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Original Article

The midpoint of sleep is associated with dietary intake and dietary behavior among young Japanese women

Natsuko Sato-Mito [a], Satoshi Sasaki [b,*], Kentaro Murakami [b], Hitomi Okubo [c], Yoshiko Takahashi [d], Shigenobu Shibata [e], Kazuhiko Yamada [f], Kazuto Sato [g], the Freshmen in Dietetic Courses Study II group

[a] Department of Food and Life Science, Azabu University, Kanagawa, Japan
[b] Department of Social and Preventive Epidemiology, School of Public Health, The University of Tokyo, Tokyo, Japan
[c] Department of Social and Preventive Epidemiology, Graduate school of Medicine, The University of Tokyo, Tokyo, Japan
[d] Department of Health and Nutrition, Wayo Women's University, Chiba, Japan
[e] Department of Physiology and Pharmacology, School of Science and Engineering, Waseda University, Tokyo, Japan
[f] Laboratory of Biochemistry, Kagawa Nutrition University, Saitama, Japan
[g] Department of Food and Nutrition, Japan Women's University, Tokyo, Japan

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A B S T R A C T

Objectives: How human chronotype is correlated to nutrient and food-group intakes and dietary behavior remains to be elucidated. We cross-sectionally examined the association between the midpoint of sleep and these dietary variables in young Japanese women. A calculated halfway point between bedtime and rise time was used as midpoint of sleep.
Methods: The subjects were 3304 female Japanese dietetics students aged 18–20 years from 53 institutions in Japan. Dietary intake during the previous month was assessed by a validated, self-administered diet history questionnaire. The midpoint of sleep was calculated using self-reported bedtimes and rise times.
Results: Late midpoint of sleep was significantly negatively associated with the percentage of energy from protein and carbohydrates, and the energy-adjusted intake of cholesterol, potassium, calcium, magnesium, iron, zinc, vitamin A, vitamin D, thiamin, riboflavin, vitamin B_6, folate, rice, vegetables, pulses, eggs, and milk and milk products. It was also significantly positively associated with the percentage of energy from alcohol and fat, and the energy-adjusted intake of noodles, confections, fat and oil, and meat. Furthermore, subjects with a later midpoint of sleep tended to begin meals later, eat for a longer time, skip meals more frequently, and watch TV at meals, not only at breakfast but also at lunch and dinner.
Conclusions: The midpoint of sleep is significantly associated with dietary intake of certain nutrients and foods and other dietary behaviors in young Japanese women. This finding may contribute to consider the relationships between chronotype and dietary intakes and behaviors.

1. Introduction

Circadian clocks controlled by clock genes regulate various biological rhythms, including the sleep/wake cycle, the endocrine system, and body temperature [1]. Recent animal studies have revealed that an abnormal circadian rhythm is associated with a number of lifestyle-related diseases, such as diabetes, obesity and cancer [2–5]. Epidemiological studies have also highlighted an increased risk of breast cancer and/or obesity in shift workers [6,7] and an association between metabolic syndrome risk and clock gene variation [8]. On the basis of such evidence, it has been suggested that the normal circadian rhythms regulated by the clock genes are important for human health.

The periodic meal intake of animals has been reported to be an important entrainment signal for the circadian clock [9]. Restriction of feeding to a particular time of day changes the output of the biological clock, locomotor activity, body temperature, and corticosterone secretion in animals [10,11]. Other studies have reported that certain nutrients and food components, such as glucose, ethanol, caffeine, thiamine and retinoic acid, directly affect the expression of clock genes [12]. It has recently been reported that a balanced diet containing carbohydrates and protein is suitable for restricted-feeding induced entrainment of the liver clock [13]. Human studies have also suggested an association between human chronotype and dietary intake [14,15]. The midpoint of sleep was reported to correlate with the intake of food groups, such

* Corresponding author. Address: Department of Social and Preventive Epidemiology, School of Public Health, The University of Tokyo, Bunkyo, Hongo 7-3-1, Tokyo 113-0033, Japan. Tel.: +81 3 5841 7873.
E-mail address: stssasak@m.u-tokyo.ac.jp (S. Sasaki).

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as fast food, cola and other caffeinated drinks, and dairy products in adolescents. [14]. Another study reported that morningness–eveningness score was positively correlated with the frequency of breakfast consumption and negatively related to alcohol consumption [15]. Furthermore, it was shown that subjective sleep, objective sleep, and napping were associated with dietary nutrients in post-menopausal women [16]. However, the relationship between human chronotype, nutrient and food-group intakes and dietary behavior remains to be elucidated.

