Original Article

Relationship of dietary factors and habits with sleep-wake regularity

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The purpose of this study was to evaluate the associations between dietary factors and sleep-wake regularity in the Japanese population. We analyzed 1368 eligible subjects (931 men and 437 women) aged 35-69 years who had participated in the baseline survey of a cohort study in Tokushima Prefecture, Japan. Information on individual lifestyle characteristics, including dietary habits and sleep-wake regularity, was obtained by a self-administrated questionnaire. Logistic regression analyses were performed to evaluate adjusted associations of the intake energy ratios of macronutrients, as well as intake frequency, and the amount of staple foods with sleep-wake regularity. The lowest quartile of protein intake as well as the highest quartile of carbohydrates showed significantly higher multivariable-adjusted odds ratios of 2.1 (95% confidence interval, 1.3-3.3) and 2.1 (1.3-3.5), respectively, for poor sleep-wake regularity compared with the respective second quartile that is thought to be moderate intake. Regarding intake of staple foods, low weekly intake frequency at breakfast (<5 times/week), the lowest intake amount (<1 bowl or slice/roll) at breakfast, and the highest intake amount (≥2 bowls or slices/rolls) at lunch and dinner exhibited significantly high adjusted odds ratios for poor sleep-wake regularity. Additionally adjusting for sleep duration, these results did not substantially alter. Our results suggested that low intake energy ratio of proteins and high intake energy ratio of carbohydrates, skipping intake of the staple foods at breakfast, and excessive intake amount of the staple foods at lunch and dinner may be associated with poor sleep-wake regularity.

Key Words: sleep-wake regularity, dietary factor, macronutrient, staple foods, cross-sectional study

INTRODUCTION

Sleep is defined as a natural periodic state of rest for the body and the mind, in which the eyes usually close and consciousness is completely or partially lost. During sleep, there is a reduction in body movements and responsiveness to external stimuli. Approximately one-third of a person's life is spent in sleep; therefore, sleep is a physiologically essential behavior in our lives. Although the functions of sleep are not fully elucidated, the most important ones are suggested to be the conservation of energy and restoration of body functions. Sleep is also recognized to be vital for hormonal homeostasis and normal cognitive functions.[1,2] During the recent decades, the prevalence of obesity has been increasing in developed countries, including Japan. Obesity is a major public health concern and one of the key risk factors for numerous chronic diseases such as type 2 diabetes and cardiovascular diseases.[3,4] Recently, many epidemiologic studies have suggested that sleep disturbances such as short sleep duration are linked to increased prevalence of obesity and type 2 diabetes in the general population.[5] Therefore, qualitatively good and sufficient sleep is crucial for performing several daily life activities.

Extreme diet pattern has been suggested to affect sleep architecture. It was reported that very-low-carbohydrate diets increased slow wave sleep (SWS) and decreased rapid eye movement (REM) sleep in adults.[6] In addition, it has been reported that vitamin B-12 deficiency results in poor sleep status.[7] Even though there may be a close correlation between dietary factors and sleep architecture which is linking to sleep quality, the associations of dietary factors such as macronutrient intake or intake frequency and the amount of staple foods at meals with sleep quality have not been fully elucidated. The purpose of this study was to investigate the associations between

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dietary factors and sleep-wake regularity, which may be one of the indicators of sleep quality, in the Japanese population.

METHODS AND MATERIALS

Study subjects

A total of 1398 participants (952 men and 446 women), aged between 35 and 69 years, were enrolled in the baseline survey of a prospective cohort study in Tokushima Prefecture in Japan, from April 2008 to March 2012. We recruited the participants, who joined the National Health Insurance in Japan, at a health checkup center. Persons who join the National Health Insurance in Japan are engaged in agriculture, self-employed, retired, or jobless (housewives, househusbands, or students). We also recruited employees of companies who were mostly office workers and were not shift workers. This cohort study was conducted as a part of the Japan Multi-Institutional Collaborative Cohort (J-MICC) Study. The details of the J-MICC Study have been described previously.[8] Briefly, the purpose of the J-MICC Study was to examine the associations of lifestyle and genetic factors and their interactions with lifestyle-related diseases. All participants in the J-MICC Study had provided written informed consent. The ethics committees of Nagoya University School of Medicine (the affiliation of the former principal investigator Nobuyuki Hamajima), of Aichi Cancer Center (the affiliation of the current principal investigator Hideo Tanaka), and of the University of Tokushima Graduate School approved the protocols of the J-MICC Study.

