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Accumulated unhealthy behaviours and insomnia in Japanese dwellers with and without cardiovascular risk factors: a cross-sectional study

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ABSTRACT

Objectives To date, the association between accumulated unhealthy behaviours and insomnia in individuals stratified according to the presence or absence of major cardiovascular risk factors is unclear. This study aimed to examine the effect of accumulated unhealthy behaviours on insomnia in Japanese dwellers.

Design Cross-sectional study.

Setting Baseline data between April 2012 and March 2015.

Participants Our study used cross-sectional data among Japanese aged 35–74 years in a rural community (N=9565), the attendees of annual municipal or work site health check-up programmes.

Main outcome measures Insomnia was assessed by Athens Insomnia Scale, which was set at 6 points and greater; other scales were given. Participants were categorised into three groups by their number of unhealthy behaviours (no exercise habit, smoking, alcohol drinking, skipping breakfast and obesity): 0–1, 2–3, 4 or more. The association between accumulated unhealthy behaviours and insomnia was estimated by logistic regression analysis. Further analysis was done after stratification of cardiovascular risk factors assessed by anthropometrics and clinical biochemistry measurements.

Results The overall prevalence of insomnia was 13.3% for men and 19.3% for women. Men with unhealthy behaviour factors were more likely to have insomnia after adjusting for potential confounders, compared with the least unhealthy group (trend p=0.013). Women with four or more unhealthy behaviour factors were more likely to have insomnia, compared with the lowest groups (OR 1.175, 95% CI 1.077 to 1.282). Insomnia has an association with the unhealthy behaviours among men without cardiovascular risk factors (lowest groups: OR 1.133, 95% CI 1.037 to 1.238, trend p=0.026). Women without hypertension were more likely to have suspected insomnia, compared with the lowest group (OR 1.215, 95% CI 1.101 to 1.341).

Conclusion The results showed accumulated unhealthy behaviours were associated with increased risk of insomnia in Japanese dwellers. For healthy population without cardiovascular risk factors, unhealthy behaviours should be considered as background conditions for insomnia.

Strengths and limitations of this study

- ► Our study showed that accumulated unhealthy behaviours were associated with increased rates of insomnia in the Japanese population.
- ► Moreover, this is the first report on the effect of accumulated unhealthy behaviours on insomnia in consideration of cardiovascular risk factors among Japanese rural dwellers.
- ► Our study showed the effect of accumulated unhealthy behaviours on insomnia in men without lifestyle-related diseases and on diabetes in women without hypertension. These results may be useful for improving unhealthy behaviour and sleep habit, in consideration of cardiovascular risk factors.
- ► This study used the Athens Insomnia Scale, which is a valid tool in screening for insomnia. However, the results cannot be considered entirely objective.

INTRODUCTION

Sleep disturbances are associated with various health problems.[1–3] Specifically, some studies have found that sleep affects mortality from cardiovascular disease and mental disorders.[1–3] Some reports have also indicated that insomnia results in substantial workplace costs and work issues.[4 5] The number of people with inadequate sleep has been rising in Japan annually, and almost one in five currently suffers from insomnia.[6]

Previous studies have reported that individuals' health behaviours and lifestyles are related to sleep disorders.[7] Prospective studies showed associations between sleep, obesity and physical exercise.[8 9] These studies reported that lifestyle-related factors were associated with non-restorative sleep in a Japanese population, and the association between the number of lifestyle-related factors and sleep quality was also pointed out in a Chinese population.[10 11] These studies

also showed that the number of unhealthy behaviours positively correlated with the risk of sleep disturbances. However, one study was conducted on subjects over 60 years of age.[11] Moreover, these studies did not use the Athens Insomnia Scale (AIS), which is a validated tool worldwide.[12 13]

However, in these previous studies, the evidence did not shed light on the effect of accumulated unhealthy behaviours on insomnia. Unhealthy behaviours are strongly related to cardiovascular risk factors, such as hypertension, diabetes and dyslipidaemia. Clinical guidelines recommended alcohol and smoking abstinence, moderate physical activity and prevention of obesity to prevent or improve these risk factors.[14–16] In particular, body weight maintenance and increased physical activity were effective for the prevention of hypertension, dyslipidaemia and diabetes. Some studies have suggested that breakfast skipping is a risk factor for high blood pressure and type 2 diabetes.[17 18] Another study also revealed the association between insomnia and the development of hypertension, diabetes and cardiovascular diseases.[19] These findings suggest there is a close relationship between cardiovascular risk factors and insomnia. However, these studies did not consider the effect of cardiovascular risk factors, such as hypertension, dyslipidaemia and diabetes on the association between accumulated unhealthy behaviours and insomnia.[10 11] Therefore, the aim of this study was to examine the effect of accumulated unhealthy behaviours on insomnia in a Japanese population.

