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Accumulated unhealthy behaviours and insomnia in Japanese dwellers with and without cardiovascular risk factors

Suzuka Kato, Sei Harada, Miho Iida, Kazuyo Kuwabara, Daisuke Sugiyama, Ayano Takeuchi, Mizuki Sata, Minako Matsumoto, Ayako Kurihara, Aya Hirata, Tomonori Okamura, Toru Takebayashi.

Department of Preventive Medicine and Public Health, School of Medicine, Keio University ,Shinjuku-ku, Tokyo, Japan

Corresponding author:

Suzuka Kato

Department of Preventive Medicine and Public Health, School of Medicine, Keio University, Shinjuku-ku, Tokyo, Japan

Address: 35 Shinanomachi, Shinjuku-ku, Tokyo 160-858, Japan

Tel: +81-3-5363-3758

Fax: +81-3-3359-3686

E-mail: kt-suzu-7k.a2@keio.jp

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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 = 9,657); The attendees of annual municipal or worksite health check-up programs.

Main outcome measures: Insomnia was assessed by Athens Insomnia, which was set as being Scale 6 points and greater. Other scales were given below; participants were categorized into three groups by their number of unhealthy behaviours (no exercise habit, smoking, alcohol drinking and 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 after stratification by 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 groups (trend p=0.017). Women with 4 or more unhealthy behaviour factors were more likely to have insomnia, compared with the lowest groups (ORs 1.176 95% CI 1.079-1.283). Insomnia has an association with the unhealthy behaviours among men without cardiovascular risk factors (ORs 1.127 95%CI 1.033-1.231 trend p=0.032). Women without hypertension were more likely to have the suspected insomnia, compared with the lowest groups (ORs 1.215 95% CI 1.102-1.340).

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

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Article Summary

Strengths and limitations of this study

・Our study showed accumulated unhealthy behaviours were associated with increased rates of insomnia in 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 dweller.

・Our study showed the effect of accumulated unhealthy behaviours on insomnia in men without the lifestyle-related diseases and on diabetes in women without hypertension. These results may be useful for improving unhealthy behaviour and sleep hygiene, in consideration of cardiovascular risk factors.

・This study used AIS is a valid tool in screening for insomnia. However, this results cannot be considered entirely objective.

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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 individual health behaviours and lifestyle are related to sleep disorders.[7] The prospective studies showed associations between sleep, obesity, and physical exercise.[8, 9]

A previous study examined the effect of lifestyle-related factors on non-restorative sleep in a population of Japanese individuals.[10] However, in these previous studies, the evidence did not shed light on the effect of accumulated unhealthy behaviours on insomnia. Significantly, although accumulated unhealthy behaviours are strongly related to cardiovascular risk factors, 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. 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 to 74 years recruited for the Tsuruoka Metabolomics Cohort study from the attendees of annual municipal or worksite health check-up programs in the city of Tsuruoka, Yamagata prefecture. Therefore, participants consisted of community population included self-employed, unemployed and employees such as city workers, medical/welfare personnel, and others. Details of the study have been described elsewhere.[11-13]

A cross-sectional study was performed using the baseline data collected for the Tsuruoka Metabolomics Cohort study from April 2012 to March 2015. We analysed the data on 9,657 participants (4,444 men and 5,213 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.

The study was approved by the Medical Ethics Committee of Keio University the School of Medicine, Tokyo, Japan (Approval No. 20110264), and conforms to the principles embodied in the Declaration of Helsinki. Informed consent was obtained from all subjects.

Measurements

Information regarding insomnia and other confounding variables were collected through a self-reported questionnaire. Quality of sleep was assessed by the Athens Insomnia Scale (AIS),[14] using a valid Japanese version.[15] 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

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quality of sleep, well-being, functioning capacity, and sleepiness during the day. We adopted a cut-off score of six or more on the AIS as "suspected insomnia" according to previous studies.[14, 15] For sleep duration, we asked participants the question, "How long do you sleep every day?" Sleep duration of fewer than six hours was defined as a "short sleep duration" according to the recommendations of the Japanese Ministry of Health, Labour, and Welfare that individuals sleep between 6-8 hours a day.[7]

These unhealthy behaviours were defined as smoking, drinking, skipping breakfast, and no habit of exercising and obesity based on Breslow's health habits, previous study and sleep guidelines for health promotion.[7,16,17] Smoking was categorized 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.[18] 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 work in shifts or night shifts. Living alone assessed living without housemate. Coffee or green tea consumption assessed 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, psychological stress was defined as a K6 score of five and above.[19]

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.[20] Diabetes was defined as HbA1c ≥6.5%, fasting blood glucose level ≥126 mg/dL or application of medication.[21] Dyslipidaemia defined as LDL cholesterol ≥140㎎／dL, triglyceride ≥150㎎／dL, HDL cholesterol <40 ㎎／dL or application of lipid-lowering medication.[22]

Patient and public involvement

Subjects of our study focussed on general population in Japanese rural area. Patients and the public were not directly involved in our study. It conducted the study 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 to 1, 2 to 3, and 4 or more factors. To assess the impact of the

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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 adjusted for age as covariates. In Model 2 included the factors relating to health behaviours; employment, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep duration were added to Model 1. Moreover, we performed further analysis after stratification by the existence of cardiovascular risk factors (hypertension, diabetes and dyslipidaemia). Statistical analysis was performed using R (version 4.0.3).

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RESULTS

A low number of unhealthy behaviours (0-1 factors) were found in 33.9% of men and 68.1% of women.

Tables 1 show the participant's socio-demographic characteristics by unhealthy behaviour group. Among the women, there was a significant difference among the groups by age, employment, education living alone, hypertension, dyslipidaemia, and K6. The men also showed the same pattern of significant differences except for caffeine drink intake, where there was a significant difference for men among the unhealthy behaviour groups.

Table 2 shows the association between each unhealthy factor and insomnia. Skipping breakfast increased the risk for suspected insomnia for both sexes, adjusted for age, employment, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep. Exercise increased the risk for suspected insomnia in men (ORs 1.025 95%CI 1.005-1.046).

Table 3 shows the crude and adjusted odds ratios of having suspected insomnia with relation to unhealthy behaviours. The overall prevalence of insomnia was 13.3% for men (590/4444) and 19.3% for women (1005/5213). Men with more unhealthy behaviour factors were more likely to increase suspected insomnia in model 2 after adjusting for age, employment, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep. (trend p = 0.017). Women with 4 or more unhealthy behaviour factors were more likely to have the 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 5 (women),when we stratified by hypertension, dyslipidaemia, and diabetes.

The association between accumulated health behaviour and insomnia was more or less the same when compared with 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 tends to 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 behaviour showed no association with insomnia in women with the absence of hypertension.

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Table1. Population characteristics by number of unhealthy behaviours

