ELSEVIER

Journal of Psychosomatic Research 57 (2004) 427–433

Journal of Psychosomatic Research

Mental fatigue, work and sleep

T. Åkerstedt[a,*], A. Knutsson[b], P. Westerholm[c], T. Theorell[a], L. Alfredsson[d], Göran Kecklund[a]

[a] *National Institute for Psychosocial Factors and Health and Departments of Public Health Sciences, Karolinska Institute, Stockholm, Sweden*
[b] *Department of Occupational Health, University of Umeå, Umeå, Sweden*
[c] *The Swedish Working Life Institute, Solna, Sweden*
[d] *Department of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden*

Received 27 May 2003; accepted 5 December 2003

Abstract

Objective: The study examined the multivariate relationship between mental fatigue and different work-related (work load, work hours) and background/life style factors, as well as disturbed sleep. **Methods:** A total of 5720 healthy employed men and women living in the greater Stockholm area participated in a questionnaire study on cardiovascular risk factors. The data were analysed using a multiple logistic regression analysis with self-rated fatigue as the dependent variable. **Results:** Fatigue was predicted by disturbed sleep (4.31; 3.50–5.45, high immersion in work (4.17; 2.93–5.94), high work demands (2.39; 1.54–3.69), social support, being a female, being a supervisor and high age. Shift work, work hours (including overtime) and influence at work did not become significant predictors. With control for work demands a high number of work hours was associated with *lower* fatigue. **Conclusion:** Disturbed sleep is an important predictor of fatigue, apparently stronger than previously well-established predictors such as work load, female gender, lack of exercise, etc.

Keywords: Work demands; Disturbed sleep; Snoring; Burnout; Decision latitude; Social support

Introduction

Fatigue has been a recurrent topic in medicine and psychology and has recently been attracting much attention as the central component of the Chronic Fatigue syndrome [1] and of the Burnout syndrome [2,3]. The latter seems to have become epidemic in some western countries and is estimated to account for a doubling of sickness absence in Sweden since the mid-1990s. It is of central importance in health care since it is prevalent in the population [4], is increased in many patient groups such as those with cancer [5], cardiovascular disease [6], and depression [7]. It also seems to be a common reason to seek medical aid [4]. It is usually also related to patients' self-care ability [8] and to future morbidity and mortality [6,9].

Despite its apparent importance the concept of fatigue does not have a clear definition. Thus, prevalence data are always dependent on the particular definition used in the particular paper. Another problem is the multidimensionality of the concept, which makes comparisons of aethiological studies difficult. However, systematic studies seem to find between three and five dimensions, including general fatigue (tired, bushed, exhausted), mental fatigue (cognitive impairment), physical fatigue, and sleepiness (tendency to fall asleep), and sometimes motivation or lack of activity [4,10,11]. Measures of burnout tend to combine several of these dimensions, except sleepiness and physical fatigue [3,12], that is they reflect general and mental fatigue.

Fatigue is often seen as resulting either from long term stress or disease [13]. However, there have also been attempts to identify what aspects of stress that are implicated in the causal chain. Thus, Hardy et al. [14] identified work demands and role conflicts as causes of fatigue. Furthermore, publications based on the Maastricht cohort have identified psychological work demands, decision latitude and social support as important predictors of follow-up fatigue [15,16]. In addition, overweight and physical inactivity were predictors in men, whereas underweight was a factor in women [17]. Another Dutch group has demonstrated that work demands are related to the exhaustion (fatigue) component

* Corresponding author. IPM, Box 230, 17177 Stockholm, Sweden. Tel.: +46-8-7286945; fax: +46-8-309910.
E-mail address: torbjorn.akerstedt@ipm.ki.se (T. Åkerstedt).

0022-3999/03/$ – see front matter
doi:10.1016/j.jpsychores.2003.12.001

of the burnout model, whereas resources for counteracting demands (support, reward) are mainly related to the lack of engagement dimension of burnout [18]. In general, the demand/reward imbalance is related to exhaustion [19].