METHODS

Subjects

The subjects were 11 002 men and women aged 35–74 years recruited from the Tsuruoka Metabolomics Cohort Study. Japan has a public health check-up system supplied by local municipalities or workplaces. This cohort study recruited from the attendees of annual health check-ups conducted by Tsuruoka city or workplaces in Tsuruoka city, in Yamagata prefecture, northeast area in Japan. Therefore, participants consisted of a community population that included self-employed, unemployed and employed people such as city workers, medical/welfare personnel and others. The baseline survey of this study was conducted from April 2012 to March 2015. The population of Tsuruoka city is 136 623 in 2010, of whom 72 171 were aged 35–74 years.[20] Participants were recruited from 12 327 attendees aged 35–74 years who had public health check-ups. Although this study did not use random sampling, participation rate was very high (N=11 002 89.2%). The study data included information on health check-ups, self-reported questionnaire (regarding lifestyle habit and socioeconomic factor, etc) and biological and medical examinations. Details of the study have been described elsewhere.[21–24] A cross-sectional study was performed using the baseline data collected from the Tsuruoka Metabolomics Cohort Study from April 2012 to March 2015. We analysed the data on 9565 participants (4402 men and 5163 women) who had been diagnosed without cancer, coronary heart disease and stroke by medical doctors, and the complete data regarding sleep and unhealthy behaviours that had been collected through a self-report questionnaire (figure 1).

Measurements

Information regarding insomnia and other confounding variables was collected through a self-reported questionnaire. Quality of sleep was assessed by the AIS,[12] using a valid Japanese version.[13] The items of this scale comprised eight questions about the following themes: difficulty in falling asleep, waking up during the night, early-morning waking, total sleep duration, overall quality of sleep, well-being, functioning capacity and sleepiness during the

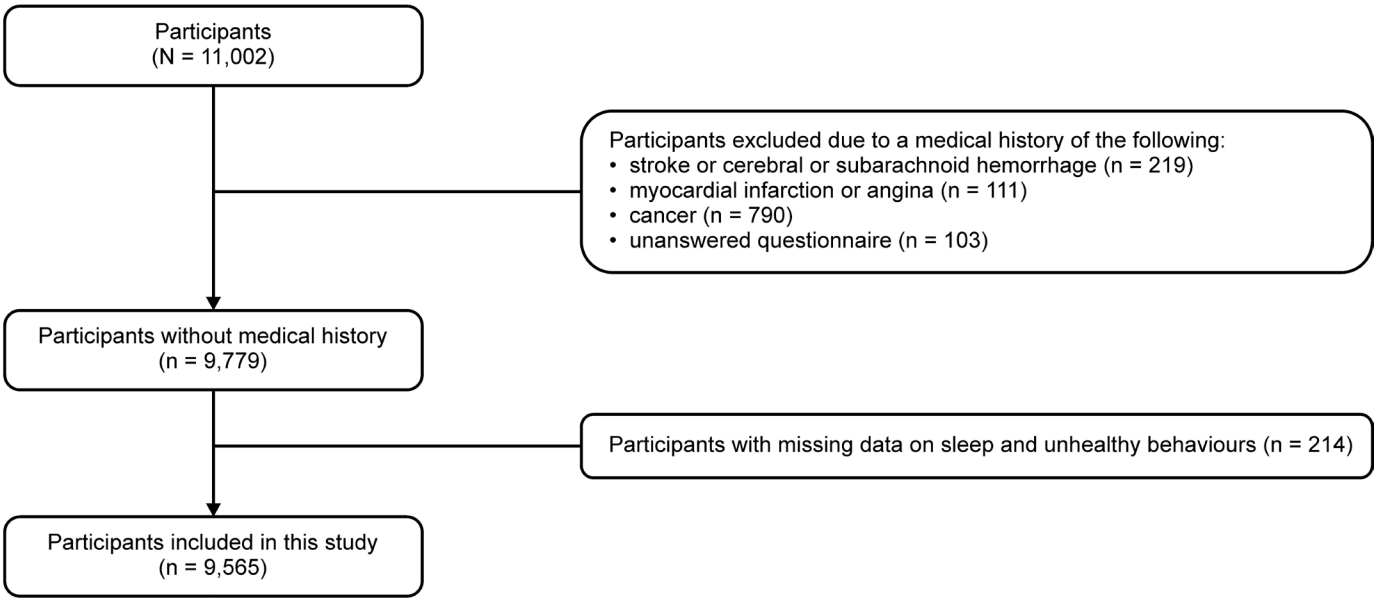

Figure 1 Flow diagram for inclusion and exclusion of participants.

day. We adopted a cut-off score of 6 or more on the AIS as 'suspected insomnia' according to previous studies.[12 13] For sleep duration, we asked participants the question, 'How long do you sleep every day?' Sleep duration of fewer than 6 hours was defined as 'short sleep duration' according to the recommendations of the Japanese Ministry of Health, Labour and Welfare that individuals sleep between 6 and 8 hours a day.[7]

