3 (Difficulty remaining alert): How often did you have trouble staying alert when you were required to refrain from sleep (at work, etc.)?
4 (Difficulty maintaining sleep [DMS]): How often do you find it difficult to go back to sleep after you have woken up during the night or too early in the morning?
5 (Use of hypnotic medication): How often have you taken medication to induce sleep?
6 (Use of the toilet): How often have you found it difficult to resume sleep after getting up in the middle of the night to use the toilet?
7 (Pain): How often have you found it difficult to fall asleep because of pain?

The subjects were instructed to answer question 1 by entering the value of their average daily sleep duration. For questions 2 to 7, the following four options were provided: (a) never; (b) less than once per week; (c) once or twice per week; and (d) three times or more per week. For each question, subjects who selected (c) or (d) as the answer were considered to have the symptoms related to the question.

For questions on sleep, we used part of the Japanese version of the Pittsburgh Sleep Quality Index (PSQI) without modification.

With regard to smoking, the current smoking status was taken as the reference. If a subject did not smoke at the time of the survey, he/she was classified as a non-smoker even if he/she had a history of smoking.

With regard to exercise habits, for the question "Do you exercise regularly?," the following five options were provided: (a) seldom; (b) once a week; (c) twice or three times a week; (d) four or five times a week; and (e) nearly every day. Those who selected (b) (c) (d), or (e) were considered to be those who routinely exercise.

Definition of high fasting plasma glucose level

For the purpose of our analyses, we defined hyperglycemia as a fasting plasma glucose level of ≥100 mg/dL. Recently, this level has often been used by the Japan Diabetes Society and the American Diabetes Association as a cut-off point for assessing the risk of glucose tolerance disorders, including diabetes mellitus.[31] As stipulated for the particular health check-up system initiated in Japan in 2008, detection of this high plasma glucose level is considered to indicate the need for health counseling.[32]

Statistical analyses

First, we calculated the prevalence of hyperglycemia in 2005 and 2007. Then, after identifying subjects whose fasting glucose level was <100 mg/dL and who did not have a medical