	Men				Women			
Unhealthy behaviours	0 or 1	2 or 3	4-		0 or 1	2 or 3	4-	
N	1505	2622	317		3548	1590	75	
	N (%)	N (%)	N (%)	p value	N (%)	N (%)	N (%)	p value
Age,mean (sd)	61.65 (9.77)	58.41 (9.79)	53.52 (9.46)	<0.001	60.49 (9.76)	55.61 (10.64)	49.72 (9.12)	<0.001
Smoking,n,%								
Non-smoker	464 (30.8)	449 (17.1)	16 (5.0)	<0.001	3293 (92.8)	1215 (76.4)	16 (21.3)	<0.001
Ex-smoker	977 (64.9)	1191 (45.4)	31 (9.8)		230 (6.5)	213 (13.4)	8 (10.7)	
Smoker	64 (4.3)	982 (37.5)	270 (85.2)		25 (0.7)	162 (10.2)	51 (68.0)	
Drinking,n,%								
Non-Drinker	459 (30.5)	299 (11.4)	10 (3.2)	<0.001	2843 (80.1)	635 (39.9)	11 (14.7)	<0.001
Ex-drinker	171 (11.4)	81 (3.1)	6 (1.9)		183 (5.2)	44 (2.8)	0 (0.0)	
Drinker	875 (58.1)	2242 (85.5)	301 (95.0)		522 (14.7)	911 (57.3)	64 (85.3)	
Exercise habits,n,%	1333 (88.6)	1055 (40.2)	18 (5.7)	<0.001	2491 (70.2)	304 (19.1)	5 (6.7)	<0.001
Eating breakfast everyday,n,%	1473 (97.9)	2225 (84.9)	108 (34.1)	<0.001	3455 (97.4)	1126 (70.8)	6 (8.0)	<0.001
BMI ≥25.0kg/m^2	125 (8.3)	1086 (41.4)	219 (69.1)	<0.001	459 (12.9)	720 (45.3)	52 (69.3)	<0.001
BMI (mean (SD))	22.78 (2.22)	24.23 (3.28)	25.31 (3.25)	<0.001	22.14 (2.95)	24.07 (4.07)	26.08 (4.43)	<0.001
Drinking coffee or tea everyday, n,%	1169 (77.8)	2011 (77.1)	231 (73.3)	0.225	3096 (87.7)	1349 (85.1)	71 (95.9)	0.003
Employment status,n,%				<0.001				<0.001
Regular employment	300 (20.0)	612 (23.4)	106 (33.4)		507 (14.3)	420 (26.4)	32 (42.7)	
Non-regular employment	197 (13.1)	347 (13.3)	44 (13.9)		716 (20.2)	418 (26.3)	22 (29.3)	
Self-employed	465 (31.0)	1199 (45.9)	139 (43.8)		742 (20.9)	394 (24.8)	15 (20.0)	
Unemployed	539 (35.9)	457 (17.5)	28 (8.8)		1583 (44.6)	356 (22.4)	6 (8.0)	
Shift work,n,%	38 (2.5)	78 (3.0)	11 (3.5)	0.560	81 (2.3)	105 (6.6)	11 (14.7)	<0.001
Education level,n,%				0.006				<0.001
Junior high school	213 (14.3)	390 (15.1)	26 (8.3)		552 (15.6)	204 (12.9)	2 (2.7)	
High school	816 (54.8)	1473 (56.9)	195 (61.9)		1865 (52.7)	792 (50.0)	42 (56.8)	
College or above	461 (30.9)	724 (28.0)	94 (29.8)		1120 (31.7)	589 (37.2)	30 (40.5)	
Living alone,n,%	62 (4.1)	121 (4.6)	26 (8.3)	0.007	227 (6.4)	97 (6.1)	12 (16.0)	0.003
Hypertension,n,%	692 (46.0)	1311 (50.0)	147 (46.5)	0.037	1288 (36.3)	613 (38.6)	15 (20.0)	0.003
Dyslipidaemia,n,%	704 (46.8)	1292 (49.3)	195 (61.5)	<0.001	1713 (48.3)	687 (43.2)	35 (46.7)	0.003
Diabetes,n,%	203 (13.5)	389 (14.8)	49 (15.5)	0.423	233 (6.6)	108 (6.8)	3 (4.1)	0.644
Sleep duration < 6 hours,n,%	73(4.9)	147(5.6)	29(9.1)	0.010	290(8.2)	196(12.3)	14(18.7)	<0.001
Depression,n,%	24 (1.6)	29 (1.1)	7 (2.2)	0.164	84 (2.4)	27 (1.7)	0 (0.0)	0.135
K6 (5 points or higher),n,%	474 (31.7)	813 (31.4)	130 (41.7)	0.001	1325 (37.7)	676 (42.9)	38 (51.4)	<0.001

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Table 2. Independent risk of insomnia and short sleep for individual unhealthy behaviours.

	Men			Women		
Unhealthy behaviours	OR	95%CI	p value	OR	95%CI	p value
Drinking	0.986	0.963 - 1.008	0.209	0.994	0.972 - 1.017	0.623
Smoking	1.002	0.981 - 1.024	0.857	1.016	0.966 - 1.068	0.544
Skipping breakfast	1.041	1.012 - 1.071	**0.006**	1.041	1.007 - 1.075	**0.017**
No exercise habit	1.025	1.005 - 1.046	**0.015**	1.004	0.983 - 1.026	0.712
BMI ≥25.0kg/m^2	1.009	0.988 - 1.030	0.407	0.979	0.955 - 1.004	0.101

Model 1: adjusted for age

Model 2: adjusted for age, employment, coffee or green tea consumption, living alone dyslipidaemia, hypertension, K6 and short sleep

Boldface p<0.05

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Table 3. Result of logistic-regression analysis with suspected insomnia.

		0 or 1		2 or 3				4-				trend p
				OR	95%CI		p value	OR	95%CI		p value	
Men	Total											
	n (%)	173/1505	11.5%		358/2622	13.7%			59/317	18.6%		
	Unadjusted	ref		1.022	1.000 -	1.044	**0.049**	1.074	1.031 -	1.119	**0.001**	**0.001**
	Model 1	ref		1.012	0.991 -	1.035	0.266	1.049	1.006 -	1.094	**0.025**	**0.039**
	Model 2	ref		1.022	1.001 -	1.043	**0.044**	1.040	0.999 -	1.083	0.054	**0.017**
Women	Total											
	n (%)	645/3548	18.2%		328/1590	20.6%			32/75	42.7%		
	Unadjusted	ref		1.025	1.001 -	1.049	**0.039**	1.277	1.168 -	1.398	**<0.001**	**<0.001**
	Model 1	ref		1.008	0.984 -	1.032	0.514	1.232	1.125 -	1.348	**<0.001**	**0.019**
	Model 2	ref		0.997	0.974 -	1.020	0.792	1.176	1.079 -	1.283	**<0.001**	0.228

Model 1: adjusted for age

Model 2: adjusted for age, employment, coffee or green tea consumption, living alone dyslipidaemia, hypertension, K6 and short sleep

Boldface p<0.05

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Table 4. Result of logistic-regression analysis with suspected insomnia in subgroup (men).

	0 or 1		2 or 3			4-			trend p
			OR	95%CI	p value	OR	95%CI	p value	
Hypertension									
Hypertension									
n (%)	72/692	10.4%		156/1311 11.9%			27/147 18.4%		
Unadjusted	ref		1.015	0.985-1.046	0.325	1.083	1.022-1.147	**0.007**	**0.022**
Model 1	ref		1.007	0.977-1.038	0.632	1.064	1.003-1.128	**0.039**	0.117
Model 2	ref		1.019	0.990-1.049	0.202	1.053	0.995-1.114	0.073	0.063
Absence of hypertension									
n (%)	101/812	12.4%		101/1311 15.4%			32/169 18.9%		
Unadjusted	ref		1.030	0.999-1.062	0.060	1.067	1.006-1.131	**0.030**	**0.012**
Model 1	ref		1.019	0.988-1.052	0.232	1.041	0.980-1.104	0.190	0.126
Model 2	ref		1.023	0.993-1.055	0.135	1.030	0.972-1.091	0.319	0.135
Dyslipidaemia									
Dyslipidaemia									
n (%)	75/704	10.7%		195/1292 15.1%			31/195 15.9%		
Unadjusted	ref		1.045	1.013-1.079	**0.006**	1.054	0.998-1.113	**0.060**	**0.007**
Model 1	ref		1.033	1.000-1.066	**0.049**	1.025	0.969-1.084	0.388	0.114
Model 2	ref		1.045	1.013-1.078	**0.005**	1.031	0.977-1.088	0.264	**0.032**
Absence of dyslipidaemia									
n (%)	98/800	12.2%		163/1330 12.3%			28/122 23.0%		
Unadjusted	ref		1.000	0.971-1.030	0.997	1.113	1.044-1.186	**0.001**	0.058
Model 1	ref		0.993	0.965-1.023	0.658	1.093	1.025-1.165	**0.007**	0.213
Model 2	ref		1.002	0.974-1.031	0.910	1.068	1.004-1.136	**0.037**	0.207
Diabetes									
Diabetes									
n (%)	29/203	14.3%		51/389 13.1%			10/49 20.4%		
Unadjusted	ref		0.988	0.932-1.048	0.696	1.063	0.954-1.185	0.269	0.607
Model 1	ref		0.982	0.925-1.043	0.565	1.048	0.937-1.172	0.412	0.830
Model 2	ref		0.994	0.939-1.052	0.841	1.046	0.938-1.165	0.419	0.691
Absence of diabetes									
n (%)	144/1302	11.1%		307/2231 13.8%			49/268 18.3%		
Unadjusted	ref		1.027	1.004-1.051	**0.022**	1.075	1.028-1.124	**0.001**	**0.001**
Model 1	ref		1.017	0.993-1.041	0.162	1.047	1.001-1.095	**0.045**	**0.037**
Model 2	ref		1.027	1.004-1.050	**0.023**	1.040	0.995-1.086	0.079	**0.015**

Cardiovascular risk factors (Hypertension, Dyslipidemia or Diabetes)

Cardiovascular risk factors

n (%)	120/1078	11.1%		263/1943	13.5%			41/251	16.3%		
Unadjusted	ref		1.024	0.999-1.050	0.059	1.053	1.006-1.103		**0.027**	**0.012**
Model 1	ref		1.013	0.988-1.039	0.317	1.025	0.977-1.074		0.316	0.228
Model 2	ref		1.021	0.996-1.046	0.097	1.017	0.972-1.064		0.469	0.166
Absence of cardiovascular risk factors										
n (%)	53/427	12.4%		95/678	14.0%			18/66	27.3%	
Unadjusted	ref		1.016	0.974-1.060	0.457	1.160	1.060-1.270		**0.001**	**0.018**
Model 1	ref		1.010	0.968-1.053	0.656	1.142	1.043-1.251		**0.004**	**0.050**
Model 2	ref		1.019	0.978-1.062	0.365	1.127	1.033-1.231		**0.007**	**0.032**

Model 1: adjusted for age

Model 2: adjusted for age, employment, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep

Boldface p<0.05

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Table 5. Result of logistic-regression analysis with suspected insomnia in subgroup (Women).