The unhealthy behaviours were defined as smoking, drinking, skipping breakfast, no habit of exercising and obesity based on Breslow's health habits, previous studies and sleep guidelines for health promotion.[7 25 26] Smoking was categorised into smoker or non-smoker including ex-smoker. Drinking was classified as drinker and non-drinker including ex-drinker. Skipping breakfast included eating breakfast every day or not. Exercise was classified by frequency, as once or more a week or not. Body mass index (BMI) was calculated using body weight and height measured by a third person. Obesity was defined as BMI ≥25 kg/m^2 based on the Japan Society for the Study of Obesity.[27] Other lifestyle and sociodemographic variables were also collected: sex, age, education level, employment status, shift work, living alone, and coffee and/or green tea consumption. Education level was classified into junior high, high school, and college or above. Employment status was divided into regular employment, non-regular employment, self-employed and unemployed. Shift work was treated as working in shifts or night shifts. Living alone was assessed as living without a housemate. Coffee or green tea consumption was assessed as more than one cup of either of them every day. Mental health was assessed using measures of depression and stress. Depression was defined as a doctor providing a diagnosis for depression per the participant's self-report, while psychological stress was defined as a K6 score of 5 and above.[28] To assess major existence of cardiovascular risk factors, several health measures including anthropometrics and clinical biochemistry measurements were also examined. Hypertension was defined as blood pressure ≥140/90 mm Hg or use of medication.[14] Diabetes was defined as HbA1c ≥6.5%, fasting blood glucose level ≥126 mg/dL or use of medication.[15] Dyslipidaemia was defined as low-density lipoprotein cholesterol (LDL) ≥140 mg/dL, triglyceride ≥150 mg/dL, high-density lipoprotein cholesterol (HDL) <40 mg/dL or use of lipid-lowering medication.[16]

Patient and public involvement

This study focused on the Japanese general population; accordingly, they were recruited from attendees of public health check-ups, and not from patient groups. Patients and the public were not directly involved in our study. The study was conducted based on the Ethics Committee for Tsuruoka Metabolomics Cohort Study (which includes representatives of Tsuruoka citizens, administration of Tsuruoka city, a lawyer and expert advisers).

Statistical analysis

We examined the impact of unhealthy behaviours on sleep in three categories according to the number of accumulated unhealthy behaviour factors: 0–1, 2–3, and 4 or more factors. Because previous studies have reported gender differences in insomnia and healthy behaviours,[29 30] gender-specific analysis was performed. To assess the impact of the unhealthy behaviours on suspected insomnia, a sex-specific logistic regression analysis was conducted, with 0–1 unhealthy behaviour factors as the reference group. Model 1 was adjusted for age as covariates. Model 2 included the factors relating to health behaviours; employment status, education level, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep duration were added to model 1. Covariate factors included both variables related to lifestyle factors identified by previous studies.[10 11] To verify multicollinearity, the variance inflation factor (VIF) and correlation were analysed in all models and variables. Correlation coefficients ranged approximately from ±0.1 to 0.6, and VIFs were <3 in all variables. Moreover, we performed further analysis after stratification of the existence of cardiovascular risk factors (hypertension, diabetes and dyslipidaemia). Statistical analysis was performed using R (V.4.0.3).

RESULTS

A low number of unhealthy behaviours (0–1 factors) were found in 33.8% of men and 68.0% of women.

Table 1 shows the participant's sociodemographic characteristics in the unhealthy behaviour group. Among the women, there was a significant difference among the group by age, employment, education, living alone, hypertension, dyslipidaemia and K6. Men also showed the same pattern of significant differences except for caffeine drink intake, where there was a significant difference for men in the unhealthy behaviour group.

Table 2 shows the association between each unhealthy factor and insomnia. Skipping breakfast increased the risk of suspected insomnia for both sexes in model 1 (adjusted for age) and model 2 (model 1 adjusted for age, employment status, education level, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep duration). Men showed the association between drinking and insomnia in model 1, but did not show significant association in model 2. No exercise habit increased the risk of suspected insomnia only in men (model 2: OR 1.027, 95% CI 1.007 to 1.048).

Table 3 shows the crude and adjusted ORs of having suspected insomnia in relation to unhealthy behaviours. The overall prevalence of insomnia was 13.3% for men (586 of 4402) and 19.3% for women (998 of 5163). Men with more unhealthy behaviour factors were more likely to have increased suspected insomnia in model 2 after adjusting for age, employment status, education level, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep duration