Since much of the burnout literature suggests that a high level of commitment is part of the causation of burnout an interesting predictor could be ''immersion'' in work tasks, as measured by the immersion scale used by Siegrist and others as part of the ''Effort/reward imbalance scale'' [20]. The immersion scale involves questions on how difficult it is to stop thinking of work during leisure time, the amount of overtime, hostility if doubted at work, impatience with slowness in others, etc. To our knowledge the scale has not been used in connection with fatigue and particularly the items involving a continuous preoccupation with work may reflect an extra load beyond that of the work demands or having an extra job.

Clearly, central aspects of fatigue are related to high demands, lack of influence and lack of support and other ''resources''. However, an overlooked component in the link between work and fatigue is insufficient sleep. Many sleep disorders are characterized by fatigue [21]. Excessive work hours, whether from overtime work, having an extra job or having household work, would be a logical contributor to fatigue. However, there is very little systematic studies on the effects of the former and research on overtime work tends to be inconclusive [22] although, for example, some studies have demonstrated higher fatigue in individuals working overtime [23–25]. Shift work is another potential contributor although previous work has shown relations mainly to sleepiness [26].

The present study sought to investigate the contribution of disturbed sleep to the explanation of mental fatigue by psychosocial work factors, and with the addition of physical work factors, work timing, as well as demographic variables.

Method

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 [27,28]. 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 ethical committee of the Karolinska Institute. 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 analysed using logistic regression analysis (SPSS-10 for Macintosh) yielding crude (mutually unadjusted) odds ratios (OR) with 95% confidence intervals (CI). A confidence interval not overlapping unity was interpreted as a ''significant'' result. The dependent variable was ''fatigue''. 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 dichotomized 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 last 12 months. The item ''fatigue'' (literally: ''tired in the head'' in Swedish) from the Karolinska Sleep Questionnaire was used as dependent variable [29]. Levels 4 and 5 were combined to form the outcome category ''fatigue''. Categories 1–3 served as reference for the computation of odds ratios. It should be emphasized that the particular item was chosen since its it describes a ''mushy'' feeling with low mental energy. It would be used typically after long duration mental activity and cannot be confused with physical fatigue or sleepiness. Most fatigue scales discussed above use items such as ''tired'', ''exhausted'', ''fresh,'' etc. which may easily apply to physical fatigue or sleepiness and could therefore not be used in the present case.

As work exposure variables were used: shift work [with night shifts (N) or without night shifts (D) vs. only day work], overtime work [1–8 h/week, 8–15 h/week, >15 h/week, and part-time work (<35 h/week) vs. full time (35–40 h)], having an extra job (vs. not), nonsedentary work (standing/walking > 50% of the time at work vs. <50%), having solitary work (working alone most of the time vs. working alone occasionally or never), physical demands at work [> 8 and 2–8 vs. < 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/Theorell [30]. 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 the following: ''often'' (4), ''sometimes'' (3), ''seldom'' (2), and ''never''(1), with the score within parentheses. There is no established way of determining a cut-off level for this scale [31] but a dominant approach uses the upper quartile vs. the remainder [31]. 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 trichotomization to clearly identify a high and a low group.

Immersion was measured using three items of a 29-item index developed by Siegrist and Peter [20]. Applying a factor analysis yielded three items that formed a particu-

larly clear factor with loadings above .70: "Not being able to stop thinking about work in the evening", "I can relax in the evening after work"(reversed score), "I start thinking about work as soon as I wake up". The items corresponded well with the search for an index to represent continuous preoccupation with work issues. The new index was called "immersion" and had a Chronbach's alpha of .82. The other 26 items were distributed across 4 factors but with very moderate factor loadings. As for cut-off points, >3.8 and >1.9 were used for low and high immersions, respectively.

Decision latitude included questions on the possibility to choose how to do ones 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) [30]. The response alternatives were the same as for work demands, high values (4) indicating high influence. Again, the upper and lower deciles were used to for trichotomization.

The index "Social support at work" contained seven items: relaxed/pleasant atmosphere/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 the following: 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 [32]. Also this variable was dichotomized at the highest and lowest deciles.

