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Original Article

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Association of Coffee Intake and Other Factors with Sleep Duration and Sleep Satisfaction: Results of Analysis of Large Cross-sectional Study

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Abstract

Objective: The purpose of this study was to perform a detailed statistical analysis on coffee's effect on sleep in Japan from an epidemiological perspective.

Methods: Subjects were 9,839 men (mean age, 50.7 ± 9.2 years) and 7,148 women (mean age, 49.4 ± 8.9 years) who received a health check-up. Coffee intake, total sleep duration, and sleep satisfaction were investigated and evaluated using univariate and multivariate analyses.

Results: Our results are for: Coffee intake [<1 cup/day: *n*=5,430 (32.0%), 1 cup/day: *n*=2,540 (14.9%), 2 cups/day: *n*=3,647 (21.5%), and ≥3 cups/day: *n*=5,370 (31.6%)], total sleep duration [average 6.1± 0.95 h/day; breakdown, <5 h/day: *n*=511 (3.0%), 5–7 h/day: *n*=10,842 (63.8%), 7–9 h/day: *n*=5,555 (32.7%), and ≥9 h/day: *n*=79 (0.5%)], sleep satisfaction [satisfaction: *n*=10,030 (59.0%), and dissatisfaction: *n*=6,957 (41.0%)]. Total sleep duration and sleep satisfaction increased with age, and were both poorer for women than men. Subjects satisfied with their sleep had a significantly longer sleep duration than those who did not (6.5 ± 0.85 h vs. 5.6 ± 0.82 h). Multivariate analyses showed that male gender, older age, smoking, drinking, and preferable dietary/fitness habits had a significantly positive association with both total sleep duration and sleep satisfaction.

Conclusions: Coffee had a weak but significant association with total sleep duration in subjects who drank ≥2 cups/day. On the other hand, no association was observed between coffee intake and sleep satisfaction.

Keywords sleep duration, sleep satisfaction, coffee intake

Sleep plays an important role in human physical health. Continued sleep deprivation increases the risk of several chronic health problems and among the physiological effects of sleep deprivation previously reported are increased risk of obesity[1–4], diabetes[5–9], hypertension[10,11], abnormal hormone levels[12–16], and cardiovascular disease[17–20]. Recent studies have also reported that sleep deprivation can damage brain cells[21] and also cause deposition of amyloid-β protein, which leads to memory disorders and Alzheimer's disease[22]. Another study has revealed that sleep has a restorative function based on the detoxification of potentially neurotoxic waste products[23].

Among many countries worldwide, sleep duration in Japan is one of the shortest[24]. Also according to a recent survey that investigated the current status of sleep in Japan, nearly 30% of Japanese have sleep disorders[25]. Sleep deprivation is a problem of public health that cannot be ignored, especially in developed countries, where a wide variety of social factors and lifestyles can cause sleep disorders. Therefore, we are of the opinion that detailed investigation of factors that may inhibit sleep is important.

Coffee is a factor that possibly influences sleep because its stimulatory effect on sympathetic nerves inhibits the function of sleep[26–32]. Furthermore, drinking a cup of coffee before bedtime could affect the sleep cycle[33]. Coffee is one of the most widely consumed beverages in the world, and Japan is one of the biggest coffee markets in Asia[34]. Therefore, in the present study, we aimed to evaluate the possible effects of coffee intake on sleep in consideration of age, gender, dietary habits and fitness habits.

In summary, the purpose of this study was to perform a detailed statistical analysis, from an epidemiological perspective, of the effect of coffee on sleep.

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Using large amounts of data from healthy subjects, we investigated the current status of sleep and coffee intake in Japan and also examined associations between sleep status and background factors including age, gender, dietary habits, fitness habits and coffee intake.

Methods

Study Subjects

The study subjects were 16,987 adults with no missing data who underwent a health check-up at Kameda Medical Center in Makuhari from January 4 to December 28, 2010. The gender breakdown of participants was 9,839 men (mean age 50.7 ± 9.2 years, range 19–86 years) and 7,148 women (mean age 49.4 ± 8.9 years, range 20–87 years). This study was approved by the ethics committees of the University of Tokyo, and written informed consent was obtained from each subject before study participation in accordance with the Declaration of Helsinki.

