Insufficient Sleep—A Population-Based Study in Adults

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Study objectives: Insufficient sleep (sleep deprivation) is a common problem of considerable health, social, and economical impact. We assessed its prevalence and associations, and the role of genetic influences.

Design: Panel study based on questionnaires administered in 1981 and 1990.

Setting/Patients: 12.423 subjects aged 33—60 years included in the Finnish Twin Cohort, representative of the Finnish population.

Interventions: N/A

Measurements: A difference of 1 hour between the self-reports of the sleep need and the sleep length was considered insufficient sleep. Associations with education, life style, work, psychological characteristics and sleep-wake variables were assessed. Structural equation modelling techniques were used to compare genetic models among monozygotic and dizygotic twin pairs.

Results: In 1990, the prevalence of insufficient sleep was 20.4% (16.2% in men and 23.9% in women). 44% of those with insufficient sleep in 1981 also had it 9 years later (Spearman correlation for persistence 0.334). In multivariate analyses, the strongest positively associated factors were daytime sleepiness (women: odds ratio 3.87, 95% confidence limits 3.24-4.63/men: 3.77,2.98-4.75), insomnia (2.48,1.92-3.19/2.91,2.17-3.90), not able to sleep without disturbance (1.95,1.47-2.60/2.54,1.66-3.89), and evening type (2.10,1.65-2.69/1.73,1.25-2.41). Among men, also weekly working hours ≥75 was strongly associated (3.23,1.54-6.78). "Not working" was negatively associated in both genders (0.68,0.51-0.89/0.59,0.42-0.83). Two thirds of the interindividual variability in the liability to insufficient sleep was attributed to non-genetic factors.

Conclusions: Insufficient sleep is a common and long-standing condition, most strongly associated with sleep/wake variables. One third of the liability to it is attributed to genetic influences. Sleep sufficiency should be assesssed in health examinations of working adults.

Key words: Sleep deprivation; prevalence; health survey; panel study; twins

INTRODUCTION

SLEEP IS ONE OF THE FUNDAMENTAL CONDITIONS FOR QUALITY OF LIFE. Many primary sleep disorders as well as medical and psychiatric disorders can interfere with the effort to satisfy the need for sleep.[1] Insomnia and other sleep disturbances are common symptoms in depression,[2] and there is evidence suggesting that insomnia may predispose to psychiatric disorders.[3]

Data from laboratory studies indicate that nocturnal sleep periods reduced by 1.3 to 1.5 hours for one night result in a reduction of daytime alertness by as much as 32% measured by the multiple sleep latency test (MSLT), the best validated objective measure of daytime sleepiness.[4] These authors also assessed that a significant sleep loss exists in one third or more of normal adult population.

The *International Classification of Sleep Disorders*[1] defines a condition of voluntary, albeit unintentional, sleep deprivation as follows: Insufficient sleep syndrome is a disorder that occurs in an individual who persistently fails to obtain sufficient nocturnal sleep required to support normally alert wakefulness. There are also polysomnographic and MSLT criteria for the diagnosis, thus requiring a sleep laboratory examination to fulfill the diagnostic criteria. The prevalence of insufficient sleep syndrome in general population is not known, but it is diagnosed in about 2% of the patients who present to sleep disorders centers.[1]

There are few population studies assessing sleep deprivation or insufficient sleep. In a questionnaire study Broman et al.[5] found among 600 subjects aged 20—64 years "persistent insufficient sleep" in 12%, half of them with "sleeping difficulties." Recently, in a Finnish questionnaire study an even higher prevalence—36% has been reported among 24—65-year-old population (3300 respondents).[6]

Our aims were to investigate the population prevalence of insufficient sleep based on a self-report of assessed length of sleep actually obtained and the amount needed. We also investigated characteristics associated with insufficient sleep. As our study population consisted of twins, we also performed pairwise analyses and genetic modelling to assess the role of genetic factors in insufficient sleep.