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

Data on disturbed sleep was obtained through the Karolinska Sleep Questionnaire [29], containing the following items: difficulties falling asleep, disturbed sleep, repeated awakenings, premature awakening, difficulties awakening, not well rested on awakening, night mares, and heavy snoring. The response alternatives were 5 = always/every day, 4 = mostly/several 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 = .76) [33] based on factor analyses [34], as presented in previous papers [35,36]. This index was dichotomised at the 90th percentile to define those "exposed" to sleep disturbances. In addition, also the item "snoring" was 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.

Table 1
N and % 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
Nonsolitary work	4781	84
Solitary work	896	16
Sedentary work	3582	64
Nonsedentary 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
Low immersion	1088	19
Intermediate immersion	3934	70
High immersion	588	10
No household work	3558	63
Household work	2080	36
BMI low	4715	84
High	917	16
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 years	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
Not disturbed sleep	5114	90
Disturbed sleep	588	10
Not snoring	4917	88
Snoring	664	12
Permanent	5178	92
Non permanent	460	8
No extra job	5099	89
Extra job	600	11

Results

The number of subjects showing high mental fatigue was 604 whereas 5031 did not show mental fatigue, that is, 10.7% vs. 89.3%. The number of subjects in the exposure groups is found in Table 1. There was an internal loss of around 100–300 individuals for most variables.

The mean value and standard deviation 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 out of a scale 1 – 4), 1.68 ± 0.55 for Decision latitude (cut-offs at 2.17 and 3.60 out of 1–4), 1.68 ± 0.50 for Social support at work (cut-off at 1.1 and 2.29 out of 1–4), 2.19 ± 0.71 (cut-off at 3 out of 1–5) for "Disturbed sleep". The latter criterion was set to approximate clinical criteria, which usually involve problems occurring several times per week [37].

Table 2 shows the results from the crude logistic regression without mutual adjustment for the effects of all predictor variables. Significant odds ratios were obtained for high work demands, low social support, being a supervisor, being female, not taking any exercise, being responsible for household work, being immersed in work, snoring, and disturbed sleep.

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 fatigue was predicted by high work demands, low social support, being a supervisor, and being a female. Higher age and exercise were associated with a reduced risk of fatigue. Adding the sleep variables yielded significant odds ratios for both snoring and disturbed sleep. The latter became the predictor with the highest odds ratio. Finally, adding immersion yielded a high odds ratio and reduced somewhat that of disturbed sleep and work demands.

To understand the details of the predictive power of the work demand index a separate multiple logistic regression was tried with its component items as input. This yielded "insufficient time" as the main predictor (1.67; 1.37–2.02), followed by "work intensity" (1.48; 1.20–1.83) and "conflicting demands" (1.39; 1.15–1.69) with "working fast" and "working hard" without any significant contributions (1.06; 0.81–1.38 and 0.89; 0.72–1.10). Removing the first item left the second item as the main predictor.

The same procedure with the sleep quality index yielded "disturbed sleep" as the main predictor (4.18; 3.28–5.32), followed by "difficulties falling asleep" (1.94; 1.45–2.59), premature awakening (1.54; 1.20–1.98) and "repeated awakenings" (1.51; 1.11–2.05). Finally, the items constituting "immersion" yielded very similar odds ratios 1.73 (1.37–2.19) for "not being able to stop thinking of work 1.68 (1.35–2.09) for beginning to think of work as soon as one wakes up" and 0.58 (0.47–0.72) for "being able to relax in after work".