Table 1 Population characteristics by number of unhealthy behaviours

	Men				Women			
	0 or 1	2 or 3	4		0 or 1	2 or 3	4	
Unhealthy behaviours	1487	2599	316		3512	1576	75	P
N	N (%)	N (%)	N (%)	P value	N (%)	N (%)	N (%)	value
Age, mean (SD)	61.61 (9.79)	58.41 (9.78)	53.56 (9.45)	<0.001	60.47 (9.75)	55.59 (10.62)	49.72 (9.12)	<0.001
Smoking, n (%)				<0.001				<0.001
Non-smoker	464 (31.2)	443 (17.0)	16 (5.1)		3259 (92.8)	1209 (76.7)	16 (21.3)	
Ex-smoker	960 (64.6)	1180 (45.4)	31 (9.8)		229 (6.5)	208 (13.2)	8 (10.7)	
Smoker	63 (4.2)	976 (37.6)	269 (85.1)		24 (0.7)	159 (10.1)	51 (68.0)	
Drinking, n (%)				<0.001				<0.001
Non-drinker	456 (30.7)	299 (11.5)	10 (3.2)		2809 (80.0)	628 (39.8)	11 (14.7)	
Ex-drinker	163 (11.0)	80 (3.1)	6 (1.9)		182 (5.2)	43 (2.7)	0 (0.0)	
Drinker	868 (58.4)	2220 (85.4)	300 (94.9)		521 (14.8)	905 (57.4)	64 (85.3)	
Exercise habits, n (%)	1320 (88.8)	1047 (40.3)	18 (5.7)	<0.001	2471 (70.4)	303 (19.2)	5 (6.7)	<0.001
Eating breakfast every day, n (%)	1457 (98.0)	2208 (85.0)	108 (34.2)	<0.001	3419 (97.4)	1119 (71.0)	6 (8.0)	<0.001
BMI (mean (SD))	22.79 (2.22)	24.23 (3.30)	25.33 (3.22)	<0.001	22.14 (2.92)	24.07 (4.07)	26.08 (4.43)	<0.001
BMI ≥25.0 kg/m^2	123 (8.3)	1080 (41.6)	219 (69.3)	<0.001	455 (13.0)	716 (45.4)	52 (69.3)	<0.001
Unhealthy behaviour factors, n (%)				<0.001				<0.001
0	236 (15.9)	0 (0.0)	0 (0.0)		1378 (39.2)	0 (0.0)	0 (0.0)	
1	1251 (84.1)	0 (0.0)	0 (0.0)		2134 (60.8)	0 (0.0)	0 (0.0)	
2	0 (0.0)	1578 (60.7)	0 (0.0)		0 (0.0)	1218 (77.3)	0 (0.0)	
3	0 (0.0)	1021 (39.3)	0 (0.0)		0 (0.0)	358 (22.7)	0 (0.0)	
4	0 (0.0)	0 (0.0)	286 (90.5)		0 (0.0)	0 (0.0)	69 (92.0)	
5	0 (0.0)	0 (0.0)	30 (9.5)		0 (0.0)	0 (0.0)	6 (8.0)	
Drinking coffee or tea every day, n (%)	1161 (78.2)	1993 (77.1)	231 (73.6)	0.194	3070 (87.7)	1337 (85.1)	71 (95.9)	0.002
Employment status, n (%)				<0.001				<0.001
Regular employment	299 (20.2)	605 (23.3)	105 (33.2)		505 (14.4)	418 (26.6)	32 (42.7)	
Non-regular employment	195 (13.1)	347 (13.4)	44 (13.9)		703 (20.0)	413 (26.2)	22 (29.3)	
Self-employed	460 (31.0)	1189 (45.9)	140 (44.3)		739 (21.0)	391 (24.8)	15 (20.0)	
Unemployed	529 (35.7)	451 (17.4)	27 (8.5)		1565 (44.6)	352 (22.4)	6 (8.0)	
Shift work, n (%)	37 (2.5)	77 (3.0)	11 (3.5)	0.527	81 (2.3)	105 (6.7)	11 (14.7)	<0.001
Education level, n (%)				0.003				<0.001
Junior high school	210 (14.3)	384 (15.0)	25 (8.0)		547 (15.6)	202 (12.9)	2 (2.7)	
High school	803 (54.6)	1463 (57.1)	195 (62.1)		1847 (52.7)	787 (50.1)	42 (56.8)	
College or above	459 (31.2)	717 (28.0)	94 (29.9)		1109 (31.7)	582 (37.0)	30 (40.5)	
Living alone, n (%)	62 (4.2)	121 (4.7)	26 (8.3)	0.008	223 (6.4)	95 (6.0)	12 (16.0)	0.003
Hypertension, n (%)	684 (46.0)	1297 (49.9)	147 (46.7)	0.048	1277 (36.4)	609 (38.6)	15 (20.0)	0.003
Dyslipidaemia, n (%)	695 (46.7)	1279 (49.2)	195 (61.7)	<0.001	1701 (48.4)	676 (42.9)	35 (46.7)	0.001
Diabetes, n (%)	202 (13.6)	387 (14.9)	49 (15.5)	0.449	232(6.6)	105(6.7)	3(4.1)	0.674
Cardiovascular risk factors (hypertension, dyslipidaemia or diabetes), n (%)	1066 (71.7)	1922 (74.0)	251 (79.4)	0.014	2262 (64.4)	940 (59.6)	40 (54.1)	0.001
AIS ≥6 scores, n (%)	169 (11.4)	358 (13.8)	59 (18.7)	0.001	641 (18.3)	325 (20.6)	32 (42.7)	<0.001
Sleep duration <6 hours, n (%)	69 (4.6)	146 (5.6)	28 (8.9)	0.011	287 (8.2)	193 (12.3)	14 (18.7)	<0.001
Depression, n (%)	23 (1.5)	28 (1.1)	7 (2.2)	0.155	84 (2.4)	27 (1.7)	0 (0.0)	0.133
K6 (5 points or higher), n (%)	465 (31.5)	805 (31.3)	130 (41.8)	0.001	1308 (37.6)	673 (43.1)	38 (51.4)	<0.001

AIS, Athens Insomnia Scale; BMI, body mass index.