Questionnaires

The Ministry of Health, Labour and Welfare of Japan established the system for Specific Health Examinations and Specific Health Guidance based on scientific evidence in 2007 and it went into operation in fiscal 2008 [35,36]. For our research, we used some parts of the questionnaires that are used under the medical care system. Regarding fitness habits, we asked the following questions: "Have you been doing exercise that produces light sweating for over 30 minutes a time, twice weekly, for over a year ?" and "In your daily life, do you walk or engage in an equivalent amount of physical activity more than one hour a day ?". We also surveyed dietary habits, asking: "Is your speed of eating quicker than that of others ?", "Do you eat supper 2 hours before bedtime more than 3 times a week ?", "Do you eat snacks after supper more than 3 times a week ?" and "Do you skip breakfast more than 3 times a week ?".

In addition to the above, we analyzed answers to the following 5 questions: i) "How often do you drink alcohol in a week ?"; ii) "Do you have a smoking habit?"; iii) "Do you sleep well and enough ?"; iv) "How long do you sleep every day ?"; and v) "How much coffee do you drink ?". The answer to question i) was selected from five options (never, seldom, sometimes, often, and always), which were used as nominal variables to categorize subjects into 2 groups: rarely drinking group (never or seldom) and habitually drinking group (sometimes, often, or always). The answers to question ii) were used as nominal variables to categorize subjects into two groups: current or past habitual smoking (smoker group), and lifelong nonsmoking (nonsmoker group). The answer to iii) was "yes" or "no". The answers to question iv) used default values. The answers to question v) were used as ordinal variables to categorize subjects into three groups: drinking less than a cup of coffee per day, 1–2 cups of coffee per day, and 3 or more cups of coffee per day. Answers provided by the participants were carefully checked by nursing staff before being recorded in our study database.

Statistical analysis

We used JMP 13.2.1 or SAS Universal Edition (SAS Institute Inc. Cray, NC, USA) for statistical analysis. Effect size (ES) indicating the quantitative measure of the intensity of the phenomenon was calculated using G*power[37]. In the univariate analysis by age and gender, to evaluate associations between coffee intake and total sleep duration or sleep satisfaction, we used Welch's test, the chi-square test, Jonckheere–Terpstra trend test, Cochran–Armitage trend test and Kruskal–Wallis test, one-way analysis of variance; for multivariate analysis, we used multiple linear regression analysis and multiple logistic regression analysis. Total sleep duration and sleep satisfaction were defined as predictive factors, and age, gender, coffee, a cigarette, an alcoholic beverage, fitness habits, dietary habit, and adult disease (diabetes, obesity, hypertension, and dyslipidemia) were defined as background factors. In all analyses, two-tailed p values < 0.05 were considered statistically significant.

Results

Characteristics of coffee intake, sleep duration and sleep satisfaction in subjects

The characteristics of coffee intake and sleep status in the study group were as follows. About 68.0% of the subjects overall (68.4% for men and 67.5% for women) drank one or more cups of coffee per day. Subjects in the 40–49 age group drank the most coffee, for both men and women. Coffee intake differed between the genders as well as among the six age groups, with both statistical ($p < 0.001$) and practical significance (ES = 0.15–0.16) (**Fig. 1**). The total sleep duration of women was significantly shorter than that of men ($p < 0.001$). Total sleep duration increased with age but regardless of gender ($p < 0.001$ by Jonckheere–Terpstra trend test) (**Table 1**). The rate of sleep satisfaction was significantly different between the two genders and among the six age groups ($p < 0.001$ by chi-square test). With regard to gender, the percentage of women who were satisfied with their sleep was much smaller than that of men (53.8% vs. 62.9%). With regard to age, subjects in the 40–49 age group were most frequently dissatisfied with their sleep. Nevertheless, the Cochran–Armitage trend test revealed that the degree of sleep satisfaction followed an increasing trend proportionally with age for both men and women ($p < 0.001$ for both) (**Fig. 2**).