Chronotype is defined as a morning type or evening type. These tendencies were assessed using the Horne–Ostberg questionnaire which includes the questions associated with sleep habits and behavioral rhythms (i.e., activity, feeling, or peak performance) [17]. The midpoint of sleep correlates well with the morningness–eveningness score by the Horne–Ostberg questionnaire [18]. Accordingly, to clarify the relationship between human chronotype and dietary intake in a large population, we calculated the midpoint of sleep using data from freshmen in Dietetics Study II, and then we analyzed the associations between the midpoint of sleep and nutrient and food intakes. We also analyzed the associations between the midpoint of sleep and dietary behaviors such as meal starting times, eating duration, eating speed, meal skipping, and watching TV at meals, which may be related to dietary habits [20,21].

2. Subjects and methods

2.1. Subjects and survey procedures

This cross-sectional study was based on a self-administered questionnaire survey among dietetics students ($n = 4672$) from 54 universities, colleges, and technical schools in 33 of 47 prefectures in Japan. Two questionnaires on dietary habits and other lifestyle variables pertaining to the previous month were used in the study. Staff at each institution distributed these questionnaires to students during an orientation session or a first lecture designed for freshman students entering dietetics courses in April 2005; in most institutions, this was carried out within 2 weeks after the course began. Students filled out the questionnaires during the orientation session, the course's opening lecture or at home and then submitted the completed form to staff at each institution. Missing answers or logistical errors were checked by staff at each institution and the survey center, and when necessary, the student was asked to complete the questionnaire again. Most surveys were completed by May 2005. The protocol of this study was approved by the Ethics Committee of the National Institute of Health and Nutrition in Japan.

A total of 4394 students (4168 women and 226 men) answered two questionnaires (response rate 93.9%). For the purposes of this study, female subjects aged 18–20 years were selected ($n = 4060$). We selected those who were living with family ($n = 3595$) because it has been reported that students living alone exhibit different dietary habits in comparison with students living with family [22]. We excluded those who were in an institution where the survey was conducted at the end of May ($n = 82$). We also excluded those with extremely low or high energy intake (<725 or > 3235 kcal/day) [23] ($n = 85$), those whose diet was being directed by a doctor or dietitian ($n = 90$), those whose midpoint of sleep was outside the range of 0–12 o'clock ($n = 25$), and those with missing information on the variables studied ($n = 19$). After these exclusions, the final analysis sample was composed of 3304 women.

2.2. Assessment of dietary intake

We assessed dietary intake for the previous month using a validated 16-page self-administered diet history questionnaire (DHQ). A detailed description of the questionnaire, the dietary intake calculations, and information on the validity of the DHQ have been provided elsewhere [24,25]. Measures of dietary intake for 148 food and beverage items, energy, and nutrients were calculated using an ad hoc computer algorithm for the DHQ based on standard tables of food composition in Japan [26]. The DHQ included data on birth date, self-reported body weight and height and self-reported eating speed (fast, medium, or slow). Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m). The subjects were classified into three BMI categories (underweight:<18.5, normal body weight: ≧18.5 and < 25, and obese: ≧25) because BMI cutoff of 25 is used for obesity according to the decision of Japan Society for the Study of Obesity in Japan [27].

2.3. Assessment of lifestyle variables and dietary behaviors

Lifestyle variables were assessed using a 12-page questionnaire to be answered with respect to the previous month. The questionnaire included current smoking habits (yes or no), currently trying to lose weight (yes or no), current supplement use (yes or no), current exercise routine (≧3 times/week, and ≧20 min/time) (yes or no), residential block (Hokkaido and Tohoku, Kanto, Hokuriku and Tokai, Kinki, Chugoku and Shikoku, or Kyushu) based on the six blocks used in the National Nutrition and Health Survey in Japan [28], and size of residential area according to population (≧1 million,<1 million, and town and village). In the questionnaire, the subjects reported dietary behaviors such as time at which they began their meals, eating duration, number of skipped meals, and instances of watching TV during meals on weekdays. Other details of variables in the questionnaire have been described in previous reports [29,30].