Since overtime work was expected to be related to mental fatigue, but failed to show a significant F ratio it was entered into the multiple regression analysis in a separate step. This

Table 2
Odds ratios (with 95% CI) from crude logistic regression against mental fatigue

Predictor	*N*/%	OR (CI)
Low work demands	35/6	1
Medium work demands	435/10	1.64 (1.15–2.34)
High work demands	136/22	4.39 (2.97–6.49)
Low decision latitude	44/11	1
Medium decision latitude	476/11	0.95 (0.68–1.32)
High decision latitude	86/10	0.85 (0.58–1.25)
Low social support vs. high	111/20	1
Medium social support	453/10	0.46 (0.36–0.58)
High social support	40/7	0.30 (0.21–0.44)
Not supervisor	498/11	1
Supervisor	98/9	0.77 (0.61–0.97)
Blue collar	269/11	1
Lower white collar	230/11	0.96 (0.80–1.16)
High white collar	94/10	0.95 (0.74–1.22)
Nonsolitary work	497/11	1
Solitary work	103/12	1.12 (0.89–1.40)
Sedentary work	403/11	1
Nonsedentary work	197/10	0.85 (0.71–1.01)
Low physical load	171/11	1
Medium physical load	344/10	0.89 (0.73–1.08)
High physical load*	88/13	1.20 (0.91–1.58)
Full time	300/11	1
Part time	64/14	1.32 (0.98–1.76)
Overtime 1–7 h	147/10	0.87 (0.70–1.07)
Overtime 8–15 h	68/11	0.99 (0.75–1.31)
Overtime >15 h	16/1.4	1.32 (0.77–2.26)
Day work	370/11	1
Shift work–day only	171/12	1.09 (0.90–1.32)
Shift work–with nights	45/8	0.77 (0.56–1.07)
No extra job	538/11	1
Extra job	62/12	1.14 (0.86–1.50)
Married	423/10	1
Unmarried*	183/12	1.12 (0.93–1.35)
Male	373/15	1
Female*	233/7	2.30 (1.93–2.73)
Age <30	103/10	1
Age 30–45	267/12	1.19 (0.93–1.51)
Age >45*	236/9	0.89 (0.70–1.14)
No children <7	309/10	1
Children <7	296/11	1.12 (0.95–1.33)
No exercise	191/15	1
Exercise*	415/10	0.63 (0.52–0.76)
Coffee <3 cups/day	438/11	1
Coffee ≥4 cups/day	168/10	0.93 (0.77–1.12)
Not smoker	439/10	1
Smoker	164/12	1.12 (0.92–1.35)
BMI <28	508/11	1
BMI ≥28*	93/10	0.94 (0.74–1.18)
No household work	347/10	1
Household work	257/12	1.31 (1.10–1.55)
Low Immersion	62/6	1
Medium Immersion	368/9	1.71 (1.29–2.55)
High Immersion	171/29	6.79 (4.97–9.27)
Permanent position	555/11	1
Nonpermanent position	49/11	0.99 (0.73–1.35)
Nondisturbed sleep	413/8	1
Disturbed sleep	193/3	5.58 (4.57–6.82)
Not snoring	489/10	1
Snoring	104/16	1.69 (1.34–2.12)

Also N in frequency and percent for each exposure group who reported fatigue.

Table 3
Results from multiple logistic regression against mental fatigue, using only significant predictors from crude analysis

	First step OR and 95% CI	Disturbed sleep and snoring added OR and 95% CI	Immersion added OR and 95% CI
Low work demands	1	1	1
Medium work demands	1.57 (1.09–2.26)	1.51 (1.04–2.19)	1.23 (0.84–1.80)
High work demands	3.84 (2.55–5.79)	3.48 (2.28–5.32)	2.39 (1.54–3.69)
Low social support	1	1	1
Medium social support	0.52 (0.41–0.66)	0.62 (0.48–0.81)	0.63 (0.52–0.88)
High social support	0.40 (0.27–0.59)	0.49 (0.32–0.74)	0.52 (0.37–0.86)
Not supervisor	1	1	1
Supervisor	0.76 (0.60–0.97)	0.75 (0.58–0.96)	0.63 (0.49–0.82)
Male	1	1	1
Female	2.24 (1.85–2.70)	2.36 (1.93–2.88)	2.31 (1.89–2.84)
Age <30	1	1	1
Age 30–45	1.09 (0.85–1.40)	1.01 (0.78–1.31)	0.95 (0.73–1.24)
Age >45*	0.83 (0.64–1.08)	0.64 (0.48–0.83)	0.60 (0.46–0.80)
No exercise	1	1	1
Exercise*	0.58 (0.48–0.70)	0.65 (0.53–0.80)	0.70 (0.57–0.86)
No household work	1	1	1
Household work	1.00 (0.83–1.20)	0.94 (0.77–1.14)	0.97 (0.79–1.18)
Nondisturbed sleep		1	1
Disturbed sleep		5.14 (4.14–6.39)	4.31 (3.50–5.45)
Not snoring		1	1
Snoring		2.14 (1.65–2.78)	2.15 (1.64–2.81)
Low immersion			1
Medium immersion			1.48 (1.10–1.99)
High immersion			4.17 (2.92–5.94)