	0 or 1		2 or 3			4-			trend p
			OR	95%CI	p value	OR	95%CI	p value	
Hypertension									
Hypertension									
n (%)	215/1288	16.7%	124/613	20.2%		4/15	26.7%		
Unadjusted	ref		1.036	0.999-1.075	0.060	1.105	0.909-1.343	0.316	**0.039**
Model 1	ref		1.025	0.987-1.064	0.200	1.070	0.879-1.302	0.498	0.164
Model 2	ref		1.020	0.984-1.058	0.280	1.031	0.855-1.243	0.747	0.271
Absence of hypertension									
n (%)	430/2260	19.0%	204/977	20.9%		28/60	46.7%		
Unadjusted	ref		1.019	0.989-1.050	0.225	1.318	1.190-1.460	**<0.001**	**0.001**
Model 1	ref		0.996	0.966-1.027	0.809	1.273	1.149-1.410	**<0.001**	0.068
Model 2	ref		0.985	0.956-1.014	0.304	1.215	1.102-1.340	**<0.001**	0.408
Dyslipidaemia									
Dyslipidaemia									
n (%)	291/1713	17.0%	128/687	18.6%		13/35	37.1%		
Unadjusted	ref		1.017	0.983-1.051	0.340	1.223	1.077-1.390	**0.002**	**0.034**
Model 1	ref		1.008	0.974-1.043	0.659	1.189	1.044-1.354	**0.009**	0.160
Model 2	ref		1.002	0.970-1.036	0.896	1.163	1.027-1.317	**0.017**	0.296
Absence of dyslipidaemia									
n (%)	354/1835	19.3%	200/903	22.1%		19/40	47.5%		
Unadjusted	ref		1.029	0.996-1.063	0.082	1.326	1.169-1.504	**<0.001**	**0.001**
Model 1	ref		1.009	0.977-1.043	0.586	1.282	1.130-1.455	**<0.001**	**0.048**
Model 2	ref		0.992	0.962-1.024	0.619	1.199	1.063-1.353	**0.003**	0.480
Diabetes									
Diabetes									
n (%)	37/233	15.9%	21/108	19.4%		2/3	66.7%		
Unadjusted	ref		1.036	0.951-1.130	0.418	1.662	1.081-2.556	**0.021**	0.138
Model 1	ref		1.018	0.933-1.111	0.688	1.548	1.003-2.388	**0.049**	0.336
Model 2	ref		1.004	0.919-1.096	0.935	1.733	1.130-2.658	**0.012**	0.396
Absence of diabetes									
n (%)	608/3315	18.3%	307/1482	20.7%		29/71	40.8%		
Unadjusted	ref		1.024	0.998-1.049	0.054	1.252	1.141-1.374	**<0.001**	**<0.001**
Model 1	ref		1.007	0.982-1.032	0.581	1.209	1.101-1.327	**<0.001**	**0.040**
Model 2	ref		0.997	0.973-1.02	0.775	1.150	1.052-1.257	**0.002**	0.338

Cardiovascular risk factors (Hypertension, Dyslipidaemia or Diabetes)

Cardiovascular risk factors

n (%)	388/2280	17.0%		186/951	19.6%			15/40	37.5%		
Unadjusted	ref		1.026	0.996-1.056		0.086	1.227	1.089-1.384		**<0.001**	**0.005**
Model 1	ref		1.013	0.984-1.044		0.389	1.18	1.045-1.333		**0.007**	0.082
Model 2	ref		1.008	0.979-1.037		0.601	1.154	1.027-1.296		**0.016**	0.182
Absence of cardiovascular risk factors											
n (%)	257/1268	20.3%		142/639	22.2%			16/34	47.1%		
Unadjusted	ref		1.020	0.981-1.060		0.325	1.307	1.137-1.503		**<0.001**	**0.014**
Model 1	ref		1.000	0.961-1.041		0.992	1.275	1.109-1.465		**0.001**	0.146
Model 2	ref		0.980	0.944-1.017		0.290	1.185	1.039-1.352		**0.012**	0.883

Model 1: adjusted for age

Model 2: adjusted for age, employment, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and short sleep

Boldface p<0.05

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DISCUSSION

Our study showed both men and women with unhealthy behaviour factors were shown to have an increased likelihood of suspected insomnia in the Japanese population. Both men and women were shown to have an increased likelihood of suspected insomnia, compared to 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 behaviour and sleep hygiene, 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 to 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 (odds ratio, 1.60 [95% confidence interval, 1.29–1.97] for men and 2.88 [1.74–4.75] 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 individual 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 Japanese populations.[23,24]

The eating patterns of individuals have been associated with their metabolism, sleep-wake distribution, and circadian rhythm. These behaviours have an effect for the hormone and neurotransmitter substance; cortisol and neurotransmitter substance.[25]

Previous studies have reported the effect of diet pattern on cortisol rhythms.[26,27] It insomnia may cause an individual's circadian rhythm to be disrupted, which may in turn lead to them not eating breakfast. Also, dietary patterns explain the association between sleep and incidence of obesity in previous study.[28]

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Especially, skipping breakfast is associated with a change in leptin and melatonin.[29] Obesity and appetite changes in hormonal responses caused by leptin and ghrelin, which may be linked to sleep and leptin reduction. Moreover, the short sleepers tends to be poor sleep quality, and cause obesity by changed in glucose metabolism.[28]

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 for sleep and these health behaviours.

In a previous study, exercise was found to be moderately effective in improving sleep.[30] 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.[31]

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.[32] 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 no effective in improving sleep in our study. A research have also found a bidirectional association between alcohol consumption and insomnia.[33] Stress-related insomnia, in particular, has been associated with increased alcohol consumption, and drinking is thought to be a stress-coping behaviour.[34] Therefore, the association between unhealthy behaviour and insomnia may be considered to be bidirectional, and other factors-related insomnia has 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 unhealthy behaviours and sleep by subgroup.

A previous study analysed the association between cardiovascular risk factors and sleep.[35] Cardiovascular risk factors lead to dysfunction and burden of treatment.[35] Regarding diabetes which is one of cardiovascular risk factors, the symptom is excessive thirst and polyposia etc. Patients with diabetes tend to wake up often during the night, which reduces the quality of 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.[36] 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.[37] Moreover, he complications of diabetes made insomnia more severe for patients with diabetes.[35] HbA1c and the complication of diabetes may have a high impact on these association. Further clarification of the association is needed.

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In our study, the association between insomnia and unhealthy behaviours was found only among women without hypertension and no found 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 in China is low in both sexes, but greater in women than men and explained that the sex differences may be caused by age.[38] Another study showed that although hypertension was not significantly associated with insomnia in middle-aged adults, a significant association was present in older adults.[39] Our results may be suggested as the cause of sex steroids among old women. In 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 estrogen levels and sleep disturbances are thought to exist in women.[40] Oestrogen in spontaneously hypertensive rats demonstrated improved quality of sleep in female.[41] Women with hypertension is older than those with the absence of it in our study. One possibility is that our study participated pre- and postmenopausal women in this study, suggesting a stronger effect on insomnia due to reduced or fluctuating of estrogen levels before and after menopause.

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

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.

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. Adding objective measures, e.g., evaluating sleep through polysomnography, are important for future research, although it should be noted that the AIS is a valid tool in screening for insomnia. Although this study was adjusted for employment status and age, unmeasured confounding factors, e.g., 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, these associations were 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 behaviour and sleep.

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Patient consent: Obtained

Ethical approval: This study was approved by the Medical Ethics Committee of the School of Medicine, Keio University, Tokyo, Japan (approval no. 20110264).