Lifestyle evaluation

Information on individual lifestyle characteristics, including dietary habits and medical history of diseases, was obtained from a structural self-administered questionnaire and verified by trained staff at the start of the survey. In this questionnaire, questions on sleep-wake regularity and usual sleep duration were also included. We measured subjective sleep-wake regularity for the past one year by asking whether the time of falling asleep at night and waking in the morning was mostly regular or irregular. We also obtained the information on average duration of sleep. Even if average sleep duration is equal, daytime life rhythm and health condition may be altered between subjects whose timing of falling asleep and waking is regular and irregular. The core questions in the questionnaire used in the current study is common among all cohort study areas, and these questions are common questions. Leisure-time physical activity was estimated by multiplying the frequency and duration of light exercise such as walking or hiking, moderate exercise such as light jogging or swimming, and heavy exercise such as marathon, combative sports and summed, and expressed as metabolic equivalent (MET)·hours/week.[9] In this estimation, 3.4 METs were assigned for light exercise, 7.0 METs for moderate exercise, and 10.0 METs for heavy exercise.

Dietary evaluation

A validated, short FFQ was used for dietary evaluations in the baseline survey of the J-MICC Study.[10-13] This FFQ included questions on the average intake frequencies of 47 varieties of foods and beverages (green tea, coffee, and alcohol) over the past year. For the 3 staple foods (i.e., rice, bread, and noodles), information concerning the intake frequency and amount at breakfast, lunch, and dinner was obtained. Intake frequency of the staple foods was classified into 6 categories: almost none, 1-3 times/month, 1-2 times/week, 3-4 times/week, 5-6 times/week, and every day; in the analyses, these 6 categories were signified by 0, 0.1, 0.2, 0.5, 0.8, and 1.0 times/day, respectively. As for the intake amount of the staple foods, the number of bowls (of rice and noodles) or slices/rolls (of bread) consumed at each meal was determined. Regarding consumption of alcoholic beverages, including sake, beer, shochu (a Japanese distilled beverage), chuhai (mixed with shochu), whiskey, and wine, intake frequencies and amount were determined. For the other 43 types of foods and beverages, only the intake frequency was determined and categorized into the following 8 categories: almost none, 1-3 times/month, 1-2 times/week, 3-4 times/week, 5-6 times/week, once a day, twice a day, and ≥3 times/day. In the analyses, these categories were signified by 0, 0.1, 0.2, 0.5, 0.8, 1.0, 2.0, and 3.0 times/day, respectively. Daily intakes of total energy (kcal/day), proteins (g/day), fat (g/day), and carbohydrates (g/day) were calculated using a program developed at the Department of Public Health, Nagoya City University School of Medicine.[10,11]

Statistical analyses

Among the 1398 participants, we excluded those with missing data concerning their sleep-wake regularity (n= 16) and those who were taking medication concurrently with an antidepressant, a sleeping pill, or a tranquilizer (n=9). We further excluded participants whose daily total energy intake was extremely high (>4000 kcal/day) or low (<1000 kcal/day) (n=5)[14]. Finally, 1368 participants (931 men and 437 women) were analyzed in this study.