2.4. Midpoint of sleep and sleep duration

Roenneberg et al. reported a questionnaire for surveys of sleeping habits and chronotype, the Munich Chrono Type Questionnaire (MCTQ) [18,19]. It was designed to collect information about the actual timing of daily sleep. In the MCTQ, the midpoint of sleep on free days and work days, is calculated from sleep onset times and rise times. In the present study, the subjects reported bedtimes and rise times in the lifestyle questionnaire. These were reported as the time when they usually arose in the morning and went to bed on weekdays. Therefore, using these data, the midpoint of sleep was calculated as the halfway point between bedtime and rise time. Sleep duration was also calculated from bedtime and rise time.

2.5. Statistical analysis

The subjects were classified into quintiles with respect to the midpoint of sleep, from the earliest (Q1) to the latest quintile (Q5). The means of dietary intake, dietary behaviors, anthropometric, and other lifestyle variables were calculated for each midpoint of sleep quintile. The median value for each midpoint of sleep quintile was tested as continuous variable for linear trends. The percentage of energy intake (% energy) for macronutrients and alcohol, and per 1000 kcal (/1000 kcal) for other nutrients and food intakes were used for energy adjustment. The means of dietary intake and dietary behaviors (time at which meals began, eating duration, number of skipped meals, and number of occasions when TV was watched during weekday meals) were adjusted for potential confounding factors. Lifestyle variables with significant correlations with the midpoint of sleep, residential block, size of residential area, and current smoking were included in the confounding factors.

We analyzed differences between the Q1 group and other groups using Dunnett's test. A Mantel–Haenszel χ^2 test was used to test for proportionate differences for categorical variants.

All analyses were performed using statistical software, SAS version 9.2 (SAS Institute Inc., Cary, NC, USA). P-values were considered statistically significant at the < 0.05 level.

3. Results

The mean age, body height, and body weight of all subjects was 18.1 ± 0.3 years, 157.9 ± 5.3 cm, and 52.2 ± 7.6 kg, respectively (mean ± standard deviation). The characteristics of the subjects divided according to the midpoint of sleep quintile are shown in Table 1. Bedtime, rise time, and sleep duration were positively associated with the midpoint of sleep. Subjects in later midpoint of sleep quintiles were more likely to smoke and tended to live in areas with larger populations and in Kinki and Kyusyu. BMI, currently trying to lose weight, current supplement use, and current exercise routine were not statistically different among the midpoint of sleep quintiles.

Total energy, % energy from alcohol, protein, fat, and carbohydrates, energy-adjusted (per 1000 kcal) nutrient and food-group intakes are presented in Table 2. A significant negative trend from the earliest to the latest midpoint of sleep quintile was observed for the % energy from protein and carbohydrate and the intake of cholesterol, potassium, calcium, magnesium, iron, zinc, vitamin A, vitamin D, thiamin, riboflavin, vitamin B_6, folate, rice, vegetables, pulses, eggs, and milk and milk products. A significant positive trend from the earliest to the latest midpoint of sleep quintile was observed for the % energy from alcohol and fat and the intake of noodles, confections, fat and oil, and meat. These nutrients and foods showed a significant reduction or increase in the latest midpoint of sleep group (Q5) compared with the earliest midpoint of sleep group (Q1), except for cholesterol, thiamin, riboflavin, fat and oil, and eggs. No statistically significant linear association was observed with the intake of sodium, alpha-tocopherol, vitamin B_{12}, vitamin C, bread, potatoes, fruits, or fish and shellfish.

The meal start times, eating duration, eating speed, number of skipped meals, and number of times watching TV at meals are presented in Table 3. Subjects in later quintiles were associated with later meal start times, longer eating duration, more skipped meals, and more frequent TV watching at meals for all meals, whereas no association between eating speed and the midpoint of sleep was detected.

4. Discussion

In this study, we found that dietary intake of some nutrients and foods differed significantly by chronotype, as assessed by the midpoint of sleep. A late midpoint of sleep was associated negatively with the % energy intake from protein and carbohydrates, and the energy-adjusted intake of cholesterol, potassium, calcium, magnesium, iron, zinc, vitamin A, vitamin D, thiamin, riboflavin, vitamin B_6, folate, rice, vegetables, pulses, eggs, and milk and milk products, whereas it was associated positively with % energy intake from alcohol and fat, and energy-adjusted intake of noodles, confections, fat and oil, and meat. Several animal studies have demonstrated that certain nutrients and food components, such as glucose, ethanol, caffeine, thiamine and retinoic acid, can phase-shift circadian rhythms [12,13]. It has also been shown that mouse clock gene (*mPer2*) mutants exhibit increased alcohol intake [31]. Because this epidemiological study was cross-sectional, we cannot identify whether reverse causation occurred. Further studies are required to understand the relationships between dietary intake in humans and the expression of clock genes.