Associations of coffee intake with total sleep duration and sleep satisfaction in univariate analyses

The associations of coffee intake with total sleep du-

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(a) men

age group	rarely drink	1cup /day	2cups /day	≧3cups /day	overall
<40	330 (28.5)	182 (15.7)	252 (21.8)	394 (34.0)	1158 [11.8]
40-49	877 (26.8)	443 (13.6)	717 (21.9)	1232 (37.7)	3269 [33.2]
50-59	1200 (31.9)	464 (12.3)	750 (20.0)	1346 (35.8)	3760 [38.2]
60≤	701 (42.4)	253 (15.3)	299 (18.1)	399 (24.2)	1652 [16.8]
all ages	3108 (31.6)	1342 (13.6)	2018 (20.5)	3371 (34.3)	9839 [100.0]

P value : Chi-squared test <0.001
effect size : Cohen's *w* 0.16

(b) women

age group	rarely drink	1cup /day	2cups /day	≧3cups /day	overall
<40	343 (33.9)	179 (17.7)	253 (25.0)	236 (23.3)	1011 [14.1]
40-49	735 (28.5)	437 (16.9)	601 (23.3)	807 (31.3)	2580 [36.1]
50-59	821 (30.9)	434 (16.3)	609 (22.9)	794 (29.9)	2658 [37.2]
60≤	423 (47.0)	148 (16.5)	166 (18.5)	162 (18.0)	899 [12.6]
all ages	2322 (32.5)	1198 (16.7)	1629 (22.8)	1999 (28.0)	7148 [100.0]

P value : Chi-squared test <0.001
effect size : Cohen's *w* 0.16

(c) overall

age group	rarely drink	1cup /day	2cups /day	≧3cups /day	overall
<40	673 (31.0)	361 (16.6)	505 (23.3)	630 (29.1)	2169 [12.8]
40-49	1612 (27.5)	880 (15.1)	1318 (22.5)	2039 (34.9)	5849 [34.4]
50-59	2021 (31.5)	898 (14.0)	1359 (21.2)	2140 (33.3)	6418 [37.8]
60≤	1124 (44.1)	401 (15.7)	465 (18.2)	561 (22.0)	2551 [15.0]
all ages	5430 (32.0)	2540 (15.0)	3647 (21.4)	5370 (31.6)	16987 [100.0]