Differences in the baseline clinical and dietary characteristics between the subjects whose sleep-wake regularity was good and poor were evaluated by the chi-square test or Wilcoxon rank sum test. Age- and sex-adjusted means of the body mass index by sleep-wake regularity were calculated using the general linear model. Logistic regression analyses were applied for the purpose of evaluating univariate associations of clinical and lifestyle factors with sleep-wake regularity. We also used logistic regression to evaluate adjusted associations of the daily percentage energy (% energy) intake of the 3 macronutrients with sleep-wake regularity. The first model (model 1) was adjusted for age (35-39, 40-49, 50-59, and 60-69 years) and sex. The second model (model 2) was adjusted for age, sex, body mass index (<18.5, 18.5-24.9, and ≥25 kg/m^2), stress level (low, middle, and high), current smoking (no/yes), current alcohol drinking (no/yes), and physical activities (MET·hours/week) (quartile categories). Sleep duration (<6, 6 to <7, and ≥7 hours) was further adjusted in model 3. Associations of weekly intake frequency and intake amount of the staple foods at breakfast, lunch, and dinner with sleep-wake regularity were also evaluated using the similar logistic regression models adjusting additionally total daily energy intake (models 2 and 3). In these analyses, weekly intake frequency was

divided into 2 groups: ≥5 and <5 times/week. The daily intake amount at each meal was calculated as the number of bowls or slices/rolls consumed during a meal and was divided into 3 categories; <1, 1 to <2, and ≥2 bowls or slices/rolls at a meal. Categorical variables were converted into dummy variables in logistic regression analyses.

The SAS software package (version 8.2; SAS Institute Inc., Cary, NC) was used for all calculations and analyses. All *p* values are two-tailed and those less than 0.05 were considered statistically significant.

RESULTS

Baseline and dietary characteristics

The baseline characteristics of the subjects are shown in Table 1. There were no gender differences with respect to sleep-wake regularity. Comparatively, men demonstrated significantly higher age, body mass index, rates of current smoking and alcohol drinking, and physical activities and lower stress level. The subjects with poor sleep-wake regularity showed significantly higher (p=0.003) age-and-sex adjusted body mass indices than those with good sleep-wake regularity (Figure 1). As shown in Table 2, daily intake energy ratio of protein was significantly lower (p=0.043) in the subjects with poor sleep-wake regularity than those with good sleep-wake regularity. Weekly intake frequency of the staple foods by meals and daily intake amount of the staple foods at each meal by sleep-wake regularity are shown in Table 3. The skipping ratio of breakfast was significantly higher (p<0.001) in the subjects with poor sleep-wake regularity. Daily intake amount of the staple foods at breakfast was significantly smaller (p<0.001) and those at lunch and dinner were significantly higher (p<0.001 and p=0.002, respectively) in the subjects with poor sleep-wake regularity.

Associations of clinical and lifestyle factors with sleep-wake regularity

As shown in Table 4, participants aged between 50-59 years and 60-69 years showed significantly lower odds ratios (ORs) for poor sleep-wake regularity compared with those aged between 35 and 39 years. High body mass index (≥25 kg/m^2) exhibited a marginally significant higher odds ratio of 1.4 (95% confidence interval (CI), 0.99-1.9) for poor sleep-wake regularity compared with normal body mass index. High stress level and current smoking showed significantly higher ORs, while higher physical activity levels showed significantly lower ORs for poor sleep-wake regularity. Short sleep duration (<6