OR=odds ratio; CI=confidence interval. Disturbed sleep and snoring added in a second step, and immersion in a third step.

yielded significant odds ratios (*reduced* risk) for the 41–48 h (0.68; 0.54–0.85) and 48–55 h (0.69; 0.50–0.95 h) groups, but not for the 55+ h (0.94; 0.51–1.73) or part-time (1.07; 0.79–1.45) groups. For the original predictors the odds ratios were not markedly affected.

The effect of adding overtime work to the multivariate logistic regression suggests an interaction with other variables. Table 4 presents a tabulation of work hours against key predictors. With increasing overtime work there was a strong increase in the proportion of males and of work demands, decision latitude, immersion, as well as a very strong decrease of physical demands. Social support varied significantly with overtime work but the relation was rather weak.

Table 4
Percent individuals in high exposure groups across work hour categories and χ^2 values

	<35 h	35–41 h	41–48 h (+1–7 h)	48–55 h (+8–14 h)	55+h >+15 h	χ^2
45+ years	47	45	41	46	48	72***
Female	77	45	37	27	15	355***
Work demand high	8	6	14	23	39	431***
Decision latitude high	10	8	20	34	42	452***
Social support high	15	11	9	8	10	25*
Phys demands high	13	15	8	7	7	142***
Immersion high	7	5	14	23	25	434***
Socioeconomic group high	13	8	21	38	55	930***

* = $P < .05$.
** = $P < .01$.
*** = $P > .001$.

Discussion

Fatigue was predicted by high work demands, low social support, not being a supervisor, female gender, lower age, lack of exercise, inability to stop thinking about work during leisure time, snoring and disturbed sleep. The latter became the major predictor.

Among the variables relating to the work situation the strong contribution of high work demands and low social support add to a number of previous studies with the same outcome [14–16,18,19]. These factors are apparently key determinants of mental fatigue. The analysis of the separate items suggests that it is the lack of time and the intensity of work that are the key components. The importance of the latter is perhaps also brought out in the strong effect of immersing oneself in work in the sense that work is always present in one's thoughts. Immersion has also been shown to predict different types of disease [20]. Also, decision latitude or "resources" was a contributor in most of the studies cited above, but not in the present one. It is worth noting that socioeconomic group, physical workload, and nonsedentary work were not related to mental fatigue. This supports the notion that the dependent variable was not misperceived as an indicator of physical fatigue.

Having to do most of the household work was a logical predictor, even if there is rather little previous work to support the result. However, the significant odds ratio from the crude analysis did not hold in the multivariate analysis. Having an extra job did not have any predictive power. Possibly this status is self-selected and may attract mainly individuals with spare capacity.

In contrast to what was expected [22–25], overtime work lacked a relation to fatigue in the crude analysis. The reason for that may be that in the present study self-reported overtime includes *voluntary* overtime work, even if that prevalence is unknown in the present sample. This self-selection (as may be the case for extra work) will probably be associated with a health status that permits extended hours, as well as one that is associated with a higher resilience. These factors were not measured in the present study, however, and their impact cannot be estimated. In addition, a reduction in risk was seen when the overtime variable was added to the multivariate regression, apparently due to the resulting control for work demands.

