ORIGINAL ARTICLE

Work organisation and unintentional sleep: results from the WOLF study

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Background: Falling asleep at work is receiving increasing attention as a cause of work accidents.
Aims: To investigate which variables (related to work, lifestyle, or background) are related to the tendency to fall asleep unintentionally, either during work hours, or during leisure time.
Methods: 5589 individuals (76% response rate) responded to a questionnaire. A multiple logistic regression analysis of the cross sectional data was used to estimate the risk of falling asleep.
Results: The prevalence for falling asleep unintentionally at least once a month was 7.0% during work hours and 23.1% during leisure time. The risk of unintentional sleep at work was related to disturbed sleep, having shift work, and higher socioeconomic group. Being older, being a woman, and being a smoker were associated with a reduced risk of unintentionally falling asleep at work. Work demands, decision latitude at work, physical load, sedentary work, solitary work, extra work, and overtime work were not related to falling asleep at work. Removing "disturbed sleep" as a predictor did not change the odds ratios of the other predictors in any significant way. With respect to falling asleep during leisure time, disturbed sleep, snoring, high work demands, being a smoker, not exercising, and higher age (>45 years) became risk indicators.
Conclusion: The risk of involuntary sleep at work is increased in connection with disturbed sleep but also with night work, socioeconomic group, low age, being a male, and being a non-smoker.

Sleepiness is usually defined as a tendency to fall asleep.[1] Obviously such a tendency is incompatible with safety at work and sleepiness has been identified as one of the major risk factors behind accidents at work and elsewhere.[2–5] Such accidents are estimated to cost society up to $50 billion per year.[6] Furthermore, the US National Transportation Safety Board estimates that 20–30% of all transportation accidents with injury are caused by sleepiness/fatigue.[7] It is therefore important to identify the factors behind severe sleepiness at work.

The most common causes of sleepiness involve sleep pathology, such as sleep apnoea and disturbed sleep,[4 5 8] but also transient sleep disturbances, such as those caused by shift work.[9] Interestingly, patients with a diagnosis of chronic insomnia (as opposed to transient sleep disturbances) do not seem to suffer from increased sleepiness, probably because of increased physiological activation.[10] With respect to shift work, a number of studies have shown high levels of sleepiness during night shifts, as well as during morning shifts.[9] More dramatic effects, such as the occurrence of involuntary sleep at work, have been found in several questionnaire studies.[4 11–14] This has also been described in a few studies with continuous electroencephalogram recordings during work.[15–19]

Aspects of work other than shift work do not seem to have been investigated in relation to sleepiness or unintentional sleep. Stress or high work demands, for example, would be expected to suppress any appearance of sleepiness during work, but might possibly lead to it during recovery after work. On the other hand, low work demands or low physical work load might be related to increased sleepiness, as might also solitary work. One might also expect overtime work to affect sleepiness, either through increasing it via disturbed sleep, or through counteracting it through stress at work. Demographic factors, such as age or gender, do not seem to have been systematically investigated in relation to sleepiness/involuntary sleep at work, even if these are observations of increased napping with increasing age.[20]

The present analysis sought to relate the most dramatic aspect of sleepiness at work—unintentional sleep—to possible causative factors in the work situation (shift work, work demands, solitary work, low physical work load), as well as to demographics (age, gender, socioeconomic group), lifestyle (exercise, body weight, coffee consumption, smoking), and disturbed sleep and snoring. Even if the main focus here is on involuntary sleep at work, it was also of interest to include involuntary sleep during leisure time because of the possibility of delayed effects after work. It should be emphasised that the concept "fatigue" is often used alternately with sleepiness. Fatigue is, however, a more heterogeneous concept, involving, for example, physical, as well as mental fatigue, apart from sleepiness.[21–23]

METHODS

The database used for the analysis was the WOLF (WOrk, Lipids, Fibrinogen) cross sectional study, which focused on cardiovascular risk factors, and has been used for a number of epidemiological analyses.[24 25] The WOLF study comprises data collected via 20 occupational health care units serving 40 companies in central Sweden. All employees in these companies receiving a salary and living in Sweden (n = 7526) were offered the possibility to participate in a health examination and to respond to a questionnaire. All participation was voluntary and the study was approved by the ethics committee of the Karolinska Institute. The questionnaire also included the Karolinska Sleep Questionnaire.[26 27] A total of 3250 men and 2470 women aged 19–70 years were included. The data collection took place between 1992 and 1995 and the response rate was 76%.