In the present study, sleep duration was longer in the late midpoint of sleep. A recent report showed that sleep duration, rise time, and number of naps were related to dietary nutrients in post-menopausal women [16]. It has been reported that total blood levels and circadian changes in leptin, cortisol, insulin, thyroid-stimulating hormone, and other parameters were affected by short sleep duration [32–35]. Additionally, one clinical report showed that sleep restriction was associated with changes in appetite-related hormones and increased hunger and appetite,

Table 1
Subject characteristics by midpoint of sleep quintile (n = 3304).

		All	Midpoint of sleep quintile					P^b
		n = 3304	Q1 n = 534 (earliest, reference)	Q2 n = 763	Q3 n = 669	Q4 n = 737	Q5 n = 601 (latest)	
Midpoint of sleep	O'clock (h:min)	3:49 ± 1:04	2:32 ± 0:23	3:10 ± 0:08[a]	3:37 ± 0:07[a]	4:11 ± 0:13[a]	5:31 ± 0:55[a]	<0.0001
Bedtime	O'clock (h:min)	0:21 ± 1:05	23:11 ± 0.46	23:49 ± 0:32[a]	0:22 ± 0:38[a]	0:48 ± 0:47[a]	1:28 ± 1:10[a]	<0.0001
Rise time	O'clock (h:min)	7:16 ± 1:29	5:52 ± 0:47	6:30 ± 0:30[a]	6:53 ± 0:37[a]	7:34 ± 0:50[a]	9:35 ± 1:24[a]	<0.0001
Sleep duration	h.min	6.56 ± 1.31	6.41 ± 1.22	6.41 ± 1.00	6.31 ± 1.14	6.46 ± 1.34	8.07 ± 1.49[a]	<0.0001
Body mass index	kg/m^2	20.9 ± 2.8	21.2 ± 3.1	20.9 ± 2.8	20.8 ± 2.5	20.9 ± 2.7	20.9 ± 2.7	0.30
<18.5	%	14.4	14.2	14.6	13.8	15.3	14.0	0.67
⩾18.5 to <25	%	78.5	77.3	78.9	79.4	77.8	79.0	
⩾25	%	7.1	8.4	6.6	6.9	6.9	7.0	
Current smoking	%	1.3	0.8	0.5	1.2	1.1	3.0	0.0004
Currently trying to lose weight	%	35.9	37.6	35.0	35.1	37.2	34.9	0.71
Current supplement use	%	18.5	18.7	16.4	18.2	18.7	20.8	0.15
Current exercise routine	%	10.0	10.3	11.8	10.0	9.0	8.8	0.10
Residential block	%							
Hokkaido and Tohoku	%	9.6	10.5	11.4	10.0	8.4	7.3	<0.0001
Kanto	%	34.5	39.1	33.4	36.8	35.4	28.1	
Hokuriku and Tokai	%	13.7	12.0	14.6	14.1	13.4	14.3	
Kinki	%	19.8	15.2	18.1	20.3	20.8	24.5	
Chugoku and Shikoku	%	10.4	14.4	12.7	8.4	9.0	7.8	
Kyushu	%	12.0	8.8	9.8	10.5	13.0	18.0	
Size of residential area								
City with population ⩾1million	%	18.8	15.9	19.1	19.9	20.2	18.1	0.0019
City with population <1million	%	65.3	64.2	62.4	65.8	65.3	69.2	
Town and village	%	15.9	19.9	18.5	14.4	14.5	12.7	

Data are presented as means ± s.d., or persons (%).
[a] Significance level compared with Q1 of midpoint of sleep (Dunnett's test): P < 0.001.
[b] Tests for linear trends used the median value in each quintile as a continuous variable in linear regression; a Mantel–Haenszel χ^2 test was used for categorical variables.

Table 2
Total energy, alcohol, nutrients, and food-group intakes by midpoint of sleep quintile (n = 3304).