Interestingly, more overtime work is found in occupations with a good physical work environment, more interesting work tasks and more decision latitude. These factors may be buffering against any ill effects of overtime work. This seems to suggest that to the present overtime workers, the extra hours in themselves were not only not a fatigue problem, but may have reflected better health or a higher resilience. It is also possible that overtime may serve as a safety valve, permitting the employee to catch up and reduce overload stress. Overall, overtime seems to be a more complicated concept than what appears from simple tabulations of hours of work. Understanding its role in occupational health probably requires a differentiation between different types of overtime, based on degree of voluntariness and other factors.

Shift work failed to show a significant relation to fatigue, and there seems no reason for a connection so long as respondents do not mistake mental fatigue for sleepiness, which clearly is related to shift work [26].

Perhaps the most important finding was the contribution of disturbed sleep and snoring. The latter could be misjudged as redundant since it reflects disturbed sleep. This is probably not true, however, since snoring and sleep apnea are normally not associated with an awareness of difficulties sleeping but rather with the bed partner's observation of respiratory obstruction and marked snoring [38]. The two sleep variables added to the explanatory power of the analysis without reducing the odds ratios of any of the other parameters. Apparently, disturbed sleep has to be considered in the aethiology of mental fatigue. All four separate items of the sleep quality index were related to fatigue, but the strongest contributor was the degree of overall disturbance.

Interestingly, immersion, became another important explaining variable, taking over part of the effect of high work demands. In a previous study we showed that the inability to turn off thoughts of work during leisure time took over the connection between high work demands and disturbed sleep [36]. This suggests that at least part of the effect of high work demands may be due to the inability to wind down after work and/or worrying about work the next day.

With regard to the other variables the contribution of female gender to mental fatigue was expected from previous work [7,39–42]. Some have failed to find an effect but these studies are few [14,43]. The explanation of the gender effect is frequently suggested to be the greater social/family responsibility of the female, but this has not been reliably demonstrated.

The significant age effect associated with lower fatigue seems counterintuitive and it should be emphasized that there was no significant effect in the crude analysis—only in the multivariate one—age was entered into this analysis as a control variable. Interestingly, a previous analysis of the same material, focusing on falling asleep at work, a very strong effect of high age on low risk was seen [44]. The results could mean that work load is lower in higher age groups, and that there perhaps might be a self-selection out of fatigue-inducing work with increasing age.

A high BMI has been related to fatigue [17], but in the present analysis only lack of exercise became a significant contributor, as has been demonstrated in a previous study [17]. Exercise seems a logical positive countermeasure of mental fatigue, but it may also be the case that mentally fatigued individuals simply cannot bring themselves to exercise.

It should be borne in mind that the dependent variable was a single item on mental fatigue. Possibly, results may have differed had a full "fatigue" scale been used measuring several dimensions. However, as mentioned in the Methods section we could not use scales that included items like "fatigued", "tired", "exhausted", "empty batteries", etc. since both physical fatigue and sleepiness are associated with such items. The lack of relation between mental fatigue and physical work load on the one hand and shift work on the other encourages us to believe that the participants interpreted "mental fatigue" (tired in the head) as intended. This is also supported by the high predictive value of mental workload and immersion, which not would be expected to be related to physical fatigue or sleepiness. The fact that disturbed sleep predicted mental fatigue does not run counter to our notions, for example, insomniacs are not characterized by sleepiness but by mental fatigue and weariness. It should also be emphasized that the present study is cross-sectional and may only suggest connections; no conclusions on causation are possible.

In summary, fatigue is closely related to high work demands, immersion in work, disturbed sleep, as well as to female gender.

Acknowledgments

This study was supported by the Swedish Work Environment Fund.

References

[1] Holmes GP, Kaplan JE, Ganz NM, Komaroff SL, Schonberger LO, Straus SE, Jones JR, Dubois KE, Cunningham-Rundles L, Paliwa S, Tosato G, Zegaus LS, Purlilo DT, Brown N, Schooley RT, Brus I. Chronic fatigue syndrome: a working case definition. Ann Intern Med 1998;108:387–9.