Authors' contributions: SH and TT designed at this study. All authors conducted the research.SK analysed the data in our study and wrote the first draft of the manuscript. SK,TO and TT contributed to draft the manuscript. All authors reviewed the manuscript critically for important intellectual content and identified this contents.

Data availability statement: Most relevant data are within this manuscript. Raw data cannot be made publicly available, as study participants did not consent to have their information freely accessible. Based on these consents, the Ethics Committee for Tsuruoka Metabolomics Cohort Study (which includes representatives of Tsuruoka citizens, administration of Tsuruoka City, a lawyer, and expert advisers) strictly inhibits any public data sharing because data contain potentially identifying or sensitive disease information.

However, data accession requests may be sent to the administration of the Ethics Committee for Tsuruoka Metabolomics Cohort Study. The data will be shared after review of the purpose and permission by the

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ethics committee. Contact information for the data used this manuscript is Suzuka Kato, kt-suzu-7k.a2@keio.jp.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 2-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 5
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 5
Methods			
Study design	4	Present key elements of study design early in the paper	Page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 5-6
Bias	9	Describe any efforts to address potential sources of bias	Page 5-6
Study size	10	Explain how the study size was arrived at	Page 5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 6-7
		(*b*) Describe any methods used to examine subgroups and interactions	Page 7
		(*c*) Explain how missing data were addressed	Page 5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Page 7
		(*e*) Describe any sensitivity analyses	Page 18
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 5,9
		(b) Give reasons for non-participation at each stage	Page 5
		(c) Consider use of a flow diagram	N/A (Page 5,9)
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 9-10
		(b) Indicate number of participants with missing data for each variable of interest	Page 5

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Outcome data	15*	Report numbers of outcome events or summary measures	Page 12-16
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 12-16
		(*b*) Report category boundaries when continuous variables were categorized	Page 12-16
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Page 12-16
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 12-16
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 17-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 17-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 20

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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

Suzuka Kato, Sei Harada, Miho Iida, Kazuyo Kuwabara, Daisuke Sugiyama, Ayano Takeuchi, Mizuki Sata, Minako Matsumoto, Ayako Kurihara, Aya Hirata, Tomonori Okamura, Toru Takebayashi.

Department of Preventive Medicine and Public Health, School of Medicine, Keio University ,Shinjuku-ku, Tokyo, Japan

Corresponding author:

Suzuka Kato

Department of Preventive Medicine and Public Health, School of Medicine, Keio University, Shinjuku-ku, Tokyo, Japan

Address: 35 Shinanomachi, Shinjuku-ku, Tokyo 160-858, Japan

Tel: +81-3-5363-3758

Fax: +81-3-3359-3686

E-mail: kt-suzu-7k.a2@keio.jp

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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 = 9,565); The attendees of annual municipal or worksite health check-up programs.

Main outcome measures: Insomnia was assessed by Athens Insomnia, which was set as being Scale 6 points and greater. Other scales were given below; participants were categorized into three groups by their number of unhealthy behaviours (no exercise habit, smoking, alcohol drinking and 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 after stratification by 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 groups (trend p=0.013). Women with 4 or more unhealthy behaviour factors were more likely to have insomnia, compared with the lowest groups (ORs 1.175 95% CI 1.077-1.282). Insomnia has an association with the unhealthy behaviours among men without cardiovascular risk factors (lowest groups: ORs 1.133 95%CI 1.037-1.238, trend p=0.026). Women without hypertension were more likely to have the suspected insomnia, compared with the lowest groups (ORs 1.215 95% CI 1.101-1.341).

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

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Article Summary

Strengths and limitations of this study

・Our study showed accumulated unhealthy behaviours were associated with increased rates of insomnia in 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 dweller.

・Our study showed the effect of accumulated unhealthy behaviours on insomnia in men without the lifestyle-related diseases and on diabetes in women without hypertension. These results may be useful for improving unhealthy behaviour and sleep hygiene, in consideration of cardiovascular risk factors.

・This study used AIS is a valid tool in screening for insomnia. However, this results cannot be considered entirely objective.

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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 individual health behaviours and lifestyle are related to sleep disorders.[7] The prospective studies showed associations between sleep, obesity, and physical exercise.[8, 9] It was reported 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 showed the number of unhealthy behaviours positively correlated to the risk of sleep disturbances. However, one study was conducted on subjects over 60 years of age.[11] Moreover, these studies weren't used Athens Insomnia Scale (AIS) validated 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 the 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 to 74 years recruited for the Tsuruoka Metabolomics Cohort study from the attendees of annual municipal or worksite health check-up programs in the city of Tsuruoka, Yamagata prefecture. Therefore, participants consisted of community population included self-employed, unemployed and employees 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 of the public health-checkups. Although this study did not use random sampling, participation rate was very high (N= 11,002 89.2%). The study was approved by the Medical Ethics Committee of Keio University the School of Medicine, Tokyo, Japan (Approval No. 20110264), and conforms to the principles embodied in the Declaration of Helsinki.This study obtained written informed consent from all participants on the basis of the Medical Ethics Committee of the School of Medicine, Keio University, Tokyo, Japan (Approval No. 20110264). This study data included information of 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 for the Tsuruoka Metabolomics Cohort study from April 2012 to March 2015. We analysed the data on 9,565 participants (4,402 men and 5,163 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.Flow diagram for inclusion and exclusion of participants).

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Measurements

Information regarding insomnia and other confounding variables were collected through a self-reported questionnaire. Quality of sleep was assessed by the Athens Insomnia Scale (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 day. We adopted a cut-off score of six 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 six hours was defined as a "short sleep duration" according to the recommendations of the Japanese Ministry of Health, Labour, and Welfare that individuals sleep between 6-8 hours a day.[7]

These unhealthy behaviours were defined as smoking, drinking, skipping breakfast, and no habit of exercising and obesity based on Breslow's health habits, previous study and sleep guidelines for health promotion.[7,25,26] Smoking was categorized 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 work in shifts or night shifts. Living alone assessed living without housemate. Coffee or green tea consumption assessed 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, psychological stress was defined as a K6 score of five 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 application of medication.[15] Dyslipidaemia defined as LDL cholesterol ≥140㎎／dL, triglyceride ≥150㎎／dL, HDL cholesterol <40 ㎎／dL or application of lipid-lowering medication.[16]

Patient and public involvement

Subjects of our study focussed on general population in Japanese rural area. Patients and the public were not directly involved in our study. It conducted the study 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 to 1, 2 to 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 adjusted for age as covariates. In 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 analyzed in all model and variables. Correlation coefficients ranged approximately

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from ±0.1 to 0.6, and VIFs were <3 in all variables. Moreover, we performed further analysis after stratification by the existence of cardiovascular risk factors (hypertension, diabetes and dyslipidaemia). Statistical analysis was performed using R (version 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.

Tables 1 show the participant's socio-demographic characteristics by unhealthy behaviour group. Among the women, there was a significant difference among the groups by age, employment, education living alone, hypertension, dyslipidaemia, and K6. The men also showed the same pattern of significant differences except for caffeine drink intake, where there was a significant difference for men among the unhealthy behaviour groups.

Table 2 shows the association between each unhealthy factor and insomnia. Skipping breakfast increased the risk for 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). Men showed the association between drinking and insomnia in model 1, but it didn't show significant association in model 2. No exercise habit increased the risk for suspected insomnia only in men (Model 2: ORs 1.027 95%CI 1.007-1.048).

Table 3 shows the crude and adjusted odds ratios of having suspected insomnia with relation to unhealthy behaviours. The overall prevalence of insomnia was 13.3% for men (586/4402) and 19.3% for women (998/5163). Men with more unhealthy behaviour factors were more likely to increase 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 (trend $p = 0.013$). Women with 4 or more unhealthy behaviour factors were more likely to have the 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 5 (women),when we stratified by hypertension, dyslipidaemia, and diabetes.

The association between accumulated health behaviour and insomnia was more or less the same when compared with 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 tends to 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 behaviour showed no association with insomnia in women with the absence of hypertension.

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Table1. Population characteristics by number of unhealthy behaviours

	Men				Women			
Unhealthy behaviours	0 or 1	2 or 3	4-		0 or 1	2 or 3	4-	
N	1487	2599	316		3512	1576	75	
	N (%)	N (%)	N (%)	p value	N (%)	N (%)	N (%)	p 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 everyday,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 ≥25.0kg/m²	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 everyday,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,%	2262 (64.4)	940 (59.6)	40 (54.1)	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

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Table 2. Independent risk of insomnia and short sleep for individual unhealthy behaviours.

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

Boldface p<0.05

Table 3. Results of logistic regression analysis with suspected insomnia.