P value : Chi-squared test <0.001
effect size : Cohen's *w* 0.15

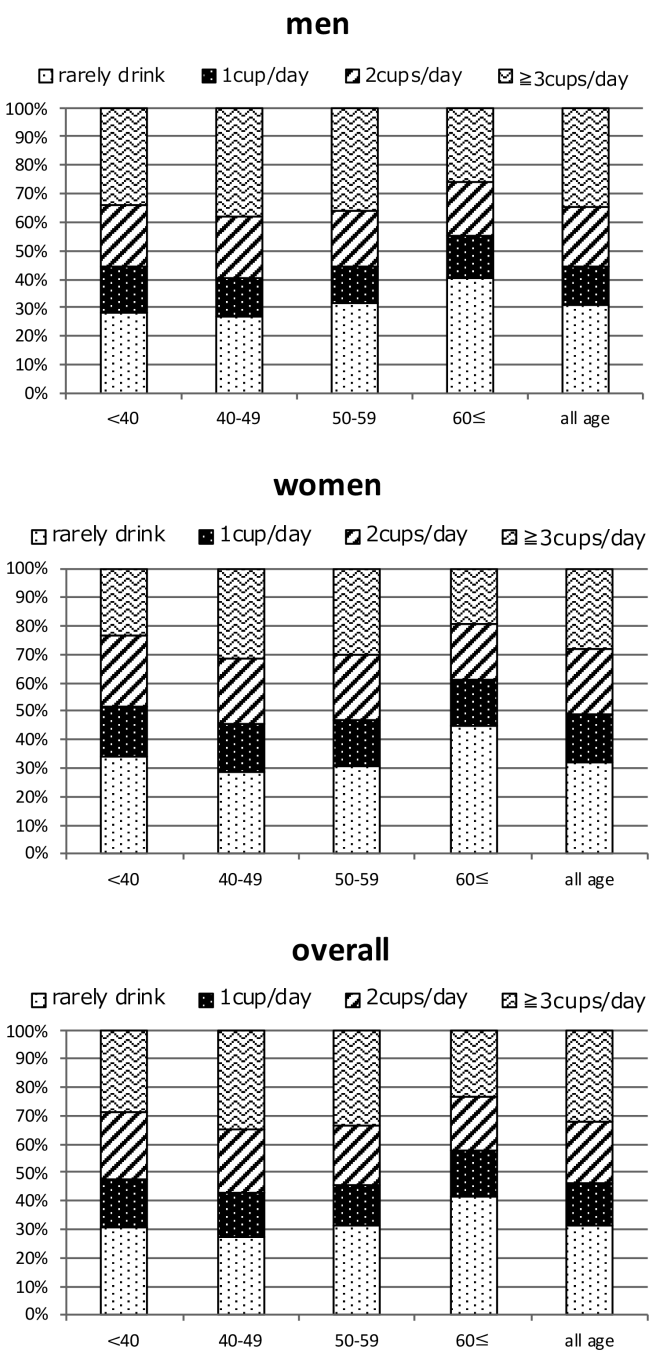

Fig.1. Coffee Intake and Age Group in Men, Women, and Subjects Overall
All panels show a frequency distribution table on the left, and a histogram 100% stacked column chart on the right. Panel (a) shows data for men, panel (b) shows data for women, and panel (c) shows data for both genders together. Values in ( ) in the frequency distribution table are percentages for rows, and values in [ ] are percentages for columns.

ration and sleep satisfaction are shown in **Table 2**. The Jonckheere–Terpstra trend test revealed that both total sleep duration and sleep satisfaction decreased with increase in coffee intake ($p < 0.001$). Subjects in the sleep satisfaction group had a longer sleep duration compared with subjects in the sleep dissatisfaction group, and the difference was statistically (6.5 ± 0.85 h vs. 5.6 ± 0.82 h; $p < 0.001$) and practically significant (ES = 1.07–1.11) (**Table 3**). Of the eight categories, "satisfying 7–9 sleeping hours" was the most frequent in men, whereas "dissatisfying 5–7 sleeping hours" was most frequently observed in women. For both genders, the degree of sleep satisfaction significantly increased with age ($p < 0.001$ by the Cochran–Armitage trend test) (**Table 4**).

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Table 1. Average Total Sleep Duration Categorized by Gender and Age

	total sleep duration											
	men				women				overall			
age group	*n*	mean ± sd	*p* value	effect size	*n*	mean ± sd	*p* value	effect size	*n*	mean ± sd	*p* value	effect size
< 40	1158	6.0 ± 0.96	<0.001 ψ	0.25	1011	6.1 ± 1.00	<0.001 ψ	0.16	2169	6.1 ± 0.98	<0.001 ψ	0.20
40–49	3269	6.0 ± 0.91			2580	6.0 ± 0.93			5849	6.0 ± 0.91		
50–59	3760	6.3 ± 0.94	<0.001 φ		2658	6.0 ± 0.86	0.0012 φ		6418	6.1 ± 0.93	<0.001 φ	
60 ≤	1652	6.7 ± 0.97			899	6.3 ± 0.97			2551	6.6 ± 0.98		
all ages	9839	6.2 ± 0.97			7148	6.0 ± 0.93			16987	6.1 ± 0.95		

ψ : Kruskal–Wallis one-way analysis of variance; φ : Jonckheere–Terpstra trend test. Effect size describes Cohen's *f*. Two-tailed *p* value less than 0.05 was considered statistically significant.

Table 2. Associations of Coffee Intake with Total Sleep Duration and Sleep Satisfaction

coffee intake	total sleep duration				sleep satisfaction				
	n	mean ± sd	*p* value	effect size ⊖	satisfaction	dissatisfaction	total	*p* value	effect size τ
rarely drink	5430	6.2 ± 1.00	<0.001 ψ	0.05	3218 (59.3)	2212 (40.7)	5430 [32.0]	<0.001 φ	0.03
1cup/day	2540	6.2 ± 0.96			1536 (60.5)	1004 (39.5)	2540 [14.9]		
2cups/day	3647	6.1 ± 0.91	<0.001 ξ		2206 (60.5)	1441 (39.5)	3647 [21.5]	0.0421 ω	
≧ 3cups/day	5370	6.1 ± 0.93			3070 (57.2)	2300 (42.8)	5370 [31.6]		
total	16987	6.1 ± 0.95			10030 (59.0)	6957 (41.0)	16987 [100.0]		

ψ: Kruskal-Wallis one-way analysis of variance; φ: Chi-squared test; ξ :Jonckheere-Terpstra trend test ; ω: Cochran-Armitage trend test. ⊖: Cohen's *f*; τ: Cohen's *w*. () is row%, [ ] is column%, Two-tailed *p* value less than 0.05 was considered statistically significant.