The data were first analysed using logistic regression analysis (SPSS-10 for Macintosh) yielding crude (mutually unadjusted) odds ratios (OR) with 95% confidence intervals

Abbreviations: BMI, body mass index; OR, odds ratio; WOLF, work, lipids, fibrinogen

Table 1 Number and percentage of total for exposure groups

Predictor variables	n	%
Low work demands	572	10
Medium work demands	4521	79
High work demands	613	11
Low decision latitude	576	10
Medium decision latitude	4442	78
High decision latitude	390	7
Low social support	560	10
Medium social support	4532	79
High social support	598	11
Not supervisor	4536	80
Supervisor	1124	20
Blue collar	2498	45
Middle white collar	2189	39
High white collar	905	16
Non-solitary work	4781	84
Solitary work	896	16
Sedentary work	3582	64
Non-sedentary work	2041	36
Low physical load	1538	27
Intermediate physical load	3462	61
High physical load	679	12
Part time	472	8
Full time	2807	50
Overtime 1–7 h	1554	28
Overtime 8–15 h	640	12
Overtime >15 h	116	2
No extra work	5153	91
Extra work	530	9
Day work	3535	63
Shift work with day work only	1512	27
Shift work with night work	539	10
Married	4097	72
Unmarried	1603	28
Male	3250	57
Female	2470	43
Age <30	990	17
Age 30–45	2203	39
Age 45+	2527	44
Not having children	3046	54
Having children <7 y	2633	46
No exercise	1331	23
Exercise	4371	77
Coffee <4 cups	4069	71
Coffee ⩾4 cups	1651	29
Not smoking	4256	74
Smoking	1439	25
BMI <28	4851	85
BMI ⩾28	844	15
Not disturbed sleep	5346	94
Disturbed sleep	356	6
Not snoring	4917	88
Snoring	664	12

(CI). A confidence interval not overlapping unity was interpreted as a "significant" result. The dependent variables were unintentional sleep during work hours and during leisure time, respectively. The significant predictor variables from the first analysis were then entered into a multiple logistic regression analysis with simultaneous adjustment for all predictor variables. The dependent variables were dichotomised to define "cases" and the predictor variables were divided into exposure groups to define "exposed" subjects (see below).

The questionnaire used for data collection was administered by the occupational health units and filled out at home. All questions regarding states and behaviour referred to the past 12 months. Work exposure variables were: shift work (with night shifts (N) or without night shifts (D) *v* only day work), overtime work (1–8 h/wk, 8–15 h/wk, >15 h/wk, and part time work (<35 h/wk) *v* full time (35–40 h) without overtime), having an extra job (*v* not), non-sedentary work (standing/walking >50% of the time at work *v* <50%), having solitary work (working alone most of the time *v* working alone occasionally or never), physical demands at work (>8 and 2–8 *v* <2, using a scale from very, very light (0) to very, very exerting (14) with 9 indicating "exerting").

The demand dimension of the demand/control model was measured according to Karasek and Theorell.[28] The work demand variable contained questions as to whether it was necessary to work fast, or hard, or excessive amounts, or whether demands were in conflict with each other, or whether there was enough time to do the job (reversed score). The response alternatives were: "often" (4), "sometimes" (3), "seldom" (2), and "never"(1), with the score in parentheses. There is no established way of determining a cut off level for this scale,[29] but a dominant approach uses the upper quartile versus the remainder.[29] Presumably, the upper or lower decile might increase the sensitivity. In the present case, the lowest and the highest deciles (see results) were selected for trichotomisation as low demands could be more likely to lead to unintentional sleep during work than high demands, whereas high demands could be expected to lead to unintentional sleep after work.

Decision latitude included questions on the possibility to choose how to do the job, what to do at work, whether creativity was necessary, whether one was learning new things at work, whether work required a high level of skill, and whether work was repetitive (reversed score).[28] The response alternatives were the same as for work demands, high values (4) indicating high influence. Again, the upper and lower deciles were used for trichotomisation.