MATERIALS AND METHODS

The Finnish Twin Cohort Questionnaire Surveys

The Finnish Twin Cohort was compiled in 1974 for the study of genetic and environmental factors in chronic diseases in the Finnish population. The database from the Central Population Registry of Finland was used to form the basis of the Cohort, 17.357 like-sexed twin pairs born before 1958. The response rate to first questionnaire in 1975 was 89% and to the second questionnaire in 1981 84%. In 1990, a third questionnaire was mailed to pairs born 1930—57 with both co-twins resident in Finland in 1987, and 16,179 twin individuals could be contacted (response

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rate 77.3%; N = 12,502).[8] The mean age in 1990 was 43.9 years (standard deviation 7.8 and range 33—60 years), and 54.4% of the subjects were women. The respondents were divided into three age-groups: 33.7% of men and 37.7% of women were 33—39 years old, and correspondingly in 40—49-year-old 39.2% and 37.5%, and in 50—60-year-old 27.1% and 24.8%. The study was approved by the ethical committee of the Department of Public Health, University of Helsinki. An informed consent was obtained from the respondents.

Assessment of Insufficient Sleep

The 1981 and the 1990 questionnaires included the following two questions, both with nine response alternatives with ½ hour intervals ranging from ≤6 hours to ≥10 hours: 1). "How many hours of sleep do you need during the night to be alert the next day ?"; and 2). "How many hours do you usually sleep per 24 hours ?" (Table 1). A difference of one hour or more was considered to indicate insufficient sleep. Both questions were answered by 12,423 individuals, including 1318 (526 male and 792 female) monozygotic (MZ) and 2475 (1060 male and 1415 female) dizygotic (DZ) pairs with both co-twins responding. Twin zygosity was determined by a validated questionnaire method.[9]

Other Variables

1. Education was assessed on the basis of schools and higher-level institutions attended. The respondents' education level was classified as primary (up to six years of education), secondary (7—11 years), or tertiary (12 years or more).

2. Lifestyle included questions on smoking status,[10] heavy alcohol use (>70 g ethanol at a time at least once monthly),[11] and leisure exercise using a four category metabolic equivalent index, based on calculating the product of intensity x duration x frequency of physical activity.[12]

3. Work effects were assessed by asking working status (working vs. not working), time of day for working (daytime vs. other than daytime work), and the number of weekly working hours (adding home work to paid hours) in seven categories ranging from <25 to ≥75.

4. Psychological characteristics—Life satisfaction was measured according to Allardt's four item scale (1973) on levels on interest, happiness, easiness and loneliness of life.[13] Scale values 4—6 indicated satisfaction, 7—11 intermediate status, and 12—20 dissatisfaction. Stress of daily activities was defined by four self-reported items on the level of feeling tense and nervous, subjective stress, mental and physical exhaustion, and being burdened.[13] Scale values 4—8 indicated a high stress level, 9—15 some stress, and 16 none. The questionnaire also included the 21-item Beck Depression Inventory.[14,15] Scores ≥14 on a range of 0 to 63 were considered to indicate the presence of depression. All the scales have good psychometric properties with Cronbach's alpha >0.7.

5. Sleep-wake variables—Diurnal type was classified by the self-report of morningness-eveningness (modified from [16]). The respondents were asked to characterize themselves as "morning type," "slightly morning type," "slightly evening type," or "evening type." Daytime sleepiness was assessed by asking "Do you feel sleepiness during daytime?" and insomnia by asking "How often do you suffer from sleeplessness?", with five alternative replies: 1) "less than once a month or never," 2) "less than once a week," 3) "on 1-2 days weekly," 4) "on three to five days weekly," and 5) "every or almost every day/night."[17] The frequency of sleeping without disturbance ("usually", "sometimes not," or "generally not") was used to determine the role of external sleep-disturbing factors. The question on napping ["Do you sleep during daytime (take naps)?"] had five response alternatives: 1) "no need", 2) "I would like to but I am unable to sleep during daytime," 3) "on two days weekly or less frequently," 4) "on three to five days weekly," and 5) "daily or almost daily." The category "napping <3 days/week" includes the following response alternatives: "napping on one to two days weekly or less often," "no need for napping," and "unable to nap."

Diurnal type and education were asked in the 1981 questionnaire and not repeated in the 1990 questionnaire, and the other items in the 1990 questionnaire.