Table 2 Independent risk of insomnia and short sleep duration for individuals' unhealthy behaviours

		Model 1			Model 2		
	Unhealthy behaviours	OR	95% CI	P value	OR	95% CI	P value
Men	Drinking	0.968	0.946 to 0.992	**0.008**	0.985	0.963 to 1.008	0.196
	Smoking	1.002	0.980 to 1.025	0.840	1.009	0.987 to 1.030	0.426
	Skipping breakfast	1.076	1.045 to 1.108	**<0.001**	1.049	1.019 to 1.079	**0.001**
	No exercise habit	1.023	1.002 to 1.044	**0.029**	1.027	1.007 to 1.048	**0.009**
	BMI ≥25.0 kg/m^2	1.013	0.992 to 1.035	0.238	1.008	0.987 to 1.029	0.469
Women	Drinking	0.996	0.972 to 1.020	0.713	0.995	0.972 to 1.018	0.665
	Smoking	1.048	0.995 to 1.105	0.079	1.019	0.969 to 1.071	0.469
	Skipping breakfast	1.081	1.045 to 1.119	**<0.001**	1.041	1.007 to 1.075	**0.016**
	No exercise habit	1.015	0.993 to 1.038	0.186	1.003	0.982 to 1.025	0.781
	BMI ≥25.0 kg/m^2	0.978	0.953 to 1.003	0.083	0.980	0.955 to 1.004	0.107

Model 1: adjusted for age.
Model 2: adjusted for age, employment status, education level, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep duration.
Boldface p<0.05.
BMI, body mass index.

(trend p=0.013). Women with four or more unhealthy behaviour factors were more likely to have suspected insomnia in model 2, compared with the lowest groups (0–1 unhealthy behaviour factors).

The results for the prevalence of suspected insomnia are shown in table 4 (men) and table 5 (women), when we stratified by hypertension, dyslipidaemia and diabetes.

The association between accumulated health behaviours and insomnia was more or less the same when compared in table 3. However, our study showed the relationship between accumulated unhealthy behaviours and insomnia in men with the absence of diabetes. Moreover, men with at least one of any cardiovascular risk factors showed the effect of accumulated unhealthy behaviours on insomnia.

Women with or without cardiovascular risk factors showed the association between accumulated unhealthy behaviours and insomnia. But then, accumulated health behaviours showed no association with insomnia in women without hypertension.

Table 3 Results of logistic regression analysis for suspected insomnia

				2 or 3			4			Trend p value
		0 or 1		OR	95% CI	P value	OR	95% CI	P value	
Men	Total									
	n (%)	169/1487	11.4%		358/2599	13.8%		59/316	18.7%	
	Unadjusted	Ref		1.024	1.002 to 1.047	**0.029**	1.076	1.032 to 1.121	**0.001**	**<0.001**
	Model 1	Ref		1.015	0.993 to 1.037	0.184	1.051	1.008 to 1.096	**0.020**	**0.025**
	Model 2	Ref		1.024	1.003 to 1.046	**0.028**	1.041	0.999 to 1.084	0.053	**0.013**
Women	Total									
	n (%)	641/3512	18.3%		325/1576	20.6%		32/75	42.7%	
	Unadjusted	Ref		1.024	1.000 to 1.048	**0.047**	1.277	1.167 to 1.397	**<0.001**	**<0.001**
	Model 1	Ref		1.008	0.984 to 1.032	0.524	1.233	1.126 to 1.349	**<0.001**	**0.019**
	Model 2	Ref		0.995	0.973 to 1.019	0.690	1.175	1.077 to 1.282	**<0.001**	0.287

Model 1: adjusted for age.
Model 2: adjusted for age, employment status, education level, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep duration.
Boldface p<0.05.

Table 4 Results of logistic regression analysis for suspected insomnia in men

	0 or 1		2 or 3				4				Trend p value
			OR	95% CI		P value	OR	95% CI		P value	
Hypertension											
Hypertension											
n (%)	70/684	10.2%		156/1297	12.0%			27/147	18.4%		
Unadjusted	Ref		1.018	0.988 to 1.049		0.240	1.085	1.024 to 1.149		**0.006**	**0.015**
Model 1	Ref		1.011	0.980 to 1.042		0.489	1.067	1.006 to 1.132		**0.032**	0.081
Model 2	Ref		1.021	0.992 to 1.051		0.157	1.051	0.993 to 1.113		0.084	0.057
Absence of hypertension											
n (%)	99/802	12.3%		202/1302	15.5%			32/168	19.0%		
Unadjusted	Ref		1.032	1.001 to 1.065		**0.046**	1.069	1.008 to 1.134		**0.025**	**0.009**
Model 1	Ref		1.021	0.99 to 1.054		0.193	1.042	0.982 to 1.106		0.178	0.107
Model 2	Ref		1.026	0.995 to 1.058		0.097	1.033	0.975 to 1.094		0.277	0.101
Dyslipidaemia											
Dyslipidaemia											
n (%)	74/695	10.6%		195/1279	15.2%			31/195	15.9%		
Unadjusted	Ref		1.047	1.014 to 1.081		**0.005**	1.054	0.998 to 1.113		0.060	**0.007**
Model 1	Ref		1.035	1.002 to 1.069		**0.038**	1.025	0.969 to 1.084		0.388	0.104
Model 2	Ref		1.048	1.016 to 1.082		**0.003**	1.032	0.978 to 1.090		0.256	**0.026**
Absence of dyslipidaemia											
n (%)	95/792	12.0%		163/1320	12.3%			28/121	23.1%		
Unadjusted	Ref		1.004	0.974 to 1.033		0.814	1.118	1.049 to 1.192		**0.001**	**0.034**
Model 1	Ref		0.996	0.967 to 1.026		0.815	1.097	1.029 to 1.170		**0.005**	0.146
Model 2	Ref		1.004	0.976 to 1.034		0.777	1.070	1.006 to 1.139		**0.033**	0.161
Diabetes											
Diabetes											
n (%)	28/202	13.9%		51/387	13.2%			10/49	20.4%		
Unadjusted	Ref		0.993	0.936 to 1.054		0.821	1.068	0.958 to 1.190		0.236	0.511
Model 1	Ref		0.987	0.930 to 1.048		0.667	1.051	0.940 to 1.175		0.385	0.744
Model 2	Ref		0.995	0.940 to 1.053		0.870	1.046	0.938 to 1.165		0.420	0.676
Absence of diabetes											
n (%)	141/1285	11.0%		307/2210	13.9%			49/267	18.4%		
Unadjusted	Ref		1.030	1.006 to 1.054		**0.014**	1.077	1.028 to 1.124		**0.001**	**<0.001**
Model 1	Ref		1.019	0.995 to 1.043		0.116	1.049	1.002 to 1.098		**0.039**	**0.026**
Model 2	Ref		1.029	1.006 to 1.053		**0.015**	1.040	0.995 to 1.087		0.080	**0.012**
Cardiovascular risk factors (hypertension, dyslipidaemia or diabetes)											
Cardiovascular risk factors											