		All[a]	Midpoint of sleep quintile[b]					P[c]
		n = 3304	Q1 n = 534	Q2 n = 763	Q3 n = 669	Q4 n = 737	Q5 n = 601	
Energy	kcal/day	1798 ± 451	1836 ± 20	1776 ± 16	1803 ± 17	1814 ± 17	1768 ± 18[1]	0.10
Alcohol	% energy	0.36 ± 1.72	0.19 ± 0.05	0.13 ± 0.04	0.24 ± 0.05	0.29 ± 0.04	0.44 ± 0.05[2]	<0.0001
Nutrients								
Protein	% energy	13.4 ± 2.1	13.5 ± 0.1	13.6 ± 0.1	13.5 ± 0.1	13.3 ± 0.1	13.2 ± 0.1	0.0010
Fat	% energy	29.6 ± 5.7	28.9 ± 0.2	29.3 ± 0.2	29.7 ± 0.2	29.9 ± 0.2[1]	30.1 ± 0.2[2]	0.0001
Carbohydrate	% energy	55.6 ± 6.6	56.3 ± 0.3	55.9 ± 0.2	55.5 ± 0.3	55.4 ± 0.2	55.1 ± 0.3[2]	0.0011
Cholesterol	mg/1000 kcal	165 ± 63	168 ± 3	169 ± 2	165 ± 2	161 ± 2	162 ± 3	0.022
Sodium	mg/1000 kcal	2120 ± 553	2070 ± 24	2128 ± 20	2148 ± 21	2143 ± 20	2095 ± 23	0.73
Potassium	mg/1000 kcal	1082 ± 279	1094 ± 12	1101 ± 10	1084 ± 11	1083 ± 10	1046 ± 11[1]	0.0006
Calcium	mg/1000 kcal	267 ± 99	275 ± 4	273 ± 4	269 ± 4	266 ± 4	251 ± 4[3]	<0.0001
Magnesium	mg/1000 kcal	119 ± 28	120 ± 1	121 ± 1	120 ± 1	119 ± 1	115 ± 1[1]	0.0012
Iron	mg/1000 kcal	3.69 ± 0.89	3.73 ± 0.04	3.72 ± 0.03	3.70 ± 0.03	3.70 ± 0.03	3.59 ± 0.04[1]	0.0031
Zinc	mg/1000 kcal	4.10 ± 0.56	4.12 ± 0.02	4.14 ± 0.02	4.11 ± 0.02	4.07 ± 0.02	4.04 ± 0.02[1]	0.0003
Vitamin A	µg/1000 kcal	291 ± 239	308 ± 10	294 ± 9	287 ± 9	297 ± 9	271 ± 10[1]	0.020
Vitamin D	µg/1000 kcal	3.6 ± 1.9	3.7 ± 0.1	3.7 ± 0.1	3.6 ± 0.1	3.5 ± 0.1	3.4 ± 0.1[2]	0.0003
Vitamin E (alpha-tocopherol)	mg/1000 kcal	4.3 ± 1.1	4.2 ± 0.05	4.3 ± 0.04	4.3 ± 0.04	4.3 ± 0.04	4.2 ± 0.04	0.48
Thiamin	mg/1000 kcal	0.41 ± 0.09	0.41 ± 0.003	0.42 ± 0.003	0.41 ± 0.003	0.41 ± 0.003	0.40 ± 0.004	0.047
Riboflavin	mg/1000 kcal	0.69 ± 0.19	0.70 ± 0.01	0.69 ± 0.01	0.69 ± 0.01	0.69 ± 0.01	0.67 ± 0.01	0.030
Vitamin B_6	mg/1000 kcal	0.53 ± 0.15	0.53 ± 0.01	0.54 ± 0.01	0.53 ± 0.01	0.52 ± 0.01	0.51 ± 0.01[2]	<0.0001
Vitamin B_{12}	µg/1000 kcal	3.2 ± 1.5	3.2 ± 0.1	3.2 ± 0.1	3.2 ± 0.1	3.3 ± 0.1	3.0 ± 0.1	0.12
Folate	µg/1000 kcal	153 ± 54	156 ± 2	155 ± 2	153 ± 2	155 ± 2	145 ± 2[2]	0.0003
Vitamin C	mg/1000 kcal	49 ± 23	49 ± 1	49 ± 1	48 ± 1	49 ± 1	47 ± 1	0.17
Food groups (g/1000 kcal)								
Rice[d]		160.0 ± 68.6	171.4 ± 2.9	167.7 ± 2.5	158.0 ± 2.6[2]	153.6 ± 2.5[3]	150.0 ± 2.8[3]	<0.0001
Noodles[e]		36.8 ± 32.2	28.8 ± 1.4	33.6 ± 1.2[1]	36.5 ± 1.2[3]	38.5 ± 1.2[3]	46.4 ± 1.3[3]	<0.0001
Bread[f]		35.3 ± 25.8	34.9 ± 1.1	34.9 ± 0.9	35.7 ± 1.0	36.7 ± 0.9	34.1 ± 1.1	0.80
Confections		44.5 ± 23.3	42.5 ± 1.0	41.8 ± 0.8	44.8 ± 0.9	46.8 ± 0.9[2]	46.7 ± 1.0[1]	<0.0001
Potatoes		15.3 ± 10.8	15.3 ± 0.5	15.5 ± 0.4	15.1 ± 0.4	15.7 ± 0.4	15.0 ± 0.4	0.66
Fat and oil		13.5 ± 6.4	13.1 ± 0.3	13.3 ± 0.2	13.4 ± 0.2	13.9 ± 0.2	13.9 ± 0.3	0.010
Fruits		55.6 ± 54.0	54.2 ± 2.3	57.1 ± 2.0	55.1 ± 2.1	54.2 ± 2.0	57.1 ± 2.2	0.66
Vegetables[g]		121.6 ± 71.6	126.7 ± 3.1	127.5 ± 2.6	121.9 ± 2.8	121.3 ± 2.6	109.8 ± 2.9[3]	<0.0001
Pulses		25.1 ± 18.4	26.6 ± 0.8	25.8 ± 0.7	25.7 ± 0.7	24.7 ± 0.7	22.5 ± 0.8[3]	<0.0001
Fish and Shell fish		30.9 ± 17.0	30.8 ± 0.7	31.6 ± 0.6	31.0 ± 0.7	31.3 ± 0.6	29.7 ± 0.7	0.14
Meat		34.2 ± 16.5	33.1 ± 0.7	34.0 ± 0.6	34.8 ± 0.6	33.4 ± 0.6	35.7 ± 0.7[1]	0.025
Eggs		18.2 ± 13.8	19.3 ± 0.6	19.4 ± 0.5	18.1 ± 0.5	17.1 ± 0.5[1]	17.4 ± 0.6	0.0013
Milk and milk products		73.1 ± 71.5	77.4 ± 3.1	76.5 ± 2.6	74.3 ± 2.8	71.4 ± 2.6	65.6 ± 2.9[1]	0.0012