Statistical Methods

Statistics were computed using the SAS (version 6.12 for PCS) program.[18] Strength of the association was assessed using odds ratio ([16];63-64). Logistic regression analyses with generalized estimating equations were used to estimate odds ratios (OR) and their 95% confidence limits (CL) for insufficient sleep, while taking into account that the observations came from clusters (twin pairs) with either one or two respondents. The OR approximates the relative risk of insufficient sleep between two categories of the associated variables. Odds ratios indicate statistical significance (corresponding to $p<0.05$) when the lower 95% CL is >1 (increased risk) and when the upper 95% CL<1 (lowered risk). Adjustment for age and associated variables were done separately for men and women. The significance of each associated variable was assessed using univariate analysis and to take into account the interdependence between the variables also multivariate analysis was done. Tests for trend in the multivariate analysis were performed by assigning a score variable with increasing values (1, 2, 3,. . ., n) to the n categories of ordered variables (e.g., weekly working hours). This score variable was entered into the regression model as a continuous variable. The test statistic was the ratio of the regression coefficient to its standard error, and a p-value was computed from that. Structural equation modelling techniques were used to estimate variance components from the pairwise data and to compare different genetic models.[17,19,20]

RESULTS

Prevalence and Persistence of Insufficient Sleep

Table 1 shows the number of subjects in each nocturnal sleep length and sleep need category by gender, with the percentage of those with insufficient sleep in each group. Insufficient sleep is linearly associated both with the length of nocturnal sleep (negatively) and the need of sleep (positively). Although the percentages of women with sleep deprivation in different sleep length and sleep need categories were higher, the differences were not statistically significant.

In 79.6% of the subjects the sleep length differed less than one hour from the need. For 20.4% the length was at least one hour less than the need, and there was a significant gender difference

Table 1—Prevalence of insufficient sleep (%) by categories of self-reports on nocturnal sleep and need of sleep, based on the 1990 questionnaire from the Finnish Twin Cohort. Numbers (N) of subjects in each response category given by genders, as also odds ratios (OR) and their 95% confidence limits (95% CL).

	TOTAL SAMPLE (N = 12,423)				MEN		WOMEN	
	MEN (N = 5,665)		WOMEN (N = 6,758)					
	N	%	N	%	OR	95% CL	OR	95% CL
Nocturnal sleep (hours)								
- ≤6.0	508	37.0	476	54.4	15.4	8.16-29.2	28.8	18.4-44.9
- 6.5-7.0	2190	24.5	2183	40.1	8.43	4.54-15.7	14.9	9.83-22.5
- 7.5-8.5	2654	6.8	3521	12.9	1.92	1.02-3.60	3.20	2.11-4.84
- ≥9.0	313	3.5	578	4.3	1.00	-	1.00	-
Need of sleep (hours)								
- ≥9.0	395	49.6	898	49.2	29.3	21.8-39.2	17.2	13.5-22.0
- 7.5-8.5	2645	23.9	4000	26.9	9.13	7.22-11.5	6.40	5.14-7.97
- ≤7.0	2625	3.3	1860	5.2	1.00	-	1.00	-

(in 16.2% of men and in 23.9% of women, chi-square=113.2, p<0.001). Of the total study population, 12.8% slept one hour less and 7.6% at least 1.5 hours less than their own assessment of need.

The persistence of insufficient sleep was assessed by comparing the reports of the two questionnaires administered in 1981 and in 1990. Of all respondents available for this analysis (N=11,836) 68.6% indicated no insufficient sleep at either survey, whereas 8.5% had insufficient sleep according to both surveys. A little less than half of those with insufficient sleep in 1981 (10.8% of the total population) reported no insufficiency in 1990. A little more than half of those with insufficient sleep in 1990 (12.1% of the total population) had sufficient sleep in 1981. Insufficient sleep was overall reported by 19.3% of respondents in 1981, and by 20.6% in 1990. The Spearman correlation for persistence over the period 1981—1990 was 0.334, giving a yearly persistence of 0.89 (estimated as an annual autocorrelation, thus the correlation for the nine year period persistence 1981—90 is 0.89^9=0.334).

Variables Associated with Insufficient Sleep in Individuals (Table 2 and 3)

There was a significant age effect among both genders (p=0.001). In men aged 33—39 years insufficient sleep occurred in 20.0% and in men aged 50—60 years in 12.8%. In women the respective figures were 27.6% and 19.3%. Table 2 gives the crude rates of insufficient sleep, while Table 3 gives the age-adjusted relative risk by covariate categories. Education was significantly (positively) associated (P < 0.05) with insufficient sleep only in men with primary level education.

Heavy alcohol use was significantly (positively) associated with insufficient sleep in both genders (p<0.05), but smoking only for currently smoking women. The most actively exercising fourth reported significantly less often insufficient sleep both in men and women (p<0.05).