Table 1. Baseline characteristics of the study subjects

	Men (n=931)		Women (n=437)		*p*-value
	n	%	n	%	
Age (years)					
35-39	143	15.4	78	17.8	<0.001
40-49	284	30.5	153	35.0	
50-59	315	33.8	156	35.7	
60-69	189	20.3	50	11.4	
Body mass index (kg/m^2)					
<18.5	22	2.4	50	11.4	<0.001
18.5-24.9	584	62.7	317	72.5	
≥25	325	34.9	70	16.0	
Sleep duration (hours)					
<6	110	11.8	96	22.0	<0.001
6 to <7	403	43.3	180	41.2	
≥7	418	44.9	161	36.8	
Sleep-wake regularity					
Good	806	86.6	375	85.8	0.702
Poor	125	13.4	62	14.2	
Stress level					
Low	158	17.0	59	13.5	<0.001
Middle	502	53.9	205	46.9	
High	270	29.0	173	39.6	
Unknown	1	0.1	-	-	
Current smoking					
No	650	69.8	408	93.4	<0.001
Yes	281	30.2	29	6.6	
Current alcohol drinking					
No	255	27	260	59.5	<0.001
Yes	676	73	177	40.5	
Physical activity (MET•hours/week)					
≤1.19	262	28.1	178	40.7	<0.001
1.20-4.78	162	17.4	75	17.2	
4.79-15.30	249	26.7	106	24.3	
>15.30	248	26.6	73	16.7	
Unknown	10	1.1	5	1.1	

MET, metabolic equivalent

hours) showed a higher OR of 2.7 (1.9-4.0), while long duration (≥7 hours) showed a lower OR of 0.45 (0.30-0.67) for poor sleep-wake regularity, compared with moderate sleep duration (6 to <7 hours).

Association between percentage energy intake of macronutrients and sleep-wake regularity

The ORs and 95% CI of daily percentage energy intake of the 3 macronutrients for prevalent poor sleep-wake regularity are presented in Table 5. The subjects with the lowest quartile of protein intake (<10.8% energy) had a significantly higher multivariable-adjusted OR of 2.1 (95% CI, 1.3-3.3) for poor sleep-wake regularity compared with those with the moderate category (second quartile). The subjects with the highest quartile of carbohydrates (≥70.7% energy) also had a significantly higher adjusted OR of 2.1 (95% CI, 1.3-3.5) for poor sleep-wake regularity compared with those with the second quartile. Further adjustment with sleep duration (model 3) did not substantially alter these results.

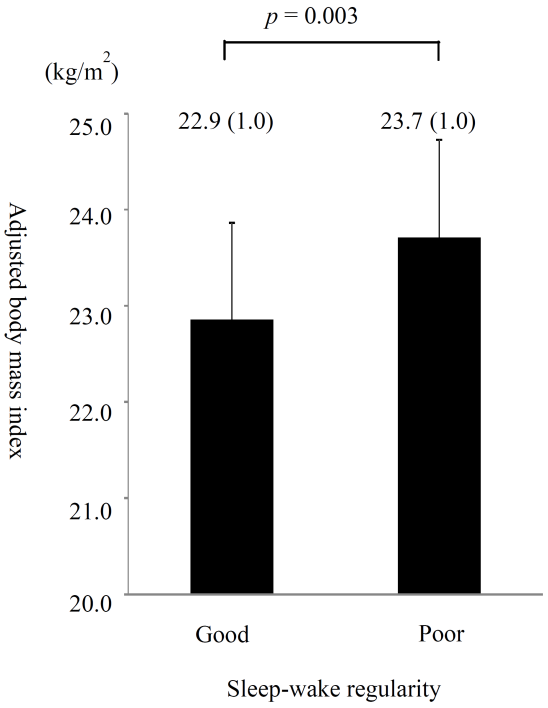

Figure 1. Associations between sleep-wake regularity and age- and sex-adjusted body mass index. The mean values (standard errors) of body mass index adjusted for age and sex using the general linear model are presented. The subjects with poor sleep-wake regularity showed significantly higher (p=0.003) adjusted body mass index than those with good sleep-wake regularity.

Associations of intake frequency and mean amount of staple foods at each meal with sleep-wake regularity

Table 6 presents the ORs and 95% CI of the weekly intake frequency of the staple foods by meals and the intake mean amount of the staple foods at each meal for prevalent poor sleep-wake regularity. Fewer intake frequency of breakfast (<5 times/week) showed a higher multivariable-adjusted OR of 3.2 (2.2-4.8) for poor sleep-wake regularity compared with the reference (≥5 times/week). The lowest intake amount of the staple foods at breakfast as well as the highest intake amount at lunch and dinner displayed significantly higher multivariable-adjusted ORs for poor sleep-wake regularity. Further adjustment with sleep duration (model 3) did not basically alter these findings.

