indicated that within the various subgroups, the workers

Table 3—Summary of tests of the association among sleep disorders/habits, excessive daytime sleepiness (EDS), and injury rate

Group	% with EDS	% sustaining occupational injury
Suspected sleep disorder (n=229)	37.1	24.8
Others (n=303)	11.6	24.2
	$\chi^2(1)=48.5, p=0.001$	$\chi^2(1)=0.004, p=0.849$
Snoring and dry mouth and witness of sleep apnea (n=21)	57.1	28.6
Snoring or dry mouth or witness of sleep apnea (n=191)	25.1	24.1
Others (n=337)	18.8	24.4
	$\chi^2(2)=17.8, p=0.001$	$\chi^2(2)=0.212, p=0.896$
Poor sleep quality (n=216)	27.8	28.2
Others (n=316)	18.6	21.9
	$\chi^2(1)=6.09, p=0.014$	$\chi^2(1)=2.76, p=0.097$
Sleep hours <6 (n=193)	25.4	23.3
Sleep hour 6-8 (n=333)	20.1	24.3
Sleep hours ≥9 (n=6)	66.7	66.7
	$\chi^2(2)=8.70, p=0.013$	$\chi^2(2)=5.93, p=0.052$

Table 4—Association between EDS and injury rate in 1997-1998 among non-shift daytime workers with and without sleep disorder

	With EDS		Without EDS		
Group	**n**	**% sustaining injury**	**n**	**% sustaining injury**	**p value[1]**
Suspected sleep disorder	85	32.9	144	20.1	0.030
Others	35	34.2	268	22.9	0.137
Snoring and/or dry mouth and/or witness of sleep apnea	60	36.7	152	19.7	0.01
Others	60	30.0	260	23.1	0.260
Poor sleep quality	60	40.0	156	23.3	0.017
Others	60	26.3	257	20.0	0.371
Sleep hours <6	49	30.6	144	20.8	0.162
Sleep hours ≥6	71	35.2	268	22.3	0.027

[1]χ^2 tests

with EDS had a significantly higher injury rate than those without EDS. We are aware, however, that the significant results obtained for sleep hours ≥6 (see bottom of Table 4) may be obtained from the inclusion of six workers reporting more than nine hours of sleep. When these workers were excluded from the analysis the trend becomes less significant. The corresponding percentages for workers with EDS and those without EDS were 32.8 and 22.4 [$\chi^2(1)=3.18$, p=0.075].

The final analysis explored the association between chronic diseases and EDS. Two chronic conditions were found to be significantly related to EDS (results not shown): low back pain and prostate problems. The results for the other conditions (cardiovascular disease, hypertension, diabetes, asthma, other pulmonary diseases, mental problems, colitis, etc.) were not significant (p>0.5).

DISCUSSION

This study explored the association between EDS and the risk of sustaining an occupational injury in non-shift daytime workers. To the best of our knowledge, this is the first such study based on objective injury data taken from organizational archives. The major finding was that in 1997-1998, before the sleep assessment/educational intervention, EDS, as assessed by the Epworth Sleepiness Scale, was associated with more than twofold increase in the risk of occupational injury (OR=2.23, 95% CI 1.30-3.81). This association can be readily explained by the chronicity of EDS: 93.3% of the participants with EDS indicated that they had experienced this propensity for two years or more and 56.6% of them had experienced it for 10 years or more. The risk of injury remained significant even after controlling for several potent confounders, particularly the factory category classified in terms of low or high injury rate. Factories varying in injury rate might have significantly different work and environmental conditions as suggested by the data from our large-scale CORDIS study.[27] Furthermore, the results remained significant after further controlling for job and environmental conditions, such as physical work and exposure to high noise levels, proven here to be independently associated with injury occurrence. Even body mass index, known to be associated with sleep disorders, and also found to be predictive of industrial accidents[29] had no effect. We wish to mention also that the above association was obtained even with the inclusion of injury data for November and December 1998. This data was included to allow for a longer sampling period that increases the reliability of the data.[27] In these months, however, the assessment/education program had already started and this could have weakened the above association. It might be that in reality the above association is even stronger than that observed in our data. Thus, the present study validates the previous investigations of an association between EDS and injury risk that were based on subjective reports of occupational injury (e.g., [17-19]). In addition, these findings indicate that EDS is associated with increased injury risk not only among physically passive drivers, as shown in earlier studies (see introduction) but also among workers who are supposedly physically active (with some performing hard physical tasks).

Our collection of data on sleep quality, sleep habits, and sleep disorders enabled us to reconfirm the relationship of these variables with EDS. We found that the existence of suspected sleep disorders, as based on the screening test of Zomer et al.,[25] the presence of symptoms such as snoring and dry mouth (known to be associated with sleep apnea), witness of sleep apnea events, poor sleep quality, limited sleeping hours, and excessive sleeping hours (as a possible indication of hypersomnia) were all significantly associated with the prevalence of EDS. It was noteworthy, though, that none of these variables per se (except for a trend for poor sleep quality and extreme sleep hours) was significantly associated with injury risk. On the other hand, results of the subgroup analyses indicated that workers with EDS sustained significantly more injuries than those without EDS. These findings suggest that it is the combination of EDS and one of these other factors (suspected sleep disorder [according to the criteria of Zomer et al.[25]], sign and symptoms of sleep apneas, poor sleep quality and sleep ≥6 hrs) that is significant for the occurrence of occupational injuries. Furthermore, our data are consistent with the recent findings of Barbe et al.[30] showing that among patients with obstructive sleep apnea, only those with daytime sleepiness have compromised functioning (in terms of objective sleepiness, cognitive function and quality of life). They are also the ones who benefited from Continuous Positive Airway Pressure (CPAP) treatment.

