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Association of changes in lifestyle with changes in sleep difficulties: an analysis of 38 400 participants over a 16-year follow-up

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ABSTRACT

Objectives To investigate the association between changes in lifestyle risk factors and changes is sleep difficulties.

Design Longitudinal repeated measures cohort study.

Setting University and national institute of occupational health.

Participants Participants of the Finnish Public Sector study with information on sleep and lifestyle-related risk factors collected in five repeat surveys with 4-year intervals from 2000 to 2017. The participants were those, who had responded at least twice and had a change in sleep difficulties (having sleep difficulties vs not) (142 969 observations from 38 400 respondents (mean age 45.5 (SD 9.2) years, 83% women).

Primary and secondary outcome measures Changes in sleep quality over time. Longitudinal fixed effects analysis, a method that accounts for time-invariant confounders by design, was used.

Results At first available response, sleep difficulties were experienced by 13 998 (36%) of the respondents. Respectively, the mean age was 44.3 (10.0) years, 7526 (20%) were obese, 13 487 (35%) reported low physical activity, 3338 (9%) extensively drinking and 6547 (17%) were smoking. Except for smoking, the changes in the studied modifiable risks were associated with changes in sleep difficulties. The ORs for having sleep difficulties were 1.41 (95% CI 1.35 to 1.48) for obesity, 1.10 (95% CI 1.06 to 1.13) for low physical activity and 1.43 (95% CI 1.35 to 1.51) for heavy drinking. For smoking, the association was negative with OR 0.81 (95% CI 0.76 to 0.86). Including all four modifiable risks into model changed the estimates only little.

Conclusions The results of this longitudinal study suggest that changes in sleep quality are interconnected with changes in lifestyle.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The main strength was the possibility to use a within-individual design, where all participants served as their own controls.
⇒ The fixed-effects method effectively controls for all stable individual characteristics and other potential confounders that do not vary over time.
⇒ However, the large cohort size and the long follow-up with four or five repeated measures ensured that the results are likely to be robust and unlikely to be attributable to type 1 error.
⇒ Also, we were not been able to measure time-variant confounders, which could lead to a change in sleep as well as a change in life style, such as incident medical conditions between the study waves.
⇒ Additionally, the set of available independent variables was limited leaving other possible significant effects unknown.

INTRODUCTION

Sleep difficulties are the well-recognised risk factor for morbidity and mortality and responsible for substantial economic losses.[1 2] Among adult populations, the prevalence of sleep difficulties varies from a few percent up to 60%, depending on the study population and diagnostic criteria for sleep difficulties.[3–10] Individuals with unhealthy lifestyle may experience more sleep difficulties as indicated by physical inactivity, heavy alcohol drinking and insufficient amount of sleep hours. Sleep difficulties are also associated with adverse life events, such as divorce or loss of a significant other.[6 9 11–18]

Most studies on correlates of sleeping difficulties are limited to designs in which the putative risk factors are measured at baseline and sleep parameters at baseline and follow-up. In contrast, a few studies have examined whether changes in risk factors are associated with parallel changes in sleep using repeat measurements, a design which better allows to determine whether favourable and unfavourable alterations in risk factors are related to corresponding changes in sleep.[19]

To address this limitation, our objective was to investigate the association between changes in obesity, physical activity and alcohol consumption and changes is sleep difficulties

based on five repeated surveys during a 16-year follow-up of working-aged adults.

METHODS

Participants were from the Finnish Public Sector cohort study of employees of 10 towns and 6 hospital districts. Data included responses to five questionnaire surveys administered in 4-year intervals in 2000, 2004, 2008, 2012 and 2016 (average response rate 70%). Of the 122 969 respondents, 86 467 respondents (mean age 44.7 (SD 9.4) years, 81% women) had answered to at least two surveys. Of these respondents, 38 400 reported sleep difficulties in at least one survey (cse time) and no sleep difficulties in at least one survey (control time) and were included into this study.