DISCUSSION

We investigated that daily intake of low percentage energy of proteins and high percentage energy of carbohydrates, skipping breakfast, and excessive intake amounts of the staple foods at lunch and dinner may be associated with poor sleep-wake regularity in the general Japanese population.

Insomnia has become a major public health problem in recent years. Sleep disturbance, such as short sleep duration and inferior sleep quality, has been suggested to be associated with increased risk of obesity, metabolic syndrome, and diabetes.[5,15,16] In the current study, the subjects with poor sleep-wake regularity, which is regarded as one of the indicators of sleep quality, manifested higher age- and sex-adjusted body mass index than those with better sleep-wake regularity. Therefore, it is vitally important to investigate the factors affecting sleep-wake regularity for the purpose of preventing obesity-related diseases.

Sleep quality is affected by various factors, including environmental, psychophysiological, and pharmacological factors. We observed that poor sleep-wake regularity decreased with advancing age category. Doi *et al*. have reported that, in men, younger age was in fact a risk factor for excessive daytime sleepiness, which might be caused by an irregular sleep-wake schedule.[17] Their finding is in accordance with our observations presented in this study. The subjects with higher body mass indices (≥25 kg/m^2) had a marginally significant higher adjusted odds ratio for poor sleep-wake regularity than those with

Table 2. Dietary characteristics of the subjects by sleep-wake regularity

	Sleep-wake regularity						p-value
	Good (n=1181)			Poor (n=187)			
	Median	25th	75th	Median	25th	75th	
Energy (kcal/day)	1740	1532	1927	1721	1464	1989	0.609
Protein (g/day)	51.5	45.5	58.0	53.0	42.2	58.5	0.066
Fat (g/day)	41.4	35.3	48.9	40.6	32.8	48.5	0.127
Carbohydrate (g/day)	247	209	286	247	201	300	0.937
Protein (% energy)	11.9	10.9	13.1	11.7	10.4	13.0	0.043
Fat (% energy)	22.1	18.2	26.0	21.5	17.6	26.1	0.414
Carbohydrate (% energy)	65.9	61.0	70.5	66.8	61.1	71.8	0.248

25th, 25 percentile; 75th, 75 percentile

Table 3. Weekly intake frequency and mean intake amount of the staple foods at each meal by sleep-wake regularity

	Sleep-wake regularity				*p*-value
	Good (n=1181)		Poor (n=187)		
	n	%	n	%	
Frequency (times/week)					
Breakfast					
≥5	1027	87.0	125	66.8	<0.001
<5	154	13.0	62	33.2	
Lunch					
≥5	1102	93.3	170	90.9	0.232
<5	79	6.7	17	9.1	
Dinner					
≥5	1028	87.0	167	89.3	0.388
<5	153	13.0	20	10.7	
Amount (bowls or slices/rolls at a meal)					
Breakfast					
<1	354	30.0	93	49.7	
1 to <2	778	65.9	84	44.9	<0.001
≥2	48	4.1	9	4.8	
unknown	1	0.0	1	0.5	
Lunch					
<1	350	29.6	61	32.6	
1 to <2	798	67.6	110	58.8	<0.001
≥2	29	2.5	14	7.5	
unknown	4	0.3	2	1.1	
Dinner					
<1	343	29.0	45	24.1	
1 to <2	770	65.2	118	63.1	0.002
≥2	66	5.6	23	12.3	
unknown	2	0.2	1	0.5	