The index "social support at work" contained seven items: relaxed/pleasant atmosphere at work, cohesion at work, "my colleagues support me", "it is OK to have a bad day", "I get along well with my superiors", "I like my work mates/colleagues", "there is an open atmosphere at work". The response alternatives were: agree completely, partly agree, hardly agree, don't agree at all. All items were scored 1–4. Some of the psychometric characteristics of social support at work and the demand/control model have been presented by Theorell.[30] This variable was also dichotomised at the highest and lowest deciles.

Background variables used were: age (30–45 years or >45 years *v* <30 years), gender (female *v* male), body mass index (BMI: weight/height^2 >28 *v* ⩽28), marriage status (married/cohabiting *v* single), having children <7 years at home *v* not, socioeconomic group according the the Nordic classification of occupations (lower white collar, higher white collar *v* blue collar), coffee consumption (⩾4 cups/day *v* <4 cups), and lack of physical exercise (seldom + never *v* sometimes + often).

Data on disturbed sleep were obtained through the Karolinska Sleep Questionnaire, [26 31] containing the items difficulties falling asleep, disturbed sleep, repeated awakenings, premature awakening, difficulties awakening, not well rested on awakening, nightmares, and heavy snoring. The response alternatives were 5 = always/every day, 4 = mostly/several

Table 2 Odds ratios (with 95% confidence intervals) from crude logistic regression for unintentional sleep during work and during leisure

	Work		Leisure	
	n/%*	OR (CI)	n/%*	OR (CI)
Low work demands	48/8	1	121/21	1
Medium work demands	307/7	0.79 (0.58 to 1.09)	1011/22	1.07 (0.86 to 1.32)
High work demands	577/6	0.66 (0.42 to 1.03)	168/28	1.40 (1.07 to 1.82)
Low decision latitide	33/9	1	87/23	1
Medium decision latitude	288/7	0.75 (0.51 to 1.09)	1029/23	1.03 (0.81 to 1.33)
High decision latitude	69/8	0.91 (0.59 to 1.41)	185/21	0.91 (0.68 to 1.22)
Low social support	50/9	1	140/25	1
Medium social support	303/7	0.74 (0.54 to 1.01)	1040/23	0.91 (0.74 to 1.11)
High social support	34/6	0.63 (0.40 to 0.98)	119/20	0.76 (0.58 to 1.01)
Not supervisor	312/7	1	1002/22	1
Supervisor	73/7	0.93 (0.72 to 1.22)	286/26	1.20 (1.03 to 1.39)
Blue collar	168/7	1	596/24	1
Lower white collar	119/6	0.79 (0.62 to 1.01)	488/22	0.90 (0.78 to 1.03)
High white collar	86/10	1.44 (1.10 to 1.89)	204/23	0.92 (0.76 to 1.10)
Non-solitary work	357/7	1	1204/23	1
Solitary work	30/11	1.20 (0.92 to 1.56)	86/30	1.07 (0.89 to 1.30)
Sedentary work	252/7	1	795/22	1
Non-sedentary work	136/7	0.99 (0.79 to 1.24)	494/24	1.12 (0.98 to 1.29)
Low physical load	94/6	1	333/22	1
Medium physical load	249/7	1.20 (0.94 to 1.53)	792/23	1.09 (0.93 to 1.25)
High physical load	43/6	1.04 (0.72 to 1.52)	169/25	1.21 (0.98 to 1.50)
Full time	202/7	1	665/24	1
Part time	26/6	0.75 (0.49 to 1.14)	104/22	0.90 (0.71 to 1.14)
Overtime 1–7 h	97/6	0.85 (0.66 to 1.09)	327/21	0.85 (0.73 to 1.01)
Overtime 8–15 h	48/8	1.04 (0.75 to 1.45)	155/25	1.03 (0.84 to 1.26)
Overtime >15 h	10/9	1.20 (0.62 to 2.34)	27/24	0.97 (0.63 to 1.51)
Day work	206/6	1	827/24	1
Shift work with day work only	114/8	1.31 (1.04 to 1.67)	339/23	0.94 (0.82 to 1.09)
Shift work with night work	535/10	1.76 (1.28 to 2.42)	109/20	0.83 (0.66 to 1.04)
No extra job	345/7	1	1183/23	1
Extra job	45/8	1.20 (0.86 to 1.67)	114/22	0.92 (0.37 to 1.14)
Married	255/6	1	965/24	1
Unmarried	135/9	1.38 (1.11 to 1.72)	336/21	0.86 (0.75 to 1.01)
Male	246/7	1	736/23	1
Female	144/6	0.75 (0.61 to 0.93)	567/23	1.01 (0.89 to 1.15)
Age <30	102/10	1	181/18	1
Age 30–45	125/6	0.53 (0.40 to 0.69)	417/19	1.05 (0.86 to 1.27)
Age >45	163/7	0.60 (0.47 to 0.78)	705/28	1.74 (1.45 to 2.09)
No children <7	226/8	1	690/23	1
Children <7	164/6	0.83 (0.67 to 1.02)	610/23	1.03 (0.91 to 1.17)
No exercise	74/6	1	357/27	1
Exercise	315/7	1.32 (1.00 to 1.71)	941/22	0.75 (0.65 to 0.86)
Coffee <3 cups/day	289/7	1	903/22	1
Coffee ⩾4 cups/day	101/6	0.84 (0.66 to 1.07)	400/24	1.07 (0.93 to 1.23)
Not smoker	322/8	1	993/24	1
Smoker	68/5	0.61 (0.46 to 0.80)	305/21	0.88 (0.75 to 1.02)
BMI <28	316/7	1	1056/22	1
BMI ⩾28	72/8	0.83 (0.52 to 1.09)	243/27	0.80 (0.67 to 1.01)
Not disturbed sleep	345/7	1	1171/22	1
Disturbed sleep	45/13	2.16 (1.52 to 3.05)	132/38	2.00 (1.56 to 2.56)
Not snoring	324/7	1	1058/22	1
Snoring	60/9	1.33 (0.98 to 1.78)	213/32	1.67 (1.49 to 2.01)