Age, gender, body mass index (BMI), level of physical activity and alcohol consumption were measured at each repeated response. Age was defined in full years. The BMI was defined as weight/height^2 and dichotomised to indicate obesity if BMI ≥30 kg/m^2. The level of physical activity was calculated from the survey responses, converted into metabolic equivalent of task (MET) and dichotomised based on the cohort-specific quartiles as 'low physical activity'—the lower quartile vs others. That way, the cut-off for low physical activity was set at 14 MET/week (online supplemental file 1). Alcohol consumption was obtained from the survey and converted into g/week, and >210 g of pure alcohol per week was considered a cut-off for excess alcohol consumption (no/yes). Smoking was defined as yes/no at the time of the survey.

The Jenkins Sleep Scale (JSS) is a four-item questionnaire to follow common sleep problems in clinical areas. Four items evaluated, in the last month, the difficulty to fall asleep, wake up at night, difficulty to stay asleep and wake up exhausted in the morning. Each item is rated on a Likert-like scale from 0 to 5, where 0 is 'never', 1 is '1–3 days', 2 is '4–7' days, 3 is '8–14 days', 4 is '15–21 days' and 5 is '22–28 days'. The responses to the JSS were dichotomised as 'yes' if any of sleep disturbances occurred 15 or more nights per 4 weeks and 'no' if the frequency was less than 14 nights. The cut-off of 15 nights was based on the Diagnostic and Statistical Manual of Mental Disorder, Fifth Edition, Text Revision and previous studies stating that sleep difficulty should be present for three or more nights per week for at least 1 month.[20–23]

Statistical analysis

For our within-individual analyses, we used the fixed effects method (also known as quasi-experimental case–control method) with conditional logistic regression models. These models used information from those who reported sleep difficulties in at least one of the five surveys (case) and no sleep difficulties in at least one survey (control), and for whom there was a change in the modifiable lifestyle factors. The fixed-effects model links changes in sleep difficulties to changes in obesity, alcohol consumption, smoking status and physical activity (for both directions) within individuals, thereby controlling for all measured and unmeasured stable individual characteristics and other potential confounders that do not vary over time, which is the main advantage of this method.[24 25] The fixed-effects model excludes all employees without changes in sleep difficulties between the repeated responses as they cannot serve as their own controls. The longitudinal fixed-effects model combines all increases and decreases of the repeated data giving only one risk estimate for the association of a change in exposure to the change in outcome. The results were reported as ORs and accompanied by 95% CIs. The analyses were performed using Stata/IC Statistical Software: Release V.16. (StataCorp).

Patient and public involvement

No patients or the members of the public were involved in the development of the research questions or the design of this study. The volunteer study cohort participants were involved in the conduct of the study.

RESULTS

Of the participants, 38 400 with sleep difficulties in at least one measurement and no sleep difficulties in at least one measurement were included in the analysis. Of them, 6538 (17%) were men and 31 862 (83%) were women. Their mean age was 45.5 (SD 9.2) years. At first available response, sleep difficulties were experienced by 13 998 (36%) of the respondents. Respectively, the mean age was 44.3 (10.0) years, 7526 (20%) were obese, 13 487 (35%) reported low physical activity, 3338 (9%) extensively drinking and 6547 (17%) were smoking.

Except for smoking, the changes in the studied modifiable risks were positively associated with sleep difficulties (table 1).

The number of person-observations in gender, risk factor status and sleep difficulties status varied from 139 178 to 1 42 969 (table 2).

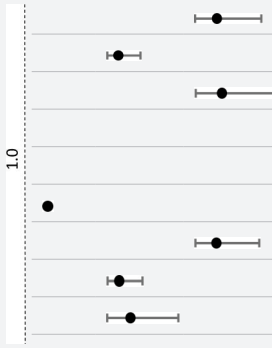
The participants were 1.41 times more likely (95% CI 1.35 to 1.48) to have sleep difficulties when they were obese compared with the times when they were non-obese. The corresponding ORs for physical activity and heavy drinking were 1.10 (95% CI 1.06 to 1.13) and 1.43 (95% CI 1.35 to 1.51), respectively. For smoking, the association was negative with OR 0.81 (95% CI 0.76 to 0.86). Including all four modifiable risks into model changed the estimates only little (model E in table 1). The effect of ageing was significant but small with OR 1.03 (95% CI 1.03 to 1.03) per 4 years for all five studied models.