		0 or 1		2 or 3				4-				trend p
				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 -	1.047	**0.029**	1.076	1.032 -	1.121	**0.001**	**<0.001**
	Model 1	ref		1.015	0.993 -	1.037	0.184	1.051	1.008 -	1.096	**0.020**	**0.025**
	Model 2	ref		1.024	1.003 -	1.046	**0.028**	1.041	1.000 -	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 -	1.048	**0.047**	1.277	1.167 -	1.397	**<0.001**	**<0.001**
	Model 1	ref		1.008	0.984 -	1.032	0.524	1.233	1.126 -	1.349	**<0.001**	**0.019**
	Model 2	ref		0.995	0.973 -	1.019	0.690	1.175	1.077 -	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

Boldface p<0.05

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Table 4. Results of logistic regression analysis with suspected insomnia in men.

	0 or 1	2 or 3			4-			trend p
		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	0.988-1.049	0.240	1.085	1.024-1.149	**0.006**	**0.015**
Model 1	ref	1.011	0.980-1.042	0.489	1.067	1.006-1.132	**0.032**	0.081
Model 2	ref	1.021	0.992-1.051	0.157	1.051	0.993-1.113	0.084	0.057
Absence of hypertension								
n (%)	99/802 12.3%		202/1302 15.5%			32/168 19.0%		
Unadjusted	ref	1.032	1.001-1.065	**0.046**	1.069	1.008-1.134	**0.025**	**0.009**
Model 1	ref	1.021	0.99-1.054	0.193	1.042	0.982-1.106	0.178	0.107
Model 2	ref	1.026	0.995-1.058	0.097	1.033	0.975-1.094	0.277	0.101
Dyslipidaemia								
Dyslipidaemia								
n (%)	74/695 10.6%		195/1279 15.2%			31/195 15.9%		
Unadjusted	ref	1.047	1.014-1.081	**0.005**	1.054	0.998-1.113	0.060	**0.007**
Model 1	ref	1.035	1.002-1.069	**0.038**	1.025	0.969-1.084	0.388	0.104
Model 2	ref	1.048	1.016-1.082	**0.003**	1.032	0.978-1.090	0.256	**0.026**
Absence of dyslipidaemia								
n (%)	95/792 12.0%		163/1320 12.3%			28/121 23.1%		
Unadjusted	ref	1.004	0.974-1.033	0.814	1.118	1.049-1.192	**0.001**	**0.034**
Model 1	ref	0.996	0.967-1.026	0.815	1.097	1.029-1.170	**0.005**	0.146
Model 2	ref	1.004	0.976-1.034	0.777	1.070	1.006-1.139	**0.033**	0.161
Diabetes								
Diabetes								
n (%)	28/202 13.9%		51/387 13.2%			10/49 20.4%		
Unadjusted	ref	0.993	0.936-1.054	0.821	1.068	0.958-1.190	0.236	0.511

Model 1	ref		0.987	0.930-1.048	0.667	1.051	0.940-1.175	0.385	0.744
Model 2	ref		0.995	0.940-1.053	0.870	1.046	0.938-1.165	0.420	0.676
Absence of diabetes									
n (%)	141/1285	11.0%		307/2210	13.9%		49/267	18.4%	
Unadjusted	ref		1.030	1.006-1.054	**0.014**	1.077	1.028-1.124	**0.001**	**<0.001**
Model 1	ref		1.019	0.995-1.043	0.116	1.049	1.002-1.098	**0.039**	**0.026**
Model 2	ref		1.029	1.006-1.053	**0.015**	1.040	0.995-1.087	0.080	**0.012**
Cardiovascular risk factors (Hypertension, Dyslipidemia or Diabetes)									
Cardiovascular risk factors									
n (%)	117/1066	11.0%		263/1922	13.7%		41/251	16.3%	
Unadjusted	ref		1.027	1.027-1.054	**0.035**	1.055	1.007-1.105	**0.023**	**0.008**
Model 1	ref		1.016	0.991-1.042	0.216	1.026	0.979-1.076	0.289	0.169
Model 2	ref		1.026	1.001-1.051	**0.045**	1.018	0.973-1.066	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	0.975-1.061	0.431	1.166	1.065-1.277	**0.001**	**0.015**
Model 1	ref		1.010	0.968-1.054	0.633	1.148	1.048-1.257	**0.003**	**0.043**
Model 2	ref		1.020	0.979-1.063	0.349	1.133	1.037-1.238	**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

Boldface p<0.05

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Table 5. Results of logistic regression analysis with suspected insomnia in women.

	0 or 1		2 or 3			4-			trend p
			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	0.999-1.077	0.051	1.105	0.909-1.343	0.316	**0.034**
Model 1	ref		1.027	0.989-1.067	0.169	1.073	0.881-1.305	0.485	0.138
Model 2	ref		1.020	0.983-1.058	0.303	1.033	0.856-1.246	0.738	0.291
Absence of hypertension									
n (%)	428/2235	19.1%		201/967 20.8%			28/60 46.7%		
Unadjusted	ref		1.016	0.986-1.048	0.288	1.317	1.189-1.459	**<0.001**	**0.001**
Model 1	ref		0.995	0.965-1.026	0.753	1.273	1.149-1.411	**<0.001**	0.076
Model 2	ref		0.983	0.954-1.012	0.247	1.215	1.101-1.341	**<0.001**	0.483
Dyslipidaemia									
Dyslipidaemia									
n (%)	290/1701	17.0%		126/676 18.6%			13/35 37.1%		
Unadjusted	ref		1.016	0.982-1.051	0.360	1.223	1.076-1.389	**0.002**	**0.037**
Model 1	ref		1.007	0.973-1.043	0.676	1.189	1.044-1.354	**0.009**	0.165
Model 2	ref		1.001	0.968-1.035	0.948	1.164	1.028-1.319	**0.017**	0.320
Absence of dyslipidaemia									
n (%)	351/1811	19.4%		199/900 22.1%			19/40 47.5%		
Unadjusted	ref		1.028	0.995-1.061	0.097	1.325	1.167-1.503	**<0.001**	**0.002**
Model 1	ref		1.009	0.976-1.043	0.593	1.284	1.131-1.457	**<0.001**	**0.049**
Model 2	ref		0.990	0.959-1.022	0.523	1.197	1.060-1.353	**0.004**	0.581
Diabetes									
Diabetes									
n (%)	36/232	15.5%		21/105 20.0%			2/3 66.7%		
Unadjusted	ref		1.046	0.959-1.141	0.313	1.668	1.086-2.562	**0.020**	0.092

Model 1	ref		1.027	0.941-1.122	0.551	1.554	1.009-2.395	**0.046**	0.248
Model 2	ref		1.018	0.931-1.112	0.700	1.723	1.125-2.640	**0.013**	0.255
Absence of diabetes									
n (%)	605/3280	18.4%		304/1471	20.7%		29/71	40.8%	
Unadjusted	ref		1.022	0.998-1.048	0.073	1.251	1.140-1.373	**<0.001**	**<0.001**
Model 1	ref		1.006	0.982-1.032	0.624	1.210	1.102-1.328	**<0.001**	**0.044**
Model 2	ref		0.994	0.972-1.019	0.674	1.148	1.050-1.256	**0.003**	0.413
Cardiovascular risk factors (Hypertension, Dyslipidaemia or Diabetes)									
Cardiovascular risk factors									
n (%)	386/2262	17.1%		184/940	19.6%		15/40	37.5%	
Unadjusted	ref		1.025	0.996-1.056	0.092	1.227	1.088-1.383	**0.001**	**0.005**
Model 1	ref		1.013	0.984-1.044	0.384	1.182	1.047-1.335	**0.007**	0.079
Model 2	ref		1.007	0.978-1.036	0.656	1.160	1.032-1.304	**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	0.979-1.058	0.375	1.306	1.136-1.501	**<0.001**	**0.018**
Model 1	ref		1.000	0.961-1.041	0.989	1.275	1.109-1.466	**0.001**	0.151
Model 2	ref		0.977	0.941-1.015	0.228	1.181	1.033-1.350	**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

Boldface p<0.05

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DISCUSSION

Our study showed both men and women with unhealthy behaviour factors were shown to have an increased likelihood of suspected insomnia in the Japanese population. Both men and women were shown to have an increased likelihood of suspected insomnia, compared to 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 behaviour and sleep hygiene, 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 to 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 (odds ratio, 1.60 [95% confidence interval, 1.29–1.97] for men and 2.88 [1.74–4.75] 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 individual 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 Japanese populations.[31,32]

The eating patterns of individuals have been associated with their metabolism, sleep-wake distribution, and circadian rhythm. These behaviours have an effect for the hormone and neurotransmitter substance; cortisol and neurotransmitter substance.[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 to them not eating breakfast.