Significance level compared with Q1 of midpoint of sleep (Dunnett's test): [1]$P < 0.05$; [2]$P < 0.01$; [3]$P < 0.001$.
[a] Data are presented as means ± s.d.
[b] Data were adjusted for residential block (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; and Kyusyu), size of residential area (city with ⩾ 1 million; city with <1 million; and town and village), and current smoking (yes or no), and are expressed as means ± s.e.
[c] Tests for linear trends used the median value in each quintile as a continuous variable in linear regression.
[d] Including white rice, white rice mixed with barley, white rice germ, 50% polished rice, 70% polished rice, and brown rice.
[e] Including Japanese noodles (buckwheat and Japanese wheat noodle), instant noodles, chinese noodles, and pasta.
[f] Including white bread, butter roll, croissant, pizza, Japanese-style pancake, pancake, and cornflakes.
[g] Including colored vegetables, other vegetables, mushrooms, and sea vegetables.

especially for calorie-dense foods with a high carbohydrate content [36]. In our studies, because we did not investigate whether differences in the midpoint of sleep affect endocrine hormones related to appetite and food choices, the mechanism underlying the present results cannot be discussed in light of the above papers. Further studies are needed to investigate this possible relationship.

A recent study showed a positive correlation between the midpoint of sleep and intake of fast food and cola and other caffeinated drinks and a negative correlation with intake of dairy products [14]. In contrast to our study, no association with sweets, vegetables and salad, or meat was observed in that study in adolescents. Another recent study, in Japanese female students aged 18–29 years, showed that subjects who had breakfast at regular time showed higher morningness–eveningness scores (morningness), while drinker and smoker showed lower morningness–eveningness scores (eveningness). [15]. These findings are consistent with our results for Japanese female students aged 18–20 years, showing that those with later midpoint of sleep quintiles were more likely to smoke, consume alcohol, and skip meals. As it has been reported that skipped meals affect nutrient intake, it is possible that skipped meals affected nutrient intake in our subjects [37]. On the other hand, it was shown that dietary nutrient intake was differently associated with subjective sleep or objective sleep parameters [16]. There were no objective parameters of chronotype in the present study, but they should be addressed in future studies.