normal body mass indices. It has been reported that obesity is commonly associated with daytime sleepiness, which is a signal for insufficient sleep at night, even in individuals without sleep apnea.[18] Altered sleep-wake patterns have been demonstrated in genetic-induced models of obesity in mice.[19] Obesity should be an independent risk factor for impaired sleep-wake regularity. Moreover, we revealed that high stress levels and current smoking were associated with higher rates of poor sleep-wake regularity, while higher physical activity was associated with lower rates of poor sleep-wake regularity. A close association between stressful conditions such as job stress and sleep problems has been documented.[20] It has been reported among Japanese workers that current smoking status is linked to various types of sleep disturbances such as difficulties in awakening and falling asleep.[21] In contrast, regular physical activities have been shown to exert favorable effects on sleep quality.[22] Our findings did not contradict these reports. We found a close relation between sleep duration and sleep-wake regularity, and subjects with short sleep duration had a higher prevalence of poor sleep-wake regularity. Therefore, we further adjusted sleep duration in evaluating the adjusted associations of the dietary factors and habits with sleep-wake regularity.

Dietary factors also may contribute to sleep quality. In our estimation, the mean values of daily intake of total energy, protein, fat, and carbohydrate were 1738 kcal/day, 51.4 g/day, 41.3 g/day, and 247 g/day, respectively. The values reported by the National Health and Nutrition Survey 2009 in Japan, estimated in Japanese aged 20 years or above, were 1876 kcal/day, 68.6 g/day, 52.5 g/day, and 263 g/day, respectively.[23] In comparison, our estimated values were relatively lower. Since our subjects were between 35 and 69 years of age, younger adults (20-34 years) who consumer greater amounts than older individuals were not included in our estimation. Moreover, we used a short FFQ and as a result, our estimated values might be smaller. However, this FFQ has been validated and the mean daily nutrient intake derived from this FFQ tolerably correlates with that estimated from 3-day weighed diet records.[10]

With respect to the association between the daily percentage energy intake of macronutrients and sleep-wake regularity, our investigation revealed that the lowest quartile of proteins and the highest quartile of carbohydrates presented negative associations with sleep-wake regularity, compared with the respective moderate category. Shaaban *et al*. suggested that protein-energy malnutrition in infants seems to exert a negative impact on sleep-wake cycle and disturbed serotonin levels may be one of its causal factors.[24] Lindseth *et al.* have suggested that high-protein diets were associated with significantly fewer waking episodes.[25] The relation between percentage energy intake of carbohydrates and sleep remains controversial. It was reported that a high quantity consumption of carbohydrates before bedtime induced frequent arousals and disturbed the sleep quality.[26] In contrast, Lindseth *et al*. reported that high-carbohydrate diets were associated with significantly shorter sleep latency.[25] We did not find

Table 4. Crude odds ratios of clinical and lifestyle factors for poor sleep-wake regularity

	Prevalence of poor sleep-wake regularity (%)	Crude OR (95% Cl)	
Age (years)			
35-39	19.9	1	
40-49	15.8	0.75	(0.50, 1.1)
50-59	11.9	0.54	(0.35, 0.84)
60-69	7.5	0.33	(0.18, 0.59)
Body mass index (kg/m^2)			
<18.5	12.5	1.0	(0.48, 2.1)
18.5-24.9	12.5	1	
≥25	16.5	1.4	(0.99, 1.9)
Sleep duration (hours)			
<6	31.1	2.7	(1.9, 4.0)
6 to <7	14.2	1	
≥7	6.9	0.45	(0.30, 0.67)
Stress level			
low	10.1	1	
middle	12.3	1.2	(0.77, 2.1)
high	17.6	1.9	(1.2, 3.2)
Current smoking			
no	11.9	1	
yes	19.7	1.8	(1.3, 2.5)
Current drinking			
no	13.4	1	
yes	13.8	0.96	(0.70, 1.3)
Physical activity (MET•hours/week)			
≤1.19	17.7	1	
1.20–4.78	14.4	0.78	(0.50, 1.2)
4.79–15.30	11.3	0.59	(0.39, 0.89)
>15.30	10.3	0.53	(0.34, 0.82)