Table 3. Average Sleep Duration of Subjects with or without Sleep Satisfaction, Categorized by Gender

	total sleep duration											
	men				women				overall			
sleep satisfaction	n	mean ± sd	*p* value	effect size	n	mean ± sd	*p* value	effect size	n	mean ± sd	*p* value	effect size
satisfaction	6185	6.6 ± 0.86	<0.001 ψ	1.11	3845	6.4 ± 0.84	<0.001 ψ	1.07	10030	6.5 ± 0.85	<0.001 ψ	1.10
dissatisfaction	3654	5.6 ± 0.84			3303	5.6 ± 0.79			6957	5.6 ± 0.82		
total	9839	6.2 ± 0.97			7148	6.0 ± 0.93			16987	6.1 ± 0.95		

Welch's test, Effect size describe Cohen's *d*. Two-tailed *p* value less than 0.05 was considered statistically significant.

Table 4. Association between Total Sleep Duration and Sleep Satisfaction, Categorized by Gender

	sleep satisfaction								
	men			women			overall		
total sleep duration	satisfaction	dissatisfaction	total	satisfaction	dissatisfaction	total	satisfaction	dissatisfaction	total
< 5 hours	26 (9.1)	261 (90.9)	287 [2.9]	17 (7.6)	207 (92.4)	224 [3.1]	43 (8.4)	468 (91.6)	511 [3.0]
5 hours ≤ and 7 hours <	2981 (50.1)	2970 (49.9)	5951 [60.5]	2105 (43.0)	2786 (57.0)	4891 [68.4]	5086 (46.9)	5756 (53.1)	10842 [63.8]
7 hours ≤ and 9 hours <	3132 (88.2)	420 (11.8)	3552 [36.1]	1696 (84.7)	307 (15.3)	2003 [28.0]	4828 (86.9)	727 (13.1)	5555 [32.7]
9 hours ≤	46 (93.9)	3 (6.1)	49 [0.5]	27 (90.0)	3 (10.0)	30 [0.4]	73 (92.4)	6 (7.6)	79 [0.5]
total	6185 (62.9)	3654 (37.1)	9839 [100.0]	3845 (53.8)	3303 (46.2)	7148 [100.0]	10030 (59.0)	6957 (41.0)	16987 [100.0]
p value :	Chi-squared test		<0.001			<0.001			<0.001
	Cochran-Armitage trend test		<0.001			<0.001			<0.001
effect size :	Cohen's *w*		0.61			0.58			0.61

Two-tailed *p* value less than 0.05 was considered statistically significant, () is row%, [ ] is column%.

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(a)

age group	men satisfaction	men dissatisfaction	men overall
<40	691 (59.7)	467 (40.3)	1158 [11.8]
40-49	1809 (55.3)	1460 (44.7)	3269 [33.2]
50-59	2387 (63.5)	1373 (36.5)	3760 [38.2]
60≤	1298 (78.6)	354 (21.4)	1652 [16.8]
all ages	6185 (62.9)	3654 (37.1)	9839 [100.0]
P value :	Chi-squared test		<0.001
	Cochran-Armitage trend test		<0.001
effect size :	Cohen's *w*		0.16

(b)

age group	women satisfaction	women dissatisfaction	women overall
<40	565 (55.9)	446 (44.1)	1011 [14.1]
40-49	1325 (51.4)	1255 (48.6)	2580 [36.1]
50-59	1363 (51.3)	1295 (48.7)	2658 [37.2]
60≤	592 (65.8)	307 (34.2)	899 [12.6]
all ages	3845 (53.8)	3303 (46.2)	7148 [100.0]
P value :	Chi-squared test		<0.001
	Cochran-Armitage trend test		<0.001
effect size :	Cohen's *w*		0.16