The injury occurrence rate found in the prospective part of the study (1999) was somewhat unexpected. We did not design this investigation as a formal interventional study. We invited workers to attend a lecture and discussion on sleep disorders, their implications for quality of life and safety, and the treatment possibilities. All the workers completed the sleep assessment questionnaires before commencing the lecture/discussion, and they all received immediate feedback regarding the assessment results, as stipulated by the regulations of our hospital's Helsinki ethics committee. We found that after the intervention, the injury rate in the workers with EDS decreased by 30%. No such change was observed in the workers without EDS who attended the same lecture.

It must be emphasized that the workers in our sample served as their own control group, and the injury data were obtained from the same sources for the same workers for all three years of the study (1997-1999). Considering this study design together with the findings of a lower injury rate exclusively among workers with EDS, we propose that it was the simple interventional procedure (lecture on sleep disorders and their implication to safety and feedback on sleep assessment results) that was responsible for the reduction in injuries. Logistic constraints and the risk of violating confidentiality prevented us from contacting the workers found to be at risk in order to learn in what ways this new awareness had impacted on them. Nevertheless, the results are very encouraging. We trust that the potential of this instrument prompts additional investigations of this issue.

Our study had several limitations. First, we did not conduct a post-study survey of possible organizational changes or new safety measures introduced in 1999 that were especially beneficial to workers with EDS. There is some indirect indication in the data, however, that the work and environmental conditions did not change in 1999. The odds ratio for injury risk by factory category essentially remained the same as in 1997-1998, (OR=3.27 and OR=3.21, respectively). Second, the follow-up period of one year may be too short. A longer period is needed to determine whether the positive effect of the intervention does not "wear off" with time. Third, we were probably dealing with a selected population. The workers who participated in the study were those who were interested to begin with in attending a lecture on sleep disorders and possible ways of treatment and in undergoing a sleep disorders assessment. Thus, they may have been characterized by a higher prevalence of sleep difficulties and were perhaps better motivated to seek help compared with workers who chose not to take part in such an activity. This probable bias may account for our somewhat high prevalence (22.6%) of workers with EDS (score >10 on the ESS) compared with other studies using the ESS (10%-16%) (see for example, [3,6]).

Thus, the replication and confirmation of the findings in a more representative sample of the target population is still needed. Nonetheless, given the magnitude of the problem (with about 23% of workers suffering from EDS and having double the risk of injury), even the finding that our simple intervention helps the more motivated worker is also meaningful. It can be used as one step, among others, taken to reduce the disability, loss of life, and huge costs associated with sleepiness-related accidents.[8]

At the same time, this study has several strong points that make the findings noteworthy. It is based on objective injury data, taken from the factory archives, and covers three years. The injury data included minor injuries, whose inclusion has specific advantages.[26] Several control variables, including factory category and markers of poor work and environmental conditions, suggest that the association between EDS and accident risk is not a spurious one. Finally, the study was conducted among workers from eight factories, which increases the generalizability of the findings.

Implications

The findings of the present study, if replicated, have several potential implications:

1. Non-shift daytime workers with EDS, even if physically active, may be at a twofold risk of occupational injury compared with their counterparts without EDS.
2. There is an ongoing debate as to whether the Epworth Sleepiness Scale (ESS) reflects objective measures of sleepiness, as do the Multiple Sleep Latency Test (MSLT) and the Maintaining Wakefulness Test (see for example,[24,31-33]). Nevertheless the ESS was shown here to be associated with an objective risk of occupational injury and, in other studies, with drivers' accident liability.[13,34] Given

the simplicity of its administration, the ESS can be effectively used to screen large populations of workers and professional drivers to identify those who are at a potential risk of sustaining injury on the job.

3. Sleep disorders (per se) and poor sleep habits do not confer an increased risk of occupational injury unless they are associated with EDS.
4. Non-shift daytime workers traditionally serve as a control group in studies of shiftwork and accidents. The findings of the present study point to the need to measure and to adjust for EDS in the control group in future studies. It is possible that the lack of an increase in the work injury rate among shiftworkers reported in some studies[35] was due to the failure to account for the prevalence of persons with EDS in the control group of daytime workers.
5. The simple intervention of EDS assessment and highlighting its implications for safety might lead to a decrease in occupational injuries among workers motivated to seek help. This could either be because of workers taking steps to reduce EDS (through improvement of sleep hygiene and/or seeking help for sleep disorders) and/or adopting safety behavior.

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ADDENDUM

While working on the revision of the present paper, a relevant study by Lindberg et al.[36] was published. This was a prospective study conducted in a mixed sample of daytime and shift workers. The authors found that men reporting both snoring and EDS were at an increased risk of future occupational accidents (taken from the National Registry) occurring during 10 years of follow-up. The adjusted odds ratio was 2.2 (95% CI 1.2-3.8), even after controlling for several possible confounders including shiftwork. Their findings are consistent with ours, and reinforce our conclusion that the combination of EDS with sleep disorders poses an increased risk for occupational injuries. Since our study was conducted in Israel and the latter in Sweden, it also emphasizes the generalizability of the findings. It seems worthwhile to conduct further studies employing our sleep assessment/education procedure to test its effectiveness in reducing the number of injuries at work.