OR, odds ratio; CI, confidence interval

Table 5. Odds ratios of daily energy intake ratios of the macronutrients for poor sleep-wake regularity

Quartiles	Prevalence of poor sleep-wake regularity (%)	Model 1 † OR (95% CI)	Model 2 ‡ OR (95% CI)	Model 3 § OR (95% CI)
Protein (% energy)				
<10.8	18.4	2.0 (1.3, 3.1)	2.1 (1.4, 3.4)	2.1 (1.3, 3.3)
10.8-11.8	11.1	1	1	1
11.9-13.0	12.6	1.1 (0.68, 1.7)	1.1 (0.70, 1.8)	1.1 (0.68, 1.8)
≥13.1	12.6	1.1 (0.67, 1.8)	1.2 (0.74, 2.0)	1.2 (0.71, 2.0)
Fat (% energy)				
<18.1	15.5	1.4 (0.90, 2.2)	1.5 (0.97, 2.4)	1.4 (0.90, 2.3)
18.1-22.0	13.2	1	1	1
22.1-25.9	12.0	0.85 (0.53, 1.3)	0.85 (0.53, 1.4)	0.86 (0.53, 1.4)
≥26.0	14.0	0.91 (0.57, 1.4)	0.93 (0.58, 1.5)	0.89 (0.54, 1.5)
Carbohydrate (% energy)				
<61.0	13.5	1.2 (0.72, 1.9)	1.2 (0.74, 1.9)	1.2 (0.71, 1.9)
61.0-66.0	10.8	1	1	1
66.1-70.6	14.0	1.5 (0.92, 2.4)	1.5 (0.92, 2.4)	1.5 (0.92, 2.5)
≥70.7	16.4	2.1 (1.3, 3.3)	2.2 (1.4, 3.6)	2.1 (1.3, 3.5)

OR, odds ratio; CI, confidence interval
† Model 1: adjusted for age and sex.
‡ Model 2: adjusted for age, sex, body mass index, stress level, current smoking, current drinking, and physical activity.
§ Model 3: adjusted for the same covariates in model 2 and additionally sleep duration.

Table 6. Odds ratios of frequency and amount of the staple foods for poor sleep-wake regularity

	Prevalence of poor sleep-wake regularity (%)	Model 1 † OR (95% CI)	Model 2 ‡ OR (95% CI)	Model 3 § OR (95% CI)
Frequency (times/week)				
Breakfast				
≥5	10.9	1	1	1
<5	28.7	3.0 (2.1, 4.3)	3.2 (2.2, 4.8)	3.2 (2.1, 4.8)
Lunch				
≥5	13.4	1	1	1
<5	17.7	1.3 (0.76, 2.3)	1.5 (0.79, 2.6)	1.2 (0.64, 2.2)
Dinner				
≥5	14.0	1	1	1
<5	11.6	0.80 (0.47, 1.3)	0.84 (0.48, 1.4)	0.80 (0.45, 1.4)
Amount (bowls or slices/rolls at a meal)				
Breakfast				
<1	20.8	2.3 (1.6, 3.1)	2.5 (1.7, 3.5)	2.5 (1.7, 3.5)
1 to <2	9.7	1	1	1
≥2	15.8	1.7 (0.77, 3.5)	1.3 (0.56, 2.8)	1.2 (0.49, 2.6)
Lunch				
<1	14.8	1.3 (0.90, 1.8)	1.2 (0.84, 1.8)	1.2 (0.79, 1.7)
1 to <2	12.1	1	1	1
≥2	32.6	3.8 (1.9, 7.3)	4.1 (1.8, 9.0)	3.2 (1.4, 7.2)
unknown	33.3			
Dinner				
<1	11.6	0.84 (0.57, 1.2)	0.77 (0.51, 1.1)	0.76 (0.50, 1.1)
1 to <2	13.3	1	1	1
≥2	25.8	2.2 (1.3, 3.7)	2.6 (1.3, 4.9)	2.5 (1.3, 4.9)