It was reported that watching television in evening may be an important social Zeitgeber for the time of going to bed [38]. In our study, subjects with later midpoint of sleep tended to watch TV at meals. Interestingly, the frequency of watching TV during not only dinner, but also breakfast and lunch on weekdays was significantly higher for later midpoint of sleep quintiles. It is possible that TV watching affects dietary intake [20,21]. There is also some evidence that links obesity and TV watching [39]. In contrast, although eating speed did not differ among the quintile groups, eating duration was longer in later quintile groups for all meals. However, nutrient intake was nearly inadequate in the later group. Furthermore, meal start times were late in the later quintiles for all meals. This result may affect circadian behaviors because animal studies indicate that periodic meals entrain clock gene expression [10,11].

Table 3
Meal start times, eating duration, eating speed, skipped meals, and watching TV at meals by midpoint of sleep quintile (n = 3304).

	All[a] n = 3304	Midpoint of sleep quintile					P[b]
		Q1 n = 534	Q2 n = 763	Q3 n = 669	Q4 n = 737	Q5 n = 601	
Meal start times [c,d] (O'clock (h:min))							
Breakfast	7:41 ± 1:19	6:35 ± 0:02	7:01 ± 0:02[3]	7:23 ± 0:02[3]	7:52 ± 0:02[3]	9:19 ± 0:02[3]	<0.0001
Lunch	12:26 ± 1:02	12:20 ± 0:02	12:20 ± 0:02	12:22 ± 0:02	12:23 ± 0:02	12:42 ± 0:02[3]	<0.0001
Dinner	19:05 ± 2:13	18:51 ± 0:06	18:55 ± 0:05	19:05 ± 0:05	19:17 ± 0:05[2]	19:19 ± 0:05[2]	<0.0001
Eating duration[c,d] (min.sec)							
Breakfast	17.36 ± 7.59	17.38 ± 0.21	17.11 ± 0.17	17.19 ± 0.19	16.38 ± 0.20	19.03 ± 0.18[2]	0.0002
Lunch	23.10 ± 8.40	21.50 ± 0.23	22.07 ± 0.19	23.21 ± 0.20[1]	22.41 ± 0.22	25.29 ± 0.19[3]	<0.0001
Dinner	30.13 ± 11.56	28.45 ± 0.31	29.26 ± 0.26	30.20 ± 0.28	29.36 ± 0.30	32.29 ± 0.26[3]	<0.0001
Eating speed[e] (%)							
Fast	36.7	35.4	35.4	35.3	37.0	40.8	0.34
Medium	29.8	33.5	31.3	27.1	30.8	26.1	
Slow	33.5	31.1	33.3	37.7	32.2	33.1	
Skipped meals[d] (times/week)							
Breakfast	1.00 ± 1.74	0.66 ± 0.07	0.57 ± 0.06	0.91 ± 0.06[3]	1.05 ± 0.06[2]	1.91 ± 0.07[3]	<0.0001
Lunch	0.20 ± 0.73	0.15 ± 0.03	0.16 ± 0.03	0.20 ± 0.03	0.22 ± 0.03	0.29 ± 0.03	0.0002
Dinner	0.32 ± 1.09	0.26 ± 0.05	0.29 ± 0.04	0.29 ± 0.04	0.33 ± 0.04	0.42 ± 0.04	0.01
Watching TV at meals[c,d] (times/weekdays)							
Breakfast	3.49 ± 1.90	3.27 ± 0.08	3.52 ± 0.07	3.50 ± 0.07	3.59 ± 0.08[1]	3.55 ± 0.07[1]	0.03
Lunch	2.04 ± 2.05	1.25 ± 0.08	1.50 ± 0.07	1.89 ± 0.08[3]	2.14 ± 0.08[3]	3.24 ± 0.07[3]	<0.0001
Dinner	3.86 ± 1.69	3.63 ± 0.07	3.87 ± 0.06[1]	3.87 ± 0.07	3.97 ± 0.07[2]	3.90 ± 0.06[1]	0.02