DISCUSSION

In this five-wave longitudinal cohort study of 38 400 people of working age, changes in obesity, low physical activity, smoking and heavy drinking (all measured dichotomously as present vs not present) were associated with changes in sleep difficulties. The strongest positive associations were observed for changes in heavy drinking

Table 1 Associations between changes in presence of sleep difficulties and changes in obesity, low physical activity, smoking and heavy drinking

Risk	N (persons)	N (observations)	OR and 95% CI	OR	95% CI
Separately age adjusted					
Obesity	38 400	142 969		1.41	1.35 to 1.48
Low physical activity	38 400	142 969		1.10	1.06 to 1.13
Heavy drinking	38 400	142 969		1.43	1.35 to 1.51
Smoking	37 170	136 604		0.81	0.76 to 0.86
All risks together	37 170	136 604			
Age				1.03	1.03 to 1.03
Obesity				1.30	1.24 to 1.36
Low physical activity				1.13	1.09 to 1.16
Heavy drinking				1.17	1.11 to 1.24
Smoking				0.81	0.76 to 0.87



and obesity. The changes in smoking status were associated with changes in sleep difficulties negatively.

The main strength of our study was the possibility to use a within-individual design, where all participants served as their own controls. The fixed-effects method effectively controls for all stable individual characteristics and other potential confounders that do not vary over time. The model did not control for possible changes in socioeconomic status, even though it could be assumed that socioeconomic status remained essentially unchanged for most of the respondents. The main limitation is that we were not able to measure time-variant confounders, which could lead to a change in sleep as well as a change in life style, such as incident medical conditions between the study waves. For example, cardiometabolic conditions such as diabetes and chronic obstructive bronchitis may cause sleep problems and simultaneously, motivate the patient to adapt a healthier lifestyle. However, in such a case, the risks would be underestimated in our study. Sleep difficulties were measured using a short Jenkins scale. The

Table 2 Number of person-observations in gender, risk factor status and sleep difficulties status

	No sleep difficulties		Sleep difficulties			Total
Status	N	%	N	%	χ^2 (p value)	N
Gender					0.85	
Men	13 576	17	10 085	16		23 661
Women	67 373	83	51 935	84		119 308
Total	80 949	100	62 020	100		142 969
Obesity					0.41	
No	62 902	78	45 552	73		108 454
Yes	18 047	22	16 468	27		34 515
Total	80 949	100	62 020	100		142 969
Low physical activity					0.66	
No	52 620	65	38 383	62		91 003
Yes	28 329	35	23 637	38		51 966
Total	80 949	100	62 020	100		142 969
Heavy drinking					0.80	
No	74 771	92	56 242	91		131 013
Yes	6178	8	5778	9		11 956
Total	80 949	100	62 020	100		142 969
Smoking					1.0	
No	68 791	87	52 420	87		121 211
Yes	10 441	13	7526	13		17 967
Total	79 232	100	59 946	100		139 178

set of available independent variables was limited leaving other possible significant effects unknown. However, the large cohort size and the long follow-up with four or five repeated measures ensured that the results are likely to be robust and unlikely to be attributable to type 1 error.

Our results are in line with previous reports on association between alcohol and sleep quality.[12] The associations between poor sleep and obesity have also been reported by numerous previous studies.[26–29] Previous studies have also noticed a correlation between low physical activity and poorer sleep.[16 18] The novelty of the present findings is that few previous studies have focused on the changes in modifiable risks comparing them to the changes in sleep quality.

The paradox negative correlation between smoking and sleep seen in this study might probably be explained by the fact that only a small group of the respondents were smoking and most changes were because of quitting smoking rather than smoking relapse.

When interpreting these findings, caution is advised regarding the direction of causality. We cannot rule out with this design whether people may seek for extensive alcohol consumption as a help for their poor sleep rather than they may sleep poorly because of drinking.[1] The same applies to low physical activity as a sedentary lifestyle can impair sleep quality but low physical activity can also be a result of poor sleep and fatigue.

CONCLUSIONS

The results of this longitudinal study suggest that changes in lifestyle and changes in sleep quality are closely interconnected.

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Patient consent for publication Not applicable.

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Data availability statement Data are available on reasonable request. Technical appendix, statistical code, and limited dataset available on request from the corresponding author.

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