Continued

Table 4 Continued

	0 or 1		2 or 3 OR	95% CI		P value	4 OR	95% CI		P value	Trend p value
n (%)	117/1066	11.0%		263/1922	13.7%			41/251	16.3%		
Unadjusted	Ref		1.027	1.027 to 1.054		**0.035**	1.055	1.007 to 1.105		**0.023**	**0.008**
Model 1	Ref		1.016	0.991 to 1.042		0.216	1.026	0.979 to 1.076		0.289	0.169
Model 2	Ref		1.026	1.001 to 1.051		**0.045**	1.018	0.973 to 1.066		0.437	0.109
Absence of cardiovascular risk factors											
n (%)	52/421	12.4%		95/676	14.1%			18/65	27.7%		
Unadjusted	Ref		1.017	0.975 to 1.061		0.431	1.166	1.065 to 1.277		**0.001**	**0.015**
Model 1	Ref		1.010	0.968 to 1.054		0.633	1.148	1.048 to 1.257		**0.003**	**0.043**
Model 2	Ref		1.020	0.979 to 1.063		0.349	1.133	1.037 to 1.238		**0.006**	**0.026**

Model 1: adjusted for age.
Model 2: adjusted for age, employment status, education level, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep duration.
Boldface p<0.05.

DISCUSSION

Our study showed both men and women with unhealthy behaviour factors have an increased likelihood of suspected insomnia in the Japanese population, compared with those with healthy behaviour factors. However, this study also revealed a bit difference between men and women in the association between sleep and the number of unhealthy behaviours in cardiovascular risk factors. Modification of unhealthy behaviours may improve sleep problems and reduce health problems. Therefore, we need to examine the motivation for healthy behaviours. This result may be useful for improving unhealthy behaviours and sleep habits, in consideration of cardiovascular risk factors.

The association between accumulated unhealthy behaviours and sleep

There are few reports regarding the effects of multiple healthy or unhealthy behaviours on sleep. In the previous study that examined the effect of a healthy lifestyle on non-restorative sleep in a Japanese population,[10] the lifestyle factors were smoking, BMI, alcohol consumption, regular exercise and eating patterns. In this study, non-restorative sleep was assessed by asking participants the question, 'Do you feel refreshed after a night's sleep?'. In this previous study, a healthy lifestyle score was calculated for each study participant by adding up the number of low-risk lifestyle factors. It showed that compared with participants with the highest healthy lifestyle score (most healthy participants), those with the lowest healthy lifestyle score had a higher prevalence of non-restorative sleep (OR 1.60 (95% CI 1.29 to 1.97) for men and 2.88 (1.74 to 4.75) for women).

In our study, the AIS, which is adequately reliable and valid, was used; and both men and women were shown to have an increased likelihood of suspected insomnia. Significantly, our study reported the effect of an increase in the number of unhealthy behaviours on insomnia among men. The prevalence of insomnia was significantly higher for women with four or more unhealthy behaviours than it was for women with healthy behaviours.

Therefore, with respect to the association between accumulated unhealthy behaviours and sleep, the results of the previous study and the present study are consistent.

With respect to the results regarding individuals' unhealthy behaviour factors, our study showed that insomnia was associated with skipping breakfast. Previous studies have reported an association between sleep and eating patterns in the Japanese population.[31 32]

The eating patterns of individuals have been associated with their metabolism, sleep–wake distribution and circadian rhythm. These behaviours have an effect on the hormone, neurotransmitter substance and cortisol.[33]

Previous studies have reported the effect of diet pattern on cortisol rhythms.[34 35] Insomnia may cause an individual's circadian rhythm to be disrupted, which may in turn lead them to not eating breakfast.