Significance level compared with Q1 of midpoint of sleep (Dunnett's test): [1]$P < 0.05$; [2]$P < 0.01$; [3]$P < 0.001$.
[a] Data are presented as means ± s.d.
[b] Tests for linear trends used the median value in each quintile as a continuous variable in linear regression; a Mantel-Haenszel χ^2 test was used for categorical variables.
[c] Those who consumed no breakfast, lunch, or dinner on weekdays were excluded. n = 3201; Q1:n = 521, Q2:n = 755, Q3: n = 645, Q4:n = 563, Q5: n = 717.
[d] Data were adjusted for residential block (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; and Kyusyu), size of residential area (city with ⩾1 million; city with <1 million; and town and village), and current smoking (yes or no), and are expressed as means ± s.e.
[e] Data are presented as persons (%).

Shift work and short or long sleep duration were associated with some health problems, such as cancer, obesity, diabetes, hypertension, or mortality [6,7,40,41]. Our present study indicated that one of the chronotype parameters, the midpoint of sleep, was associated with certain nutrient intake, food intake, and dietary behaviors in a large Japanese population. Subjects with the late midpoint of sleep had the characteristics of dietary intake and dietary behavior. Investigations are needed to determine whether these characteristics of dietary intake and dietary behavior affect future health problems in the subject with abnormal chronotype.

We should note several limitations of our study. First, we calculated the midpoint of sleep using weekday bedtimes and rise times in the previous month. Roenneberg et al. reported that the midpoint of sleep differs between free days and work days, and the score on the Horne–Ostberg questionnaire appears to correlate better with the midpoint of sleep on free days than on work days [18,42]. In the present study, we did not assess the subjects' daily schedule during the month. Accordingly, it is possible that the subjects in the early midpoint of sleep group might have had a special reason for needing to wake up early during that month. Therefore, the midpoint of sleep calculated on the basis of bedtime and rise times in this study might not be the same as the midpoint of sleep on free days. However, as the subjects were freshman students who had started their college courses within the previous 2 weeks, the month preceding this survey was either a spring vacation after graduation from high school or time off for students between schools. Therefore, the students probably had spare time during the month covered by the survey. Second, in this study, we did not collect the data of sleep latency. Therefore, we could not use sleep latency-adjusted midpoint of sleep. Third, there are the statistical limitations. The present study cannot avoid Type I error in the findings of dietary intake and dietary behaviors. However, because of a scarcity of similar studies and of basic studies, it was hard for us to make a clear hypothesis with one or a few nutrient or food groups to examine. Therefore, we investigated exhaustive analysis in the present study. Furthermore, the range of midpoint of sleep differed among five quintiles. This was markedly wider in the latest quintile, although the number of subjects was close to each other. This difference on the range of midpoint of sleep among groups may have created artificial findings. But at the time of present study we did not have any cutoff values with worldwide consensus for midpoint of sleep. Therefore, we simply divided the subjects into some groups with the same or similar number of subjects. We have used five quintiles in some previous reports in which the same data were used [29,43,44]. We therefore used the same number of groups, i.e., five quintiles in the present study too. Fourth, the subjects in the present study were dietetics students of young women aged 18–20 years. It has been reported that the midpoint of sleep and the Horne–Ostberg score vary by age and sex [19,45,46]. In the National Nutrition and Health Survey in Japan, mean nutrient and food intakes were also different between young and middle and elderly women [28]. It indicates that the subjects and the results of the present study may not be representative of general Japanese population with a wide age-range. However, mean values of nutrient and food intakes, body height, body weight, and prevalence of obesity in this population were almost the same as those in the women with similar age-class in the National Nutrition and Health Survey in Japan [28]. Therefore, the subjects of the present study may be representative at least for these variables, although they were dietetic course students and were not randomly sampled from a general population. Finally, it was reported that actual sleep-time duration was affected by season [47]. Because our data were collected at the same time of year, the seasonal variable of chronotype and dietary intake may affect the findings.

In conclusion, our study found that the midpoint of sleep, which indicates human chronotype, was significantly and independently associated with the dietary intake of certain nutrients and foods as well as with certain dietary behaviors in young Japanese women living with family members. This finding may help to reveal the characteristics of chronotype.

Conflict of Interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: doi:10.1016/j.sleep.2010.09.012.

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