OR, odds ratio; CI, confidence interval
† Model 1: adjusted for age and sex.
‡ Model 2: adjusted for age, sex, body mass index, stress level, current smoking, current drinking, physical activity, and total energy.
§ Model 3: adjusted for the same covariates in model 2 and additionally sleep duration.

any associations between percentage energy intake of fats and sleep-wake regularity. According to some reports, excessive fat intake may induce shorter sleep durations and sleep disturbance.[27] In contrast, it was reported that high-fat diets were not associated with waking episodes and sleep latencies,[25] and this is in accordance with our findings. Further studies such as interventional studies are needed to clarify the associations between dietary carbohydrates and fats with sleep.

An insufficient intake amount of the staple foods at

breakfast as well as excessive intake amount at lunch and dinner was associated with poor sleep-wake regularity in this study. It was reported that nocturnal caloric intake correlated positively with sleep latency and correlated negatively with sleep efficiency in healthy women.[28] Skipping breakfast is commonly accompanied by compensatory intake of snacks or overeating in later meals.[29] Therefore, we consider that skipping breakfast is probably linked to overeating and a more ferocious appetite at lunch and dinner, and this vicious cycle may be associated with poor sleep-wake regularity.

The strength of this study lies in the fact that we obtained detailed information on the intake frequency and amount of the staple foods at each meal from the questionnaire. However, this study poses several limitations. First, due to the nature of the cross-sectional study design, causal relationships between dietary factors and sleep-wake regularity should be interpreted with caution, and reverse causation could be considered. We presume that the relation between dietary factors and sleep quality, including sleep-wake regularity, is likely to be bidirectional. Second, information on diet and other lifestyle factors was based on a self-reporting mechanism, and non-differential misclassification may be inevitable. This misclassification might attenuate the observed associations. Third, residual confounding by uncontrolled or unmeasured factors may have distorted genuine associations between dietary factors and sleep-wake regularity. Finally, the information on sleep-wake regularity was subjective and can be considered as lacking in objectivity.

In conclusions, our results suggest that an unbalanced intake of macronutrients such as a low intake energy ratio of proteins and a high intake energy ratio of carbohydrates, skipping intake of the staple food at breakfast, and excessive intake amount of the staple foods at lunch and dinner may be closely associated with poor sleep-wake regularity, independent of sleep duration. Further studies by objective assessment of sleep quality, and desirably, interventional studies, will be needed.

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AUTHOR DISCLOSURES

The authors declare no conflicts of interest.

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Original Article

Relationship of dietary factors and habits with sleep-wake regularity

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飲食特性與規律睡眠習慣之相關性

本研究之目的，為評估日本民眾的飲食特性與規律睡眠之間的相關性。分析對象為 1368 位參與日本德島縣世代研究，具有完整基礎資料的 35-69 歲參與者(931 位男性與 437 位女性)。藉由自填式問卷，獲取個人生活型態的資料，其中包含飲食特性及睡眠習慣。利用邏輯斯迴歸，分析巨量營養素熱量比、主食攝取頻率及攝取量，與規律睡眠的校正相關。多變項校正後，蛋白質攝取最低組，和碳水化合物攝取最高組，比起最適攝取量的第二分位組，睡眠不規律的風險都為 2.1(95%CI 分別為 1.3-3.3 和 1.3-3.5)。早餐攝取主食頻率小於每週五次者、早餐飯麵攝取少於一碗或麵包攝取少於一片/卷者，以及午晚餐主食攝取最高量者，在多變項校正後，有顯著較高睡眠不規律的風險。進一步校正睡眠時間後，相關依然存在。本研究結果顯示，蛋白質熱量攝取較低、碳水化合物熱量攝取較高、早餐的主食攝取太少、午晚餐主食攝取過量，會伴隨有睡眠不規律的情形。

關鍵字：睡眠規律性、飲食特性、巨量營養素、主食、橫斷性研究