*Numbers in frequency and percent for each exposure group who reported unintentional sleep.

Table 3 Odds ratios with 95% confidence intervals from multiple logistic regression against unintentional sleep during work and during leisure time

	OR (95% CI)
During work (n=5370)	
Disturbed sleep	2.09 (1.46 to 3.00)
Age 30–45	0.58 (0.43 to 0.79)
Age >45	0.69 (0.51 to 0.93)
Shift work with night work	1.60 (1.14 to 2.23)
Shift work with day work	1.05 (0.81 to 1.36)
Socioeconomic: high white collar	1.52 (1.13 to 2.05)
Socioeconomic: lower white collar	0.88 (0.08 to 1.14)
Smoking	0.57 (0.42 to 0.77)
Female	0.74 (0.59 to 0.94)
Social support—intermediate	0.77 (0.55 to 1.18)
Social support—high	0.73 (0.46 to 1.18)
Exercise	1.19 (0.90 to 1.58)
Single	1.24 (0.97 to 1.58)
During leisure time (n=5333)	
Disturbed sleep	1.98 (1.57 to 2.50)
Snoring	1.54 (1.28 to 1.85)
Age >45 years	1.47 (1.20 to 1.83)
Age 30–45 years	0.97 (0.80 to 1.19)
Exercise	0.79 (0.68 to 0.92)
High work demands	1.33 (1.01 to 1.76)
Intermediate work demands	1.07 (0.86 to 1.33)
Gender: female	1.04 (0.89 to 1.24)
Supervisor	1.05 (089 to 1.23)

Only significant predictors from the crude logistic regression have been introduced.

days per week, 3 = sometimes/several times per month, 2 = seldom/a few times per year, 1 = never. The first four items on the list were used to form an index (mean of items) of disturbed sleep (Cronbach's alpha = 0.76)[32] based on factor analyses,[33] as presented previously.[26 31] This index was dichotomised at the 90th centile to define those "exposed" to sleep disturbances. In addition, the item "snoring" was also tried in the analyses as this item did not enter any of the factors produced by the factor analysis, but often is found to be related to sleepiness.