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

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Especially, skipping breakfast is associated with a change in leptin and melatonin.[37] Obesity and appetite changes in hormonal responses caused by leptin and ghrelin, which may be linked to sleep and leptin reduction. Moreover, the short sleepers tend to be poor sleep quality, and cause obesity by changed in glucose metabolism.[36]

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 for 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 no effective in improving sleep in our study. A research have 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 insomnia has 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 cardiovascular risk factors, the symptom is excessive thirst and polyposia etc. Patients with diabetes tend to wake up often during the night, which reduces the quality of 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, the complications of diabetes made insomnia more severe for patients with diabetes.[43] HbA1c and the complication of diabetes may have a high impact on these association. Further clarification of the association is needed.

In our study, the association between insomnia and unhealthy behaviours was found only among women without hypertension and no found 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 in China is low in both sexes, but greater in women than men and 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] Our results may be suggested as the cause of sex steroids among old women. In 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 estrogen levels and sleep disturbances are thought to exist in women.[48] Estrogen in spontaneously hypertensive rats demonstrated improved quality of sleep in female.[49] Women with hypertension is older than those with the absence of it in our study. One possibility is that our study participated pre- and postmenopausal women in this study, suggesting a stronger effect on insomnia due to reduced or fluctuating of estrogen levels before and after menopause.

However, regardless of the presence or absence of lifestyle-related diseases, these associations were nearly similar because the subjects were participated in the general population and were not severely diseased. 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 checkup, and health guidance to improve unhealthy behaviours is usually provided, which is common preventive measures 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; self-reporting bias. Adding objective measures, e.g., evaluating sleep through polysomnography, are important for future research, although it should be noted that the AIS is a valid tool in screening for insomnia. Although this study was adjusted for employment status and age, unmeasured confounding factors, e.g., 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, these associations were 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 behaviour and sleep.

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Competing interests: None declared

Patient consent: Obtained

Ethical approval: This study was approved by the Medical Ethics Committee of the School of Medicine, Keio University, Tokyo, Japan (approval no. 20110264).

Authors' contributions: SH and TT designed at this study. All authors conducted the research.SK analysed the data in our study and wrote the first draft of the manuscript. SK,TO and TT contributed to draft the manuscript. SK,SH,MI,KK,DS,AT,MS,MM,AK,AH,TO and TT reviewed the manuscript critically for important intellectual content and identified this contents. reviewed the manuscript critically for important intellectual content and identified this contents.

Data availability statement: Raw data cannot be made publicly available, as study participants did not consent to have their information freely accessible. Based on these consents, 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.[22]

Provenance and peer review: Not commissioned; externally peer reviewed

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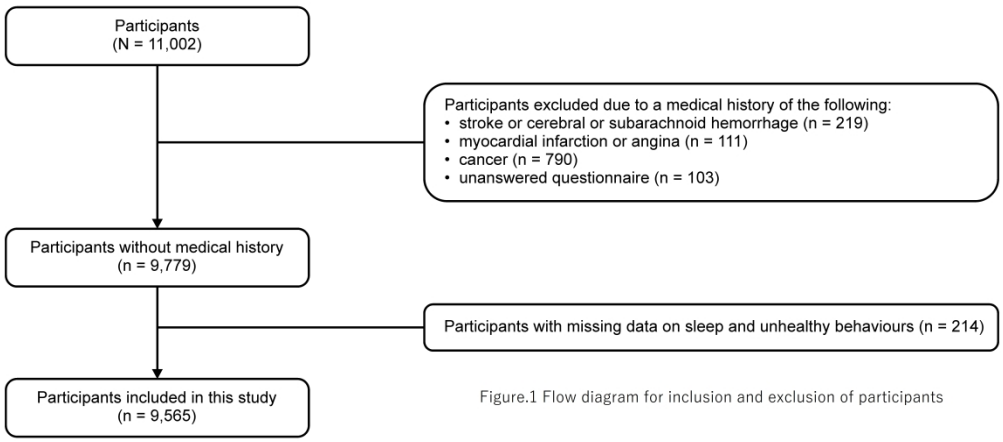

Figure.1 Flow diagram for inclusion and exclusion of participants

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 6
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 6
Methods			
Study design	4	Present key elements of study design early in the paper	Page 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7
Bias	9	Describe any efforts to address potential sources of bias	Page 7
Study size	10	Explain how the study size was arrived at	Page 7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 7-8
		(*b*) Describe any methods used to examine subgroups and interactions	Page 7
		(*c*) Explain how missing data were addressed	Page 6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Page 7
		(*e*) Describe any sensitivity analyses	Page 19
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 6,8
		(b) Give reasons for non-participation at each stage	Page 6
		(c) Consider use of a flow diagram	Page 27
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 8-10
		(b) Indicate number of participants with missing data for each variable of interest	Page 6
Outcome data	15*	Report numbers of outcome events or summary measures	Page 11-15

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 11-15
		(*b*) Report category boundaries when continuous variables were categorized	Page 11-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Page 11-15
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 11-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 17-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 17-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 20

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article. Information on the STROBE Initiative is available at www.strobe-statement.org.

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

Suzuka Kato, Sei Harada, Miho Iida, Kazuyo Kuwabara, Daisuke Sugiyama, Ayano Takeuchi, Mizuki Sata, Minako Matsumoto, Ayako Kurihara, Aya Hirata, Tomonori Okamura, Toru Takebayashi.

Department of Preventive Medicine and Public Health, School of Medicine, Keio University ,Shinjuku-ku, Tokyo, Japan

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Corresponding author:

Suzuka Kato

Department of Preventive Medicine and Public Health, School of Medicine, Keio University, Shinjuku-ku, Tokyo, Japan

Address: 35 Shinanomachi, Shinjuku-ku, Tokyo 160-858, Japan

Tel: +81-3-5363-3758

Fax: +81-3-3359-3686

E-mail: kt-suzu-7k.a2@keio.jp

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 = 9,565); The attendees of annual municipal or worksite health check-up programs.

Main outcome measures: Insomnia was assessed by Athens Insomnia, which was set as being Scale 6 points and greater. Other scales were given below; participants were categorized into three groups by their number of unhealthy behaviours (no exercise habit, smoking, alcohol drinking and 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 after stratification by 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 groups (trend p=0.013). Women with 4 or more unhealthy behaviour factors were more likely to have insomnia, compared with the lowest groups (ORs 1.175 95% CI 1.077-1.282). Insomnia has an association with the unhealthy behaviours among men without cardiovascular risk factors (lowest groups: ORs 1.133 95%CI 1.037-1.238, trend p=0.026). Women without hypertension were more likely to have the suspected insomnia, compared with the lowest groups (ORs 1.215 95% CI 1.101-1.341).

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

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Article Summary

Strengths and limitations of this study

・Our study showed accumulated unhealthy behaviours were associated with increased rates of insomnia in 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 dweller.

・Our study showed the effect of accumulated unhealthy behaviours on insomnia in men without the lifestyle-related diseases and on diabetes in women without hypertension. These results may be useful for improving unhealthy behaviour and sleep hygiene, in consideration of cardiovascular risk factors.

・This study used AIS is a valid tool in screening for insomnia. However, this results cannot be considered entirely objective.

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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 individual health behaviours and lifestyle are related to sleep disorders.[7] The prospective studies showed associations between sleep, obesity, and physical exercise.[8, 9] It was reported 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 showed the number of unhealthy behaviours positively correlated to the risk of sleep disturbances. However, one study was conducted on subjects over 60 years of age.[11] Moreover, these studies weren't used Athens Insomnia Scale (AIS) validated 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 the 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 to 74 years recruited for 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 community population included self-employed, unemployed and employees 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 of the public health-checkups. Although this study did not use random sampling, participation rate was very high (N= 11,002 89.2%). The study was approved by the Medical Ethics Committee of Keio University the School of Medicine, Tokyo, Japan (Approval No. 20110264), and conforms to the principles embodied in the Declaration of Helsinki.This study obtained written informed consent from all participants on the basis of the Medical Ethics Committee of the School of Medicine, Keio University, Tokyo, Japan（Approval No. 20110264）. This study data included information of 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 for the Tsuruoka Metabolomics Cohort study from April 2012 to March 2015. We analysed the data on 9,565 participants (4,402 men and 5,163 women) who had been diagnosed without cancer, coronary heart disease, and stroke by medical doctors and the complete data regarding sleep and

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unhealthy behaviours that had been collected through a self-report questionnaire (Figure 1.Flow diagram for inclusion and exclusion of participants).