Also, dietary patterns explain the association between sleep and incidence of obesity in a previous study.[36]

Skipping breakfast is especially associated with a change in leptin and melatonin.[37] Obesity and appetite changes in hormonal responses are caused by leptin and ghrelin, which may be linked to sleep and leptin reduction. Moreover, the short sleep duration tends to cause poor sleep quality and obesity because of changes in glucose metabolism.[36]

Table 5 Results of logistic regression analysis for suspected insomnia in women

	0 or 1		2 or 3				4				Trend p value
			OR	95% CI		P value	OR	95% CI		P value	
Hypertension											
Hypertension											
n (%)	213/1277	16.7%		124/609	20.4%			4/15	26.7%		
Unadjusted	Ref		1.038	0.999 to 1.077		0.051	1.105	0.909 to 1.343		0.316	**0.034**
Model 1	Ref		1.027	0.989 to 1.067		0.169	1.073	0.881 to 1.305		0.485	0.138
Model 2	Ref		1.020	0.983 to 1.058		0.303	1.033	0.856 to 1.246		0.738	0.291
Absence of hypertension											
n (%)	428/2235	19.1%		201/967	20.8%			28/60	46.7%		
Unadjusted	Ref		1.016	0.986 to 1.048		0.288	1.317	1.189 to 1.459		**<0.001**	**0.001**
Model 1	Ref		0.995	0.965 to 1.026		0.753	1.273	1.149 to 1.411		**<0.001**	0.076
Model 2	Ref		0.983	0.954 to 1.012		0.247	1.215	1.101 to 1.341		**<0.001**	0.483
Dyslipidaemia											
Dyslipidaemia											
n (%)	290/1701	17.0%		126/676	18.6%			13/35	37.1%		
Unadjusted	Ref		1.016	0.982 to 1.051		0.360	1.223	1.076 to 1.389		**0.002**	**0.037**
Model 1	Ref		1.007	0.973 to 1.043		0.676	1.189	1.044 to 1.354		**0.009**	0.165
Model 2	Ref		1.001	0.968 to 1.035		0.948	1.164	1.028 to 1.319		**0.017**	0.320
Absence of dyslipidaemia											
n (%)	351/1811	19.4%		199/900	22.1%			19/40	47.5%		
Unadjusted	Ref		1.028	0.995 to 1.061		0.097	1.325	1.167 to 1.503		**<0.001**	**0.002**
Model 1	Ref		1.009	0.976 to 1.043		0.593	1.284	1.131 to 1.457		**<0.001**	**0.049**
Model 2	Ref		0.990	0.959 to 1.022		0.523	1.197	1.060 to 1.353		**0.004**	0.581
Diabetes											
Diabetes											
n (%)	36/232	15.5%		21/105	20.0%			2/3	66.7%		
Unadjusted	Ref		1.046	0.959 to 1.141		0.313	1.668	1.086 to 2.562		**0.020**	0.092
Model 1	Ref		1.027	0.941 to 1.122		0.551	1.554	1.009 to 2.395		**0.046**	0.248
Model 2	Ref		1.018	0.931 to 1.112		0.700	1.723	1.125 to 2.640		**0.013**	0.255
Absence of diabetes											
n (%)	605/3280	18.4%		304/1471	20.7%			29/71	40.8%		
Unadjusted	Ref		1.022	0.998 to 1.048		0.073	1.251	1.140 to 1.373		**<0.001**	**<0.001**
Model 1	Ref		1.006	0.982 to 1.032		0.624	1.210	1.102 to 1.328		**<0.001**	**0.044**
Model 2	Ref		0.994	0.972 to 1.019		0.674	1.148	1.050 to 1.256		**0.003**	0.413
Cardiovascular risk factors (hypertension, dyslipidaemia or diabetes)											
Cardiovascular risk factors											

Continued

Table 5 Continued

	0 or 1		2 or 3				4				Trend p value
			OR	95% CI		P value	OR	95% CI		P value	
n (%)	386/2262	17.1%		184/940	19.6%			15/40	37.5%		
Unadjusted	Ref		1.025	0.996 to 1.056		0.092	1.227	1.088 to 1.383		**0.001**	**0.005**
Model 1	Ref		1.013	0.984 to 1.044		0.384	1.182	1.047 to 1.335		**0.007**	0.079
Model 2	Ref		1.007	0.978 to 1.036		0.656	1.160	1.032 to 1.304		**0.013**	0.192
Absence of cardiovascular risk factors											
n (%)	255/1250	20.4%		141/636	22.2%			16/34	47.1%		
Unadjusted	Ref		1.018	0.979 to 1.058		0.375	1.306	1.136 to 1.501		**<0.001**	**0.018**
Model 1	Ref		1.000	0.961 to 1.041		0.989	1.275	1.109 to 1.466		**0.001**	0.151
Model 2	Ref		0.977	0.941 to 1.015		0.228	1.181	1.033 to 1.350		**0.015**	0.982

Model 1: adjusted for age.
Model 2: adjusted for age, employment status, education level, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep duration.
Boldface p<0.05.

Therefore, obesity and behaviours like skipping breakfast can cause insomnia and can also be the consequences of insomnia. The impact of skipping breakfast may be explained by the previous results on sleep and these health behaviours.