The dependent variables used were "unintentionally falling asleep at work" and "unintentionally falling asleep outside work hours", both from the Karolinska Sleep Questionnaire. Levels 3–5 (at least several times per month) were combined to form the category "falling asleep" and 1–2 to form the category "not falling asleep".

RESULTS

The number of subjects falling asleep unintentionally during work several times per month or more was 390 (7%) versus 5282 (93%) never or seldom doing so. The corresponding figures for unintentionally falling asleep during leisure time were 1303 (23%) versus 4363 (77%) never or seldom doing so. Table 1 shows the number of subjects in the exposure groups. There is an internal loss of around 100 individuals for most variables, with the lowest number of respondents for the socioeconomic index (n = 5592) and the shift work variable (n = 5586), because of difficulties of classification. A χ^2 analysis between unintentional sleep before and after work showed a $\chi^2 = 488$, $p < 0.001$. Of those who experienced unintentional sleep during work, 69% also did so after work. Of those experiencing unintentional sleep during leisure time, 20% also did so at work.

The mean value (SD) for the predictors based on indices were: 2.59 (0.55) for work demands (cut off at 2 for low demands and 3.40 for high demands from a scale 1–4), 1.68 (0.55) for decision latitude (cut offs at 2.17 and 3.60 from 1–4), 1.68 (0.50) for social support at work (cut off at 1.1 and 2.29 from 4–1), and 2.19 (0.71) for disturbed sleep (cut off at 3.5 from 1–5). The latter criterion was set to approximate clinical criteria, which usually involve problems occurring several times per week.[34]

Table 2 shows the results from the crude logistic regression without mutual adjustment for the effects of all predictor variables. Significant odds ratios for unintentional sleep during work were obtained for: high social support, shift work (with and without night shifts), being unmarried, female gender (lower risk), low age, exercise, smoking, disturbed sleep, and high socioeconomic group. For unintentional sleep during leisure time, significant odds ratios were obtained for: high work demands, being a supervisor, high age (lower risk), exercise (lower risk), disturbed sleep, and snoring.

Even if work demands did not show a significant odds ratio the separate items were also tested in a separate analysis. Having to work fast was the only item of the index that showed a significant result (OR 0.64, CI: 0.50 to 0.82).

The significant predictor variables from table 2 were then entered into a multiple logistic regression analysis with mutual adjustment for the effect of the predictors. Table 3 shows that unintentional sleep during work hours had significant odds ratios (with increased risk) for: disturbed sleep, low age, shift work with nights, high white collar socioeconomic group, and being male. Exercise and marriage status did not remain significant from the crude analysis.

For unintentional sleep during leisure time, significant odds ratios (increased risk) were obtained for: disturbed sleep, snoring, high work demands, age >45 years, and no exercise. Gender and being a supervisor did not remain significant from the crude analysis.

As disturbed sleep was the strongest predictor variable and could be suspected of accounting for some of the effects of the other predictors, it was tested to remove it from the multiple logistic regression analyses. This did not, however, affect the other predictor variables in any significant way.

The effect of loss of subjects from the multiple logistic regression analyses caused by missing data on one or more variables (350 and 387 for the two analyses, respectively, in table 3) was tested by comparing (χ^2) the drop outs with the remainder of the subjects. No significant differences were seen for any of the predictor variables or dependent variables.

DISCUSSION

One work related predictor variable with a significant odds ratio for unintentional sleep at work was shift work with night shifts. The odds ratio was moderate but the increased risk is in line with previous studies of the prevalence of sleepiness.[4 11–14] It should be emphasised, however, that in the present study a number of alternative causes of involuntary sleep were controlled for. One such variable was "disturbed sleep", and this suggests that it is some other aspect of shift work that is the key factor in falling asleep at work. The most likely candidates are work at the night time circadian trough and possibly the long time since the end of the prior sleep episode.[9] Both these factors are important determinants of alertness/sleepiness.[35] Other possible confounders accounted for by the model are coffee consumption, smoking, BMI, family status, education, physical activity at work, solitary work, amount of overtime work, etc.