The effect of work showed significant gender differences. In women working in general and in men daytime work decreased the frequency of insufficient sleep. A higher level of weekly working hours (≥40) was positively associated with insufficient sleep in women (p<0.05).

Stress of daily activities, life satisfaction, and depression were all significantly (positively) associated with insufficient sleep (p<0.05).

Evening type persons of both genders reported significantly more insufficient sleep (p<0.05). Frequent daytime sleepiness and insomnia were also strongly (positively) associated with insufficient sleep as well as not being able to sleep without disturbance in both genders (in all three variables p<0.05), but frequent napping was significant only in women.

We repeated the analyses after excluding the following defined subgroups with suspected higher frequencies of insufficient sleep: the retired, unemployed, and those who never have been working (14.9% of the total study population); persons with depression (as indicated by a Beck Depression Inventory total score ≥14; 8.3%); subjects working outside normal daytime working hours (18.6%); persons with chronic insomnia (≥ three days per week; 7.1%); and persons taking regularly naps during wake period (≥ three days per week; 14.8%). After these exclusions the sample for further analyses included 6505 subjects (52.0% of the original sample). The original associations to the other variables remained significant and essentially unchanged.

Multivariable Analysis

In multivariable logistic regression analyses (Table 4) 10 of the 17 analyzed factors initially associated (based on age-adjusted analyses) with insufficient sleep remained significant. Among those that became non-significant were all lifestyle factors (smoking, heavy alcohol use, and leisure exercise). The strongest positively associated factors (in order) were among women daytime sleepiness (≥3 days weekly; OR 3.87, 95% CL 3.24-4.63), insomnia (≥3 days weekly; 2.48, 1.92-3.19), and evening type (2.10, 1.65-2.69). Correspondingly, among men the strongest associations were to daytime sleepiness (≥3 days weekly; 3.77, 2.98-4.75), weekly working hours ≥75 (3.23, 1.54-6.78), and insomnia (≥3 days weekly; 2.91, 2.17-3.90). Weekly working hours showed a linear association in men (linear trend test p=0.0037, d.f.=1), but a more complex association in women (trend test p=0.081, d.f.=1), with a maximum at 55—64 hours, and decreasing with both fewer and more working hours. Not working was significantly negatively associated with insufficient

Table 2—Prevalence of insufficient sleep (%) by categories of associated variables, based on the 1990 questionnaire from the Finnish Twin Cohort (N=12,423). Numbers (N) of subjects in each response category given by genders.

VARIABLE	MEN		WOMEN	
	N	%	N	%
Total sample	5665	16.2	6758	23.9
Age (years)				
- 33-39	1907	20.0	2546	27.6
- 40-49	2220	15.1	2537	23.1
- 50-60	1538	12.8	1675	19.3
Education				
- primary	1966	16.9	2304	22.6
- secondary	2676	16.3	3084	23.8
- tertiary	744	14.9	1115	27.4
Smoking				
- never	1923	15.2	3832	22.1
- occasionally	220	15.0	195	17.4
- former	1616	15.2	1143	25.6
- current	1722	17.8	1390	28.4
Heavy alcohol use				
- no	3071	14.3	5832	23.0
- yes	2511	18.2	812	29.1
Leisure exercise				
- least active fourth	1588	18.3	1407	25.4
- 2nd fourth	1346	15.7	1739	24.6
- 3rd fourth	1139	15.7	1619	22.9
- most active fourth	1524	14.5	1886	22.5
Working	4523	16.7	5766	24.6
Not working	943	13.6	857	18.2
Daytime work	4613	15.5	5270	23.8
Other than daytime work	954	19.2	1305	23.9
Weekly working hours (paid)				
- none	755	13.9	1254	21.3
- <40	1601	14.3	3168	23.2
- ≥40	3226	17.6	2216	26.5
Weekly working hours (paid and at home)				
- <25	625	13.9	492	19.7
- 25-35	139	13.7	382	18.8
- 35-45	1129	15.1	623	24.1
- 45-54	1866	15.0	2469	22.3
- 55-64	1505	18.1	1475	28.3
- 65-74	242	21.1	873	25.5
- ≥75	56	32.1	303	24.4
Stress of daily activities				
- none	1251	8.4	1573	13.0
- intermediate	3871	17.0	4375	26.0
- high	266	36.1	380	44.5
Life satisfaction				
- satisfied	1099	10.0	1363	16.2
- intermediate	3671	15.3	4270	23.3
- dissatisfied	866	27.0	1090	35.7
Beck Depression Inventory				
- non-depressed	5067	14.5	5751	21.9
- depressed	419	36.8	768	40.0
Diurnal type				
- morning type	1283	12.5	1726	18.1
- slightly morning type	1656	14.2	1817	20.1
- slightly evening type	1899	19.8	2323	28.4
- evening type	512	20.5	609	34.7
Daytime sleepiness				
- ≥3 days/week	733	34.9	1194	45.9
- 1-2 days/week	1104	25.3	1491	32.8
- < 1day/week	3786	9.9	4029	14.1