(c)

age group	overall satisfaction	overall dissatisfaction	overalll
<40	1256 (57.9)	913 (42.1)	2169 [12.8]
40-49	3134 (53.6)	2715 (46.4)	5849 [34.4]
50-59	3750 (58.4)	2668 (41.6)	6418 [37.8]
60≤	1890 (74.1)	661 (25.9)	2551 [15.0]
all ages	10030 (59.0)	6957 (41.0)	16987 [100.0]
P value :	Chi-squared test		<0.001
	Cochran-Armitage trend test		<0.001
effect size :	Cohen's *w*		0.16

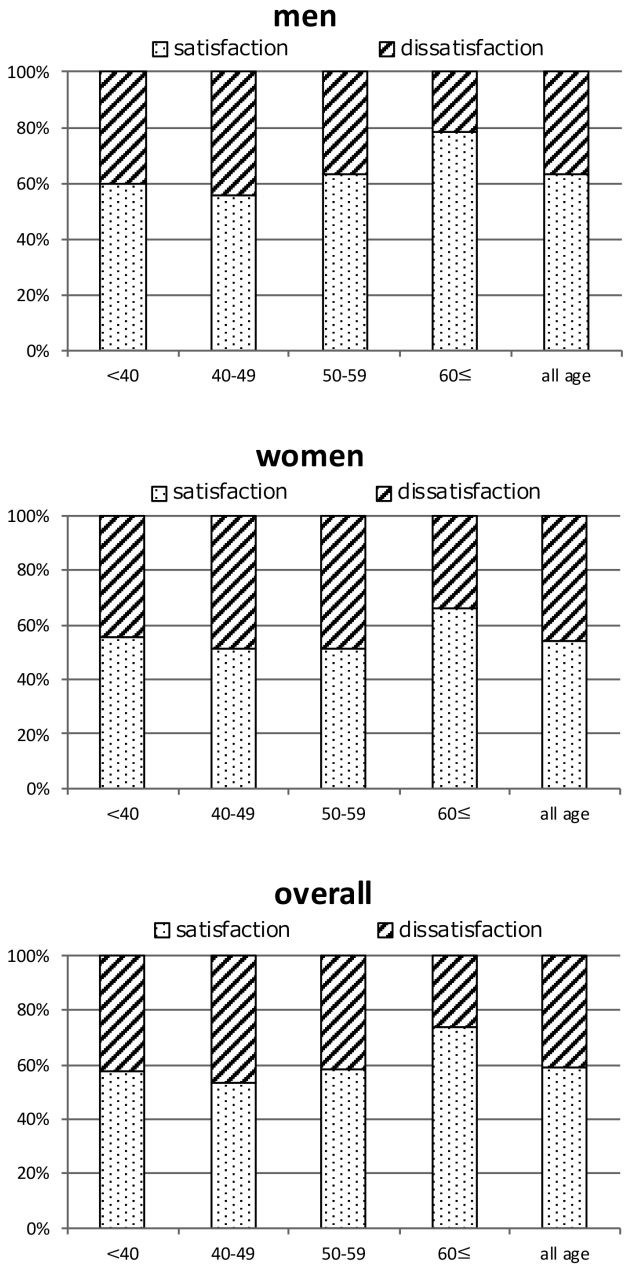

Fig.2. Sleep Satisfaction and Age Group in Men, Women, and Subjects Overall

All panels show a frequency distribution table on the left, and a histogram 100% stacked column chart on the right. Panel a shows data for men, panel b shows data for women, and panel c shows data for both genders together. Values in ( ) in the frequency distribution table are percentages for rows, and values in [ ] are percentages for columns. The effect size was estimated by Cohen's w and we used the Chi-square test to determine whether there was a statistically significant difference. Furthermore, we used the Cochran–Armitage trend test to determine whether there was a statistically significant trend.

Association of coffee intake with total sleep duration and sleep satisfaction in multivariate analyses

The results of the multivariate analyses focusing on total sleep duration and sleep satisfaction are shown in **Table 5**. Almost all background factors other than small amounts of coffee intake were associated with sleep. When focusing simply on significant factors, older age, male gender, alcohol, smoking, and fitness habits were positively associated with both total sleep duration and sleep satisfaction. In contrast, non-preferable dietary habits were negatively associated with both total sleep time and sleep satisfaction. Based on the values of standardized coefficients, the background factor with the greatest effect on total sleep duration was older age, whereas that for sleep satisfaction was having supper late at night.