[2] Weber A, Jaekel-Reinhard A. Burnout syndrome: a disease of modern societies? Occup Med 2000;50:512–7.

[3] Maslach C, Schaufeli WB, Leiter MP. Job Burnout. Annu Rev Psychol 2001;52:397–422.

[4] Watt T, Gronenvold M, Bjorner JB, Noerholm V, Rasmussen N-A, Bech P. Fatigue in the Danish general population. Influence of sociodemographic factors and disease. J Epidemiol Comm Health 2000;54:827–33.

[5] Richardson GS, Wyatt JK, Sullivan JP, Orav EJ, Ward AE, Wolf MA, Zeisler CA. Objective assessment of sleep and alertness in medical house staff and the impact of protected time for sleep. Sleep 1996; 19:718–26.

[6] Appels A, Mulder P. Excess fatigue as a precursor of myocardial infarction. Eur Heart J 1988;9:758–64.

[7] Fuhrer R, Wessely S. The epidemiology of fatigue and depression: a French primary-care study. Psychol Med 1995;25:895–905.

[8] Visser MRM, Smets EMA. Fatigue, depression and quality of life in cancer patients: how are they related? Support Care Cancer 1998;6: 101–8.

[9] Avlund K, Schultz-Larsen K, Davidsen M. Tiredness in daily activities at age 70 as a predictor of mortality during the next 10 years. J Clin Epidemiol 1998;51:323–33.

[10] Ream E, Richardson A. Fatigue: a concept analysis. J Nurs Stud 1996;33:519–29.

[11] Dalakas MC, Mock V, Hawkins MJ. Fatigue: definitions, mechanisms, and paradigms for study. Semin Oncol 1998;25:48–53.

[12] Melamed S, Kushnir T, Shirom A. Burnout and risk factors for cardiovascular diseases. Behav Med 1992;18:53–60.

[13] Lewis G, Wessely S. The epidemiology of fatigue: more questions than answers. J Epidemiol Comm Health 1992;46:92–7.

[14] Hardy GE, Shapiro DA, Borrill CS. Fatigue in the workforce of national health service trusts: levels of symptomatology and links with minor psychiatric disorder, demographic, occupational and work role factors. J Psychosom Res 1997;43:83–92.

[15] Bültmann U, Kant IJ, van den Brandt PA, Kasl SV. Psychosocial work characteristics as risk factors for the onset of fatigue and psychological distress: prospective results from the Maastrich Cohort study. Psychol Med 2002;32:333–45.

[16] Bültmann U, Kant I, van Amelsvoort LGPM, Kasl SV. Differences in fatigue and psychological distress across occupations: results from the Maastrich Cohort Study of fatigue at work. JOEM 2001;43: 976–83.

[17] Bültmann U, Kant I, Kasl SV, Schröer KAP, Swaen GMH, van den Brandt PA. Lifestyle factors as risk factors for fatigue and psychological distress in the working population: prospective results from the Maastrich Cohort Study. JOEM 2002;44:116–24.

[18] Demerouti E, Bakker AB, Nachreiner F, Schaufeli WB. The job demands–resources model of burnout. J Appl Psychol 2001;86: 499–512.

[19] Bakker AB, Killmer CH, Siegrist J, Schaufeli WB. Effort–reward imbalance and burnout among nurses. J Adv Nurs 2000;31:884–91.

[20] Siegrist J, Peter R. The effort–reward imbalance model. Occup Med 2000;15:83–7.

[21] Lichstein KL, Means MK, Noe SL, Anguillard RN. Fatigue and sleep disorders. Behav Res Ther 1997;35:733–40.

[22] Spurgeon A, Harrington JM, Cooper CL. Health and safety problems associated with long working hours: a review of the current position. Occup Environ Med 1997;54:367–75.

[23] Proctor SP, White RF, Robins TG, Echeverria D, Rocskay AZ. Effect of overtime work on cognitive function in automotive workers. Scand J Work Environ Health 1996;22:124–32.