Table 2 Continued

VARIABLE	MEN		WOMEN	
	N	%	N	%
Able to sleep without disturbance				
- usually	4677	13.7	5230	20.6
- sometimes not	807	24.8	1155	32.4
- generally not	153	42.5	337	44.8
Insomnia				
- <3 days/week	5266	14.2	6243	21.8
- ≥3 days/week	377	44.0	497	49.7
Napping				
- <3 days/week	4664	16.1	5804	23.5
- ≥3 days/week	929	16.0	890	25.6

sleep both in women (0.68, 0.51-0.89) and in men (0.59, 0.42-0.83), as also was age in men (0.98, 0.96-0.99). In interaction analysis there were no significant interactions between weekly working hours, stress of daily activities, Beck Depression Inventory, and diurnal type.

Role of Genetic Factors (Table 5)

The best fitting model in both genders was that including an additive genetic component and non-shared environmental components (AE-model), and the estimate for the genetic component was in men 0.32 (95% CL 0.18-0.45) and in women 0.29 (0.20-0.38), implying that about one third of the interindividual variability in the liability to insufficient sleep is due to interindividual genetic variability. The fits for the models also including dominant genetic effects (ADE-model; in men χ^2 goodness of fit=15.2, p=0.23, and Akaike Information Criterion=-8.8; in women respectively 15.1, 0.24, and -8.9) and common environmental effects (ACE-model; statistics in men 17.1, 0.15, and -6.9; in women 15.4, 0.22, and -8.6, respectively) were almost equally good, but from the point of parsimony the AE-model can be considered best.

DISCUSSION

We found insufficient sleep (determined as a difference of one hour or more between the self-reports of the need of sleep and the actual length of sleep) to occur in one fifth of middle-aged general population. Insufficient sleep was about 1.5 times more common in women than in men. Frequent daytime sleepiness and frequent insomnia were among the three variables strongest positively associated to insufficient sleep in both genders. Those not working suffered significantly less often of insufficient sleep. Insufficient sleep was measured twice with a nine-year interval in our sample and showed stability. Thus, insufficient sleep seems to be a long-standing condition in a large part of the population. As our study population consisted of twins, we were also able to estimate the role of genetic factors. About one third of the variability in the liability to insufficient sleep could be attributed to interindividual genetic variability.

We had three aims when planning this study, as stated at the end of the introduction, one being to elucidate which characteristics are associated with insufficient sleep. Two factors affected the choice of these characteristics: first, empirically and based on our clinical experiences, what features often occur together with patients' assessments of insufficient sleep, and second, which variables were available in our data set. The design of our study does not permit strong inference as to causality, and our primary aim was to study insufficient sleep as a phenomenon in population. Therefore, this part of our work could be characterized as descriptive.

There are only few population studies on insufficient sleep although awareness of this problem has increased.[4] Sleeping difficulties are common, about one third of general population suffers from transient insomnia and about one tenth from severe and/or chronic insomnia.[22] In a Swedish population sample aged 30—65 years 28% of women and 21% of men experienced too little sleep, but only about one third of them had concomitant symptoms suggesting insomnia.[23] In a telephone survey done in Australia insufficient sleep was reported by 28%, and about three quarters of these respondents related it to external factors and the remaining quarter to internal factors.[24] Insufficient sleep has been claimed to decrease with age,[5] but, on the other hand, in a healthy population aged 50—65 years about one third of the subjects reported not getting enough sleep.[25] In our study population there was a significant age effect, a self-report of insufficient sleep being more common in younger age groups in both genders.