With regard to coffee intake, "more than two cups per day" was negatively associated with total sleep duration,

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Table 5. Summary of Estimated Total Sleep Duration and Sleep Satisfaction in Multivariate analyses

			total sleep duration Ψ			sleep satisfaction Φ		
			Standardized Coefficient	*t*-value	*p* value	Standardized Coefficient	Odds Ratio (95% CI)	*p* value
Age			0.114	14.97	<.001*	0.128	1.14 (1.10–1.18)	<.001*
Gender	females			reference			reference	
	males		0.069	7.83	<.001*	0.139	1.15 (1.11–1.20)	<.001*
Coffee intake	non-drinker			reference			reference	
	1 cup/day		-0.005	-0.61	0.543	0.019	1.02 (0.99–1.06)	0.318
	2 cups/day		-0.019	-2.30	0.021*	0.021	1.03 (0.99–1.06)	0.274
	≧ 3 cups/day		-0.051	-6.00	<.001*	-0.035	0.97 (0.93–1.00)	0.068
BMI			-0.068	-8.89	<.001*	-0.020	0.98 (0.95–1.01)	0.246
Alcohol	rarely drinking			reference			reference	
	usually drinking		0.040	5.20	<.001*	0.087	1.09 (1.05–1.13)	<.001*
Smoking	never smoker			reference			reference	
	former smoker		0.041	4.84	<.001*	0.064	1.07 (1.03–1.11)	<.001*
	current smoker		0.055	6.30	<.001*	0.078	1.08 (1.04–1.12)	<.001*
Dietary habits	Is your speed of eating quicker than that of others?	normal		reference			reference	
		later	-0.017	-2.30	0.022*	-0.074	0.93 (0.90–0.96)	<.001*
		quicker	-0.008	-1.05	0.294	-0.042	0.96 (0.93–0.99)	0.012*
	Do you eat supper two hours before bedtime more than 3 times a week?	no		reference			reference	
		yes	-0.076	-10.13	<.001*	-0.211	0.81 (0.78–0.84)	<.001*
	Do you eat snacks after supper more than 3 times a week?	no		reference			reference	
		yes	-0.050	-6.92	<.001*	-0.118	0.89 (0.86–0.92)	<.001*
	Do you skip breakfast more than 3 times a week ?	no		reference			reference	
		yes	-0.038	-5.07	<.001*	-0.080	0.92 (0.89–0.95)	<.001*
Fitness habits	Have you been doing exercise that produces light sweating for over 30 minutes a time, twice weekly, for over a year?"	no		reference			reference	
		yes	0.054	7.11	<.001*	0.166	1.18 (1.14–1.22)	<.001*
	In your daily life, do you walk or engage in an equivalent amount of physical activity more than one hour a day?	no		reference			reference	
		yes	0.013	1.70	0.09	0.096	1.10 (1.06–1.14)	<.001*
Interaction Ω	1 cup/day * age					-0.039	0.96 (0.93–1.00)	0.034*
	≧ 3 cups/day * BMI					0.045	1.05 (1.01–1.09)	0.021*
	≧ 3 cups/day * current smoker					-0.073	0.93 (0.89–0.97)	0.001*
	1 cup/day * Are you in a habit of doing exercise to sweat lightly for over 30 minutes a time, twice weekly, for over a year?		0.023	2.81	0.005*			
	1 cup/day * former smoker		-0.022	-2.33	0.020*			
	interactions with other variables in coffee intake				n.s.			n.s.

Ψ: multiple linear regression analysis; Φ: multiple logistic regression analysis. Ω:First-order interaction. n.s.:not significant. Two-tailed *p* value less than 0.05 was considered statistically significant.

with statistical significance, by the linear regression model. In contrast, there was no association between coffee intake and sleep satisfaction by the logistic regression model. Estimating the interaction between coffee intake and other variables using the linear regression model, there were statistically significant interactions in the associations of coffee intake with fitness habit and former smoker. There were also statistically significant interactions in the associations of coffee intake with age, BMI and current smoker.