In a previous study, exercise was found to be moderately effective in improving sleep.[38] Another study found that for older people, sleep quality was related to behaviours and habits that increase glycative stress, and significantly, an increase in glycative stress induced by exercise was found to be related to the quality of sleep.[39]

Our study showed that sleep quality was associated with exercise among only men. However, a study involving a population of elderly Korean individuals reported that sleep was associated with exercise among only women.[40] The age and sex of an individual may affect the frequency and intensity of exercise and, therefore, may affect the impact of exercise on sleep.

Drinking was not effective in improving sleep in our study. A research has also found a bidirectional association between alcohol consumption and insomnia.[41] Stress-related insomnia, in particular, has been associated with increased alcohol consumption, and drinking is thought to be a stress-coping behaviour.[42] Therefore, the association between unhealthy behaviour and insomnia may be considered to be bidirectional, and other factors related to insomnia have been associated with healthy behaviour. However, since there is an association between the accumulated health behaviours and sleep, individual healthy behaviour may be effective as a preventive intervention for insomnia.

The association between accumulated unhealthy behaviours and sleep by subgroup

A previous study analysed the association between cardiovascular risk factors and sleep.[43] Cardiovascular risk factors lead to dysfunction and burden of treatment.[43] Regarding diabetes, which is one of the cardiovascular risk factors, the symptom is excessive thirst or polyposia. Patients with diabetes tend to wake up often during the night, which reduces the quality of their sleep.

We also performed analyses stratified by cardiovascular risk factors. Through a subgroup analysis, this study also revealed the association between accumulated unhealthy behaviours and insomnia among men without diabetes and the association between accumulated unhealthy behaviours and cardiovascular risk factors among women without hypertension. Among men, insomnia has been associated with HbA1c levels.[44] A previous study reported that patients with both diabetes and insomnia tended to have worse glycaemic control than patients with diabetes who did not have insomnia. The effect of insomnia on glycaemic control was stronger in men than in women.[45] Moreover, diabetes complications made insomnia more severe for patients with diabetes.[43] HbA1c and diabetes complication may have a high impact on this association. Further clarification of this association is needed.

In our study, the association between insomnia and unhealthy behaviours was found only among women without hypertension and not among men with or without hypertension. One of the reasons of these sex differences may be that men and women have different attitudes towards health. Awareness, treatment and control of hypertension are low in both sexes, but greater in women than men; this explained that the sex differences may be caused

by age.[46] Another study showed that although hypertension was not significantly associated with insomnia in middle-aged adults, a significant association was present in older adults.[47] With regard to sex steroids, there is uncertainty about the effect of testosterone levels, particularly in men, on sleep disturbances; however, an association between decreased or fluctuating oestrogen levels and sleep disturbances is thought to exist in women.[48] Oestrogen in spontaneously hypertensive rats demonstrated improved quality of sleep in female.[49] Women with hypertension are older than those without it in our study. One possibility is that our study was participated by premenopausal and postmenopausal women, suggesting a stronger effect on insomnia due to reduced or fluctuating oestrogen levels before and after menopause.

However, regardless of the presence or absence of lifestyle-related diseases, these associations were nearly similar because the subjects who participated were from the general population and were not severely ill.

In the present study, we conducted a sensitivity analysis of depression diagnosis, insomnia and shift work, and found no differences compared with the main result. This study highlighted the association of accumulated unhealthy behaviours with cardiovascular risk factors and insomnia. Screening for cardiovascular risk factors is conducted at clinical practice or health check-up facilities, and health guidance to improve unhealthy behaviours is usually provided, which is a common preventive measure for both cardiovascular risk factors and insomnia. However, it is also important to provide preventive measures to improve unhealthy behaviours for the prevention of insomnia in apparently healthy individuals without cardiovascular risk factors.

Study limitations

Our study was limited in not showing a causal association between unhealthy behaviours and sleep, given its cross-sectional design. Further, since we used a self-reported questionnaire except for the definition of cardiovascular risk factors, results cannot be considered entirely objective. There may be potentially information bias due to a self-reported questionnaire. However, we believe that it is currently within a reasonable range for a survey of a large population. Adding objective measures, for example, evaluating sleep through polysomnography, is important for future research, although it should be noted that the AIS is a valid tool in screening for insomnia. Prospective studies with objective measurement of lifestyle factors are needed to clarify the validity and causal relationship between unhealthy behaviours and sleep. Although this study was adjusted for employment status and age, unmeasured confounding factors, for example, other socioeconomic and environmental factors, may be related to both healthy behaviours and sleep quality.

CONCLUSIONS

Having multiple unhealthy behaviours was associated with an increased likelihood of insomnia in a Japanese community population. Furthermore, this association was nearly similar regardless of the presence or absence of lifestyle-related disease. Moving forward, prospective studies are needed to clarify the causal relationship between unhealthy behaviours and sleep.

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Data availability statement Data may be obtained from a third party and are not publicly available. Raw data cannot be made publicly available, as study participants did not consent to have their information freely accessible. Based on this consent, the Ethics Committee for Tsuruoka Metabolomics Cohort Study (which includes representatives of Tsuruoka citizens, administration of Tsuruoka City, a lawyer and expert advisers) inhibits any public data sharing because the data contain individual and sensitive information such as personal history of diseases. The data will be shared after review of the purpose and permission by the ethics committee.

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