In a Swedish questionnaire study done in a population sample aged 20—64 years "persistent insufficient sleep" was found in 12% of the subjects.[5] "Persistent insufficient sleep" was defined as a sleep sufficiency index below 80% and an experience of getting too little sleep at least three times per week during the last three months. The authors considered the 80% cut-off arbitrary but corresponding rather well to about 6.5 hours of sleep in the average individual with an estimated need for sleep of about eight hours.[5] One half of the subjects with persistent insufficient sleep also reported concomitant sleeping difficulties, and in the remaining the most conspicuous causes were work-related factors and simply too little time for sleep. As consequences of insufficient sleep the respondents reported cognitive/behavioral fatigue, somatic symptoms, sleepiness, swelling, headache, and dysphoric mood.[5] In a recent Finnish population study the results were quite similar to ours.[6] However, the prevalence of insufficient sleep was even higher (36%), being about one third more common in women than in men (31% vs. 41%). There was a significant age effect: insufficient sleep was twice as prevalent in the youngest compared to the oldest. The association to work status was also similar. Their study also included younger age groups which suffer more from insufficient sleep.

Table 3—Risk of insufficient sleep by categories of associated variables, based on the 1990 questionnaire from the Finnish Twin Cohort (N = 12,423). Age-adjusted odds ratios (OR) and their 95% confidence limits (95% CL) given by genders.

VARIABLE	MEN		WOMEN	
	OR	95% CL	OR	95% CL
Age (years)				
- 33-39	1.70	1.41-2.06	1.58	1.35-1.84
- 40-49	1.21	1.0004-1.47	1.25	1.07-1.46
- 50-60	1.00	-	1.00	-
Education				
- primary	1.35	1.06-1.72	0.87	0.73-1.03
- secondary	1.16	0.92-1.46	0.89	0.75-1.04
- tertiary	1.00	-	1.00	-
Smoking				
- never	1.00	-	1.00	-
- occasionally	1.00	0.68-1.48	0.69	0.47-1.02
- former	1.05	0.87-1.27	1.14	0.97-1.34
- current	1.16	0.97-1.39	1.28	1.10-1.48
Heavy alcohol use				
- no	1.00	-	1.00	-
- yes	1.26	1.09-1.46	1.25	1.06-1.49
Leisure exercise				
- least active fourth	1.00	-	1.00	-
- 2nd fourth	0.82	0.68-1.01	0.95	0.81-1.13
- 3rd fourth	0.83	0.67-1.02	0.86	0.73-1.02
- most active fourth	0.72	0.59-0.87	0.82	0.70-0.97
Working	0.89	0.72-1.09	0.75	0.62-0.91
Not working	1.00	-	1.00	-
Daytime work	0.78	0.65-0.93	0.97	0.84-1.12
Other than daytime work	1.00	-	1.00	-
Weekly working hours (paid)				
- none	1.00	-	1.00	-
- <40	0.90	0.69-1.16	1.03	0.87-1.21
- ≥40	1.12	0.88-1.42	1.24	1.05-1.46
Weekly working hours (paid and at home)				
- <25	1.00	-	1.00	-
- 25-35	0.96	0.56-1.65	0.97	0.69-1.37
- 35-45	0.97	0.73-1.29	1.20	0.90-1.60
- 45-54	0.95	0.72-1.24	1.10	0.87-1.40
- 55-64	1.17	0.89-1.54	1.50	1.17-1.92
- 65-74	1.43	0.97-2.10	1.30	1.00-1.70
- ≥75	2.49	1.36-4.57	1.24	0.88-1.75
Stress of daily activities				
- none	1.00	-	1.00	-
- intermediate	2.17	1.74-2.71	2.27	1.93-2.68
- high	6.08	4.41-8.38	5.09	3.97-6.53
Life satisfaction				
- satisfied	1.00	-	1.00	-
- intermediate	1.61	1.28-2.02	1.60	1.35-1.89
- dissatisfied	3.15	2.42-4.10	2.87	2.35-3.50
Beck Depression Inventory				
- non-depressed	1.00	-	1.00	-
- depressed	3.59	2.89-4.45	2.44	2.07-2.86
Diurnal type				
- morning type	1.00	-	1.00	-
- slightly morning type	1.11	0.89-1.38	1.10	0.93-1.31
- slightly evening type	1.58	1.29-1.94	1.71	1.46-1.99
- evening type	1.67	1.27-2.19	2.30	1.86-2.84
Daytime sleepiness				
- ≥3 days/week	5.25	4.34-6.33	5.30	4.57-6.15
- 1-2 days/week	3.02	2.53-3.62	2.95	2.56-3.40
- < 1day/week	1.00	-	1.00	-