Discussion

Epidemiology of sleep in Japan

According to the statistics provided by the Organisation for Economic Co-operation and Development (OECD)[24], at 456 min, the sleep duration of women in Japan was the shortest among the 26 countries surveyed. Furthermore, according to the statistics from the Survey on Time Use and Leisure Activities provided by Japan's Statistics Bureau, Ministry of Internal Affairs and Communications[38], the national average total sleep duration was 451 min, and the total sleep duration of women was significantly shorter than that of men. In both of the above surveys[24,38], total sleep duration increased with age. Differences in sleep duration between the genders were similar to those in the present research. In contrast, total sleep duration in our study was much shorter than that in the 2 surveys, probably because the percentage of middle-aged subjects (40–59 years) was higher in our study population and the Ministry of Internal Affairs and Communications survey had reported that people in 40–59 age group, considered to be those in the most productive years of working life, had a shorter sleeping time than other age groups[39].

A systematic literature review aiming to determine the right amount of sleep found that adults 26–64 years old need 7–9 h sleep each day and older adults 65 years or older need 7–8 h sleep each day[40]. Compared with its findings, the overall sleep duration in our study

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population was much shorter. In addition, the rates for subjects who were dissatisfied with their sleep were very high in Japan.

Sleep durations that are too short have been reported as a risk factor for diabetes, probably due to the associated decrease in insulin sensitivity[41]. In addition, sleep deprivation has been reported to increase the risk of obesity[1–4], hypertension[10,11], cardiovascular disease [17–20], and Alzheimer's disease[22]. Furthermore, less than 6 h sleep per day has been shown to be associated with a 12% higher probability of death compared with 6–8 h sleep per day[42]. To validate these previous findings, we are planning a prospective observational study to clarify the effect of decreased sleep duration on health.

Non-preferable dietary habits should have great influence on sleep

Food intake and sleep are closely related to each other. Food intake late at night has a negative influence on sleep latency and efficiency[43]. Additionally, poor sleep-wake regularity has an undesirable effect on food intake and frequency[44,45]. Furthermore, several past studies have reported that people who have satisfactory eating habits tend to get enough sleep[46,47]. Our results from the multivariate analyses are consistent with these studies. Consequently, we believe that stopping bad dietary habits can improve quality of sleep by preventing their multiple negative effects.

Although the mechanism of the close relationship between sleep and food intake has not been adequately elucidated, two hormones may be important in this regard: ghrelin that stimulates appetite and leptin that suppresses appetite. It was reported that shorter sleep duration induces a higher serum level of ghrelin and a lower serum level of leptin[48]. It was also reported that leptin and ghrelin have positive and negative correlations, respectively, with sleep duration[49]. We think that the subtle balance between these two hormones may play an essential role in the significant association between sleep and food intake.

Effect of coffee intake upon sleep possibly minimal

Our multivariate analyses showed that coffee intake had a significant association with total sleep duration but not with sleep satisfaction. This discrepancy is very intriguing as total sleep duration and sleep satisfaction usually have a strong positive association. We suggest that the shorter sleep duration frequently observed in heavy coffee drinkers is not an undesirable effect of drinking too much coffee, but results from the intention to take advantage of its stimulant effects.

When the sizes of the effect were calculated, the Effect Size (f) of total sleep duration was 0.05, and Effect Size (ω) of sleep satisfaction was 0.03. Despite the significant association between coffee intake and sleep duration, the small values of ES suggested that the effect of coffee intake upon sleep is practically insignificant.

Limitations

The first limitation of our study is the cross-sectional design. Therefore, we were not able to accurately analyse effect sizes. The second limitation is that our study subjects were people who underwent a health check-up, so we could not evaluate the actual conditions of patients with critical disease. The third limitation is that sleep duration might have been inaccurate because it was self-reported. The fourth limitation is that we could not consider other beverages and habits that may affect sleep in these analyses.

Conclusions

Our results showed that coffee intake is significantly associated with shorter sleep duration, but not with sleep satisfaction. However, our results also showed that the effects of coffee intake upon substantial sleep are almost negligible because of their small effect sizes. Since coffee is one of the most widely consumed beverages in the world, this study will provide important, new insights in the epidemiology of sleep regarding sleep status because we have presented evidence that sleep is associated not only with coffee intake but also with typical lifestyle habits in advanced countries. These effects could vary depending on various factors such as types of coffee, place where it is drunk (home, workplace, or coffee shop), mode of drinking coffee (black, with sugar, or with cream), and time period of sleep.

Conflicts of Interest

No author reports a conflict of interest related to our manuscript.

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