Measurements

Information regarding insomnia and other confounding variables were collected through a self-reported questionnaire. Quality of sleep was assessed by the Athens Insomnia Scale (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 day. We adopted a cut-off score of six 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 six hours was defined as a "short sleep duration" according to the recommendations of the Japanese Ministry of Health, Labour, and Welfare that individuals sleep between 6-8 hours a day.[7]

These unhealthy behaviours were defined as smoking, drinking, skipping breakfast, and no habit of exercising and obesity based on Breslow's health habits, previous study and sleep guidelines for health promotion.[7,25,26] Smoking was categorized 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 work in shifts or night shifts. Living alone assessed living without housemate. Coffee or green tea consumption assessed 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, psychological stress was defined as a K6 score of five 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 application of medication.[15] Dyslipidaemia defined as LDL cholesterol ≥140㎎／dL, triglyceride ≥150㎎／dL, HDL cholesterol <40 ㎎／dL or application 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, not recruited from patient groups. Patients and the public were not directly involved in our study. It conducted the study 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 to 1, 2 to 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 adjusted for age as covariates. In Model 2 included the factors relating to health behaviours; employment status, education level, coffee or green tea consumption, living alone, dyslipidaemia, hypertension, K6 and

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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 analyzed in all model 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 by the existence of cardiovascular risk factors (hypertension, diabetes and dyslipidaemia). Statistical analysis was performed using R (version 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.

Tables 1 show the participant's socio-demographic characteristics by unhealthy behaviour group. Among the women, there was a significant difference among the groups by age, employment, education living alone, hypertension, dyslipidaemia, and K6. The men also showed the same pattern of significant differences except for caffeine drink intake, where there was a significant difference for men among the unhealthy behaviour groups.

Table 2 shows the association between each unhealthy factor and insomnia. Skipping breakfast increased the risk for 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). Men showed the association between drinking and insomnia in model 1, but it didn't show significant association in model 2. No exercise habit increased the risk for suspected insomnia only in men (Model 2: ORs 1.027 95%CI 1.007-1.048).

Table 3 shows the crude and adjusted odds ratios of having suspected insomnia with relation to unhealthy behaviours. The overall prevalence of insomnia was 13.3% for men (586/4402) and 19.3% for women (998/5163). Men with more unhealthy behaviour factors were more likely to increase 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 (trend p = 0.013). Women with 4 or more unhealthy behaviour factors were more likely to have the 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 5 (women),when we stratified by hypertension, dyslipidaemia, and diabetes.

The association between accumulated health behaviour and insomnia was more or less the same when compared with 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 tends to 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 behaviour showed no association with insomnia in women with the absence of hypertension.

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Table1. Population characteristics by number of unhealthy behaviours

	Men				Women			
Unhealthy behaviours	0 or 1	2 or 3	4-		0 or 1	2 or 3	4-	
N	1487	2599	316		3512	1576	75	
	N (%)	N (%)	N (%)	p value	N (%)	N (%)	N (%)	p 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 everyday,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 ≥25.0kg/m²	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 everyday,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,%	2262 (64.4)	940 (59.6)	40 (54.1)	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

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Table 2. Independent risk of insomnia and short sleep for individual unhealthy behaviours.

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

Boldface p<0.05

Table 3. Results of logistic regression analysis with suspected insomnia.

		0 or 1		2 or 3				4-				trend p
				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 -	1.047	**0.029**	1.076	1.032 -	1.121	**0.001**	**<0.001**
	Model 1	ref		1.015	0.993 -	1.037	0.184	1.051	1.008 -	1.096	**0.020**	**0.025**
	Model 2	ref		1.024	1.003 -	1.046	**0.028**	1.041	1.000 -	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 -	1.048	**0.047**	1.277	1.167 -	1.397	**<0.001**	**<0.001**
	Model 1	ref		1.008	0.984 -	1.032	0.524	1.233	1.126 -	1.349	**<0.001**	**0.019**
	Model 2	ref		0.995	0.973 -	1.019	0.690	1.175	1.077 -	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

Boldface p<0.05

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Table 4. Results of logistic regression analysis with suspected insomnia in men.

	0 or 1	2 or 3			4-			trend p
		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	0.988-1.049	0.240	1.085	1.024-1.149	**0.006**	**0.015**
Model 1	ref	1.011	0.980-1.042	0.489	1.067	1.006-1.132	**0.032**	0.081
Model 2	ref	1.021	0.992-1.051	0.157	1.051	0.993-1.113	0.084	0.057
Absence of hypertension								
n (%)	99/802 12.3%	202/1302	15.5%		32/168	19.0%		
Unadjusted	ref	1.032	1.001-1.065	**0.046**	1.069	1.008-1.134	**0.025**	**0.009**
Model 1	ref	1.021	0.99-1.054	0.193	1.042	0.982-1.106	0.178	0.107
Model 2	ref	1.026	0.995-1.058	0.097	1.033	0.975-1.094	0.277	0.101
Dyslipidaemia								
Dyslipidaemia								
n (%)	74/695 10.6%	195/1279	15.2%		31/195	15.9%		
Unadjusted	ref	1.047	1.014-1.081	**0.005**	1.054	0.998-1.113	0.060	**0.007**
Model 1	ref	1.035	1.002-1.069	**0.038**	1.025	0.969-1.084	0.388	0.104
Model 2	ref	1.048	1.016-1.082	**0.003**	1.032	0.978-1.090	0.256	**0.026**
Absence of dyslipidaemia								
n (%)	95/792 12.0%	163/1320	12.3%		28/121	23.1%		
Unadjusted	ref	1.004	0.974-1.033	0.814	1.118	1.049-1.192	**0.001**	**0.034**
Model 1	ref	0.996	0.967-1.026	0.815	1.097	1.029-1.170	**0.005**	0.146
Model 2	ref	1.004	0.976-1.034	0.777	1.070	1.006-1.139	**0.033**	0.161
Diabetes								
Diabetes								
n (%)	28/202 13.9%	51/387	13.2%		10/49	20.4%		
Unadjusted	ref	0.993	0.936-1.054	0.821	1.068	0.958-1.190	0.236	0.511

Model 1	ref		0.987	0.930-1.048	0.667	1.051	0.940-1.175	0.385	0.744
Model 2	ref		0.995	0.940-1.053	0.870	1.046	0.938-1.165	0.420	0.676
Absence of diabetes									
n (%)	141/1285	11.0%		307/2210	13.9%		49/267	18.4%	
Unadjusted	ref		1.030	1.006-1.054	**0.014**	1.077	1.028-1.124	**0.001**	**<0.001**
Model 1	ref		1.019	0.995-1.043	0.116	1.049	1.002-1.098	**0.039**	**0.026**
Model 2	ref		1.029	1.006-1.053	**0.015**	1.040	0.995-1.087	0.080	**0.012**
Cardiovascular risk factors (Hypertension, Dyslipidemia or Diabetes)									
Cardiovascular risk factors									
n (%)	117/1066	11.0%		263/1922	13.7%		41/251	16.3%	
Unadjusted	ref		1.027	1.027-1.054	**0.035**	1.055	1.007-1.105	**0.023**	**0.008**
Model 1	ref		1.016	0.991-1.042	0.216	1.026	0.979-1.076	0.289	0.169
Model 2	ref		1.026	1.001-1.051	**0.045**	1.018	0.973-1.066	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	0.975-1.061	0.431	1.166	1.065-1.277	**0.001**	**0.015**
Model 1	ref		1.010	0.968-1.054	0.633	1.148	1.048-1.257	**0.003**	**0.043**
Model 2	ref		1.020	0.979-1.063	0.349	1.133	1.037-1.238	**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

Boldface p<0.05

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Table 5. Results of logistic regression analysis with suspected insomnia in women.