Table 3 Continued

VARIABLE	MEN		WOMEN	
	N	%	N	%
Able to sleep without disturbance				
- usually	1.00	-	1.00	-
- sometimes not	1.98	1.65-2.38	1.77	1.54-2.05
- generally not	4.38	3.10-6.19	2.97	2.37-3.73
Insomnia				
- <3 days/week	1.00	-	1.00	-
- >_3 days/week	5.25	4.20-6.55	3.96	3.27-4.80
Napping				
- <3 days/week	1.00	-	1.00	-
- >_3 days/week	1.09	0.90-1.33	1.20	1.02-1.41

The differences in the prevalences in the various studies are probably explained to a large extent by methodological and definitional differences. Actually, there are no established measures or criteria for sleep insufficiency, and it is unclear how the need of sleep in a single individual may vary along time depending on factors like health status and life circumstances.

One additional problem is the inherent inaccuracy of the self-assessment of the sleep length especially in insomniac subjects (they often assess it shorter than it actually is). The confirmation of the diagnosis of insufficient sleep syndrome[1] requires sleep laboratory studies, which are too expensive to be used in large population samples.

When assessing as single factors, psychological characteristics are strongly associated with insufficient sleep. However, in the multivariate model the different characteristics seem to be incorporated into "stress of daily activities" and in the sleep-wake variables to a large extent. A plausible explanation for this is the fact that sleep disturbance symptoms—especially insomnia—are common symptoms in many psychiatric disorders (e.g., in depression and anxiety measured in this study). In any case, psychological and psychiatric factors are involved in insufficient sleep, but do not alone account for the variation in its occurrence in the population.

There were complex associations between education, work, and insufficient sleep. Less education was significantly (positively) associated but only in men. This may reflect differences in way of life in different educational (social) classes. It is also possible that the healthy worker effect[26] may explain this at least partly. Working was significantly more often positively associated with insufficient sleep than not working, a result reported earlier.[5] Increasing number of working hours was positively associated with insufficient sleep linearly in men, while in women the highest proportion of insufficient sleep peaked at 55—64 hours weekly. This may reflect many differences in the working patterns between the genders, and further lifestyle differences between those working many hours and those working less. However, the measured lifestyle, psychological, and other health-related factors did not account for the relationships between education or work with insufficient sleep in the multivariate analysis.

The relationship of diurnal types and insufficient sleep is also interesting. Our result indicating a significant positive association between eveningness and insufficient sleep is plausible: those with increasing sleepiness early in the evening are less prone to shorten their sleep period than those being "night owls."

According to our results morningness (morning type or slightly morning type) seem to be slightly predominant (about 55% in both genders) in middle-aged population. We also found significant age effect (insufficient sleep being more prevalent in younger age groups), and this may be explained by the gradual shift from more eveningness to more morningness over age.[16]

It is frequently claimed that sleep disorders are generally increasing and especially chronic sleep deprivation. This conclusion may be more due to the increased awareness of these factors and their consequences. So far, we have lacked convincing epidemiological evidence of an increase of sleep disorders. In our population, we did not find significant changes in the prevalence of insufficient sleep between 1981 and 1990, not even a slight decrease which may have been anticipated as an age-effect. It may be speculated that this age related effect has been cancelled by an absolute increase in the prevalence of insufficient sleep. There is some additional evidence suggesting this possibility. Using the same questions but one-hour response alternative intervals (Mikael Sallinen, pers. comm.) seven years later in 1997, Sallinen et al.[6] found a clearly higher prevalence (almost two-fold) of insufficient sleep in a 24—65-year-old population. The results are, however, not quite comparable as also the study populations are different, regarding (e.g., age and working status). Interestingly, in both Finnish studies insufficient sleep was positively associated with working. Among the respondents of Sallinen et al., 70% were "working," and insufficient sleep occurred in 41% of them (in 20% among those "not working," including also students and retired persons). Among the respondents of our 1990 questionnaire 85% were "working" and 21% of them had insufficient sleep (16% among those "not working"). One interpretation could be that a real increase in the prevalence of insufficient sleep in population may have occurred and those working are one risk group. Longitudinal studies to examine determinants, both social and medical, of insufficient sleep could address this issue.