Unexpectedly, shift workers did not show any increased risk for unintentional sleep during leisure time. Possibly, this could be a result of shift workers' tendency to plan their sleep/naps, rather than succumbing involuntarily to the urge to sleep. Intentional or planned napping is very frequent in shift workers.[36–38]

The other significant work related predictor variable was socioeconomic group. High level white collar workers showed an increased risk. There are no comparable data from published studies, but the group in question is made up of

supervisors and professionals in senior positions, less physically active and with a more comfortable physical work situation than blue collar workers.

The lack of a connection between involuntary sleep at work and work demands, physical activity at work, physical work load, or solitary work was somewhat unexpected as measurable sleepiness is usually strongly affected by the level of activity, at least in the laboratory.[39] Possibly, the levels of monotony need to be extremely low to result in unintentional sleep and it is not clear whether individual differences in such monotony may be picked up in an epidemiological study.

Interestingly, high work demands were associated with increased risk of involuntary sleep during leisure time. This may suggest that high work involvement increases the need for recovery after work. Very little data are available on this possibility, but rats exposed to high levels of stress sleep more,[40] and humans tend to have more stages 3 and 4 after a stimulating day.[41]

As expected,[3–5] disturbed sleep was a major contributor to the occurrence of unintentional sleep—during work or during leisure. Importantly, however, removal of disturbed sleep from the model did not change any of the other odds ratios other than marginally. This suggests that disturbed sleep was not a confounder in the relation between the other variables and involuntary sleep. It also suggests that the effects of the other variables were not mediated via sleep.

Snoring was not associated with an increased risk of falling asleep at work despite good reason to expect such a relation,[42] but the confidence interval was close to becoming dissociated from unity and the lack of relation may have been spurious. Indeed, snoring was related to involuntary sleep outside work hours.

The connection between low age and a high risk of involuntary sleep at work was unexpected as previous work has not indicated such a relation,[4] and other studies have found higher sleepiness in older subjects.[43] However, there have been reports of more sleep related road accidents in younger individuals,[44] as well as higher sleepiness during night shift work.[45] One possible explanation of the age effects is that morningness increases with age.[46 47 48] This would protect against daytime sleepiness in older individuals because of a circadian rise of alertness/metabolism during the morning and noon. It would also promote evening sleepiness through an earlier circadian decrease of metabolism/alertness. This effect would be exacerbated if prior sleep had been shortened and disturbed, as is often the case in higher age groups.[49–51 52] This may explain the higher risk of involuntary sleep during leisure time observed in the present study and is in agreement with the observation of more frequent (voluntary) napping often seen in higher age groups.[20]

Interestingly, the risk of involuntary sleep at work was lower for women than for men. This disagrees with studies that have found a higher risk in women[43] or no differences.[4] The reason for this discrepancy is not clear but the present study included only employed women (and men) and controlled for many possible confounders.

The relation between smoking and lack of involuntary sleep could be a result of the alerting effects of nicotine,[53] or perhaps to the activity involved in the act of smoking or in finding a site where smoking is permitted. Indeed, smokers have difficulties in initiating sleep,[54] which agrees with the lack of involuntary sleep in the present study. However, the same, and other[43] studies, also report higher sleepiness in smokers. The reasons for these discrepancies are not clear.

From the point of view of accident prevention the results suggest that night shift work in particular presents a danger of involuntary sleep and night work has been associated with increased accident risk.[2 3] Other work related factors seem to be of little importance—the increased risk of involuntary sleep in higher socioeconomic groups probably does not involve any significant accident risk comparable to that of blue collar workers operating vehicles or machinery. The countermeasures of increased risk during night work have been extensively discussed.[55] Disturbed sleep may not be a factor amenable to work place intervention, but sleep related issues should be included in occupational health considerations. The results on age and gender suggest that such issues should be discussed when recruiting for positions that may have a particular impact on safety.

Policy implications

- Results suggest that disturbed sleep and night work involve increased risks of unintentional sleep at work and therefore require special attention with respect to occupational safety. The increased risk with low age and male gender should be followed up, but requires further corroboration.

It should be emphasised that the cross sectional nature of the present study makes it difficult to draw conclusions on causation. The results do, however, suggest that the risk of unintentional sleep at work is higher in younger age groups, in men, in non-smokers, in shift workers, and in individuals with disturbed sleep. Unintentional sleep outside work is also related to disturbed sleep and non-smoking, but to increased age and a high work involvement.

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