	0 or 1		2 or 3			4-			trend p
			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	0.999-1.077	0.051	1.105	0.909-1.343	0.316	**0.034**
Model 1	ref		1.027	0.989-1.067	0.169	1.073	0.881-1.305	0.485	0.138
Model 2	ref		1.020	0.983-1.058	0.303	1.033	0.856-1.246	0.738	0.291
Absence of hypertension									
n (%)	428/2235	19.1%		201/967 20.8%			28/60 46.7%		
Unadjusted	ref		1.016	0.986-1.048	0.288	1.317	1.189-1.459	**<0.001**	**0.001**
Model 1	ref		0.995	0.965-1.026	0.753	1.273	1.149-1.411	**<0.001**	0.076
Model 2	ref		0.983	0.954-1.012	0.247	1.215	1.101-1.341	**<0.001**	0.483
Dyslipidaemia									
Dyslipidaemia									
n (%)	290/1701	17.0%		126/676 18.6%			13/35 37.1%		
Unadjusted	ref		1.016	0.982-1.051	0.360	1.223	1.076-1.389	**0.002**	**0.037**
Model 1	ref		1.007	0.973-1.043	0.676	1.189	1.044-1.354	**0.009**	0.165
Model 2	ref		1.001	0.968-1.035	0.948	1.164	1.028-1.319	**0.017**	0.320
Absence of dyslipidaemia									
n (%)	351/1811	19.4%		199/900 22.1%			19/40 47.5%		
Unadjusted	ref		1.028	0.995-1.061	0.097	1.325	1.167-1.503	**<0.001**	**0.002**
Model 1	ref		1.009	0.976-1.043	0.593	1.284	1.131-1.457	**<0.001**	**0.049**
Model 2	ref		0.990	0.959-1.022	0.523	1.197	1.060-1.353	**0.004**	0.581
Diabetes									
Diabetes									
n (%)	36/232	15.5%		21/105 20.0%			2/3 66.7%		
Unadjusted	ref		1.046	0.959-1.141	0.313	1.668	1.086-2.562	**0.020**	0.092

Model 1	ref		1.027	0.941-1.122	0.551	1.554	1.009-2.395	**0.046**	0.248
Model 2	ref		1.018	0.931-1.112	0.700	1.723	1.125-2.640	**0.013**	0.255
Absence of diabetes									
n (%)	605/3280	18.4%		304/1471	20.7%		29/71	40.8%	
Unadjusted	ref		1.022	0.998-1.048	0.073	1.251	1.140-1.373	**<0.001**	**<0.001**
Model 1	ref		1.006	0.982-1.032	0.624	1.210	1.102-1.328	**<0.001**	**0.044**
Model 2	ref		0.994	0.972-1.019	0.674	1.148	1.050-1.256	**0.003**	0.413
Cardiovascular risk factors (Hypertension, Dyslipidaemia or Diabetes)									
Cardiovascular risk factors									
n (%)	386/2262	17.1%		184/940	19.6%		15/40	37.5%	
Unadjusted	ref		1.025	0.996-1.056	0.092	1.227	1.088-1.383	**0.001**	**0.005**
Model 1	ref		1.013	0.984-1.044	0.384	1.182	1.047-1.335	**0.007**	0.079
Model 2	ref		1.007	0.978-1.036	0.656	1.160	1.032-1.304	**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	0.979-1.058	0.375	1.306	1.136-1.501	**<0.001**	**0.018**
Model 1	ref		1.000	0.961-1.041	0.989	1.275	1.109-1.466	**0.001**	0.151
Model 2	ref		0.977	0.941-1.015	0.228	1.181	1.033-1.350	**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

Boldface p<0.05

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DISCUSSION

Our study showed both men and women with unhealthy behaviour factors were shown to have an increased likelihood of suspected insomnia in the Japanese population. Both men and women were shown to have an increased likelihood of suspected insomnia, compared to 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 behaviour and sleep hygiene, 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 to 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 (odds ratio, 1.60 [95% confidence interval, 1.29–1.97] for men and 2.88 [1.74–4.75] 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 individual 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 Japanese populations.[31,32]

The eating patterns of individuals have been associated with their metabolism, sleep-wake distribution, and circadian rhythm. These behaviours have an effect for the hormone and neurotransmitter substance; cortisol and neurotransmitter substance.[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 to them not eating breakfast.

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

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Especially, skipping breakfast is associated with a change in leptin and melatonin.[37] Obesity and appetite changes in hormonal responses caused by leptin and ghrelin, which may be linked to sleep and leptin reduction. Moreover, the short sleepers tend to be poor sleep quality, and cause obesity by changed in glucose metabolism.[36]

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 for 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 no effective in improving sleep in our study. A research have 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 insomnia has 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 cardiovascular risk factors, the symptom is excessive thirst and polyposia etc. Patients with diabetes tend to wake up often during the night, which reduces the quality of 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, the complications of diabetes made insomnia more severe for patients with diabetes.[43] HbA1c and the complication of diabetes may have a high impact on these association. Further clarification of the association is needed.

In our study, the association between insomnia and unhealthy behaviours was found only among women without hypertension and no found 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 in China is low in both sexes, but greater in women than men and 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] Our results may be suggested as the cause of sex steroids among old women. In 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 estrogen levels and sleep disturbances are thought to exist in women.[48] Estrogen in spontaneously hypertensive rats demonstrated improved quality of sleep in female.[49] Women with hypertension is older than those with the absence of it in our study. One possibility is that our study participated pre- and postmenopausal women in this study, suggesting a stronger effect on insomnia due to reduced or fluctuating of estrogen levels before and after menopause.

However, regardless of the presence or absence of lifestyle-related diseases, these associations were nearly similar because the subjects were participated in the general population and were not severely diseased. 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 checkup, and health guidance to improve unhealthy behaviours is usually provided, which is common preventive measures 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, e.g., evaluating sleep through polysomnography, are 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, e.g., other socioeconomic and environmental factors, may be related to both healthy behaviours and sleep quality.

CONCLUSIONS

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Having multiple unhealthy behaviours was associated with an increased likelihood of insomnia in a Japanese community population. Furthermore, these associations were 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 behaviour and sleep.

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Competing interests: None declared

Patient consent: Obtained

Ethical approval: This study was approved by the Medical Ethics Committee of the School of Medicine, Keio University, Tokyo, Japan (approval no. 20110264).

Authors' contributions: SH and TT designed at this study. All authors conducted the research.SK analysed the data in our study and wrote the first draft of the manuscript. SK,TO and TT contributed to draft the manuscript. SK,SH,MI,KK,DS,AT,MS,MM,AK,AH,TO and TT reviewed the manuscript critically for important intellectual content and identified this contents.

Data availability statement: Raw data cannot be made publicly available, as study participants did not consent to have their information freely accessible. Based on these consents, 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.[22]

Provenance and peer review: Not commissioned; externally peer reviewed

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Figure 1. Flow diagram for inclusion and exclusion of participants

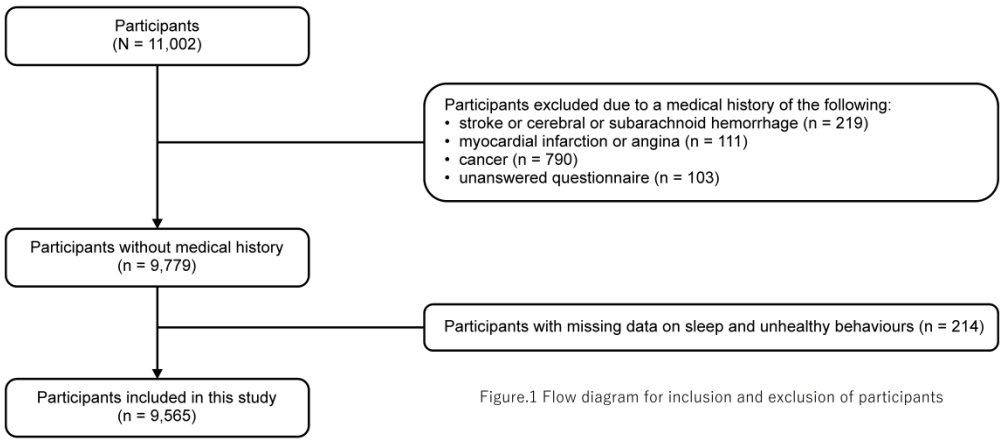

Figure.1 Flow diagram for inclusion and exclusion of participants

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 6
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 6
Methods			
Study design	4	Present key elements of study design early in the paper	Page 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7
Bias	9	Describe any efforts to address potential sources of bias	Page 7
Study size	10	Explain how the study size was arrived at	Page 7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 7-8
		(*b*) Describe any methods used to examine subgroups and interactions	Page 7
		(*c*) Explain how missing data were addressed	Page 6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Page 7
		(*e*) Describe any sensitivity analyses	Page 19
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 6,8
		(b) Give reasons for non-participation at each stage	Page 6
		(c) Consider use of a flow diagram	Page 27
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 8-10
		(b) Indicate number of participants with missing data for each variable of interest	Page 6
Outcome data	15*	Report numbers of outcome events or summary measures	Page 11-16

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 11-16
		(*b*) Report category boundaries when continuous variables were categorized	Page 11-16
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Page 11-16
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 11-16
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 17-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 17-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 20

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article. Information on the STROBE Initiative is available at www.strobe-statement.org.

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