In conclusion, it is a common situation not to be able to satisfy the subjectively assessed need of sleep, and seems to be a long-standing condition in almost half of those reporting it. There also are considerable genetic effects explaining the occurrence of insufficient sleep. These effects may act directly on sleeping and/or indirectly through the associated variables. Insufficient sleep is associated with several life quality and health-related

Table 4—Multivariable logistic regression analysis of insufficient sleep in the Finnish Twin Cohort (N=12,423). Odds ratios (OR) and 95 % confidence limits (95 % CL) indicate the strength of the association of the given associated variable with insufficient sleep adjusted for the effect of the other variables in the model. These 10 variables of the 17 analyzed (Table 3) remained significant. Non-significant variables initially included in the model: smoking, heavy alcohol use, leisure exercise, time of day of work, weekly paid working hours, life satisfaction, and napping.

VARIABLE	MEN		WOMEN	
	OR	95 %CL	OR	95 %CL
Age	0.98	0.96-0.99	0.99	0.98-1.00
Education				
- tertiary	1.00	-	1.00	-
- secondary	1.36	1.04-1.77	1.00	0.83-1.20
- primary	1.53	1.15-2.03	0.98	0.80-1.20
Working	1.00	-	1.00	-
Not working	0.59	0.42-0.83	0.68	0.51-0.89
Weekly working hours (paid and at home)				
- <25	1.00	-	1.00	-
- 25-35	1.20	0.64-2.22	1.09	0.72-1.64
- 35-45	1.19	0.75-1.89	1.16	0.80-1.69
- 45-54	1.17	0.75-1.83	1.18	0.85-1.64
- 55-64	1.23	0.79-1.92	1.62	1.15-2.27
- 65-74	1.58	0.93-2.68	1.27	0.88-1.82
- ≥75	3.23	1.54-6.78	1.15	0.73-1.80
Stress of daily activities				
- none	1.00	-	1.00	-
- intermediate	1.53	1.20-1.95	1.58	1.31-1.90
- high	1.92	1.26-2.93	1.90	1.39-2.59
Beck Depression Inventory				
- non-depressed	1.00	-	1.00	-
- depressed	1.43	1.06-1.92	1.21	0.98-1.48
Diurnal type				
- morning type	1.00	-	1.00	-
- slightly morning type	1.25	0.97-1.60	1.19	0.98-1.45
- slightly evening type	1.77	1.40-2.25	1.72	1.43-2.06
- evening type	1.73	1.25-2.41	2.10	1.65-2.69
Daytime sleepiness				
- < 1 day/week	1.00	-	1.00	-
- 1-2 days/week	2.54	2.08-3.11	2.46	2.10-2.88
- ≥3 days/week	3.77	2.98-4.75	3.87	3.24-4.63
Able to sleep without disturbance				
- usually	1.00	-	1.00	-
- sometimes not	1.42	1.14-1.75	1.33	1.12-1.57
- generally not	2.54	1.66-3.89	1.95	1.47-2.60
Insomnia				
- <3 days/week	1.00	-	1.00	-
- ≥3 days/week	2.91	2.17-3.90	2.48	1.92-3.19

variables which are important on both the individual and community level. The increased burden may affect the risk of psychiatric and other disorders, and the daytime sleepiness may increase the risk of accidents. Those with long working time seem to be in a risk zone at least in the middle-aged population. The assessment of sleep sufficiency should be considered to be included in health examinations of working adults.

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Table 5—Insufficient sleep in the Finnish Twin Cohort: the role of genetic factors. Numbers of twin pairs and statistics of the best fitting model to estimate the genetic and environmental components in the variation of the liability to insufficient sleep. Akaike Information Criterion (AIC) is a measure of overall model fit and it is computed as χ_2-2 d.f., where d.f. is degrees of freedom. A small goodness-of-fit χ^2 -value and a high p indicate good correspondence between the model and the data.

TWIN PAIRS	MEN		WOMEN	
	MZ	DZ	MZ	DZ
Number of pairs	526	1060	792	1415
Intraclass correlation (r)	0.378	0.073	0.314	0.119
MODEL FITTING				
Additive genetic component (A)	0.32		0.29	
95% confidence limits	0.18-0.45		0.20-0.38	
Non-shared environmental component (E)	0.68		0.71	
95% confidence limits	0.55-0.82		0.62-0.80	
χ^2 goodness of fit	17.1		15.4	
p-value	0.20		0.28	
Akaike Information Criterion (AIC)	-8.9		-10.6	

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