[24] Kageyama T, Nishikido N, Kabayashi T, Kukokawa Y, Kaneko T, Kabuto M. Long commuting time, extensive overtime, and sympathodominant state assessed in terms of short-term heart rate variability among male white-collar workers in the Tokyo megalopolis. Ind Health 1998;36:209–17.

[25] Park J, Kim Y, Chung HK, Hisanaga N. Long working hours and subjective fatigue symptoms. Ind Health 2001;39:250–4.

[26] Åkerstedt T. Shift work and disturbed sleep/wakefulness. Sleep Med Rev 1998;2:117–28.

[27] Peter R, Alfredsson L, Knutsson A, Siegrist J, Westerholm P. Does a stressful psychosocial work environment mediate the effects of shift work on cardiovascular risk factors? Scand J Work Environ Health 1999;25:376–81.

[28] Theorell T, Alfredsson L, Westerholm P, Falck B. Coping with unfair treatment at work—what is the relationship between coping and hypertension in middle-aged men and women? Psychother Psychosom 2000;69:86–94.

[29] Åkerstedt T, Fredlund P, Gillberg M, Jansson B. Work load and work hours in relation to disturbed sleep and fatigue in a large representative sample. J Psychosom Res 2002;53:585–8.

[30] Karasek R, Theorell T, editors. Healthy work. New York: Basic Book, 1990.

[31] Landsbergis PA, Schnall PL, Warren K, Pickering TG, Schwartz JE. Association between ambulatory blood pressure and alternative formulations of job strain. Scand J Environ Health 1994;20:349–63.

[32] Theorell T. The demand–control–support model for studying health in relation to the work environment: an interactive model. In: Orth-Gomér K, Schneiderman N, editors. Behavioral medicine approaches to cardiovascular disease prevention. New Jersey: Erlbaum, 1996. pp. 69–85.

[33] Cronbach LJ. Coefficient alpha and the internal structure of tests. Psykometrika 1951;16:297–333.

[34] Winer BJ, editor. Statistical principles in experimental design. New York: McGraw-Hill, 1971.

[35] Kecklund G, Åkerstedt T. The psychometric properties of the Karolinska Sleep Questionnaire. J Sleep Res 1992;1(Suppl 1):113.

[36] Åkerstedt T, Knutsson A, Westerholm P, Theorell T, Alfredsson L, Kecklund G. Sleep disturbances, work stress and work hours. A cross-sectional study. J Psychosom Res 2002;53:741–8.

[37] Krystal AD, Edinger JD, Wohlgemuth WK, Marsh CR. NREM sleep EEG frequency spectral correlates of sleep complaints in primary insomnia subtypes. Sleep 2002;25:630–40.

[38] Maislin G, Pack AI, Kribbs NB, Smith PL, Schwartz AR, Kline LR, Schwab RJ, Dinges DF. A survey screen for prediction of apnea. Sleep 1995;18:158–66.

[39] Chen MK. The epidemiology of self-perceived fatigue among adults. Prev Med 1986;15:74–81.

[40] Hickie IB, Hooker AW, Hadzi-Pavlovic D, Bennett BK, Wilson AJ, Lloyd AR. Fatigue in selected primary care settings: sociodemographic and psychiatric correlates. Med J Aust 1996;164:585–8.

[41] Van Mens-Verhulst J, Bensing J. Distinguishing between chronic and nonchronic fatigue, the role of gender and age. Soc Sci Med 1998; 47:621–34.

[42] Wessely S, Chalder T, Hirsch S, Wallace P, Wright D. The prevalence and morbidity of chronic fatigue and chronic fatigue syndrome: a prospective primary care study. Am J Publ Health 1997; 87:1449–55.

[43] Wessely S, Chalder T, Hirsch S, Pawlikowska T, Wallace P, Wright D. Postinfectious fatigue: prospective cohort study in primary care. Lancet 1995;345:1333–8.

[44] Åkerstedt T, Knutsson A, Westerholm P, Theorell T, Alfredsson L, Kecklund G. Work organization and unintentional sleep: results from the WOLF study. Occup Environ Med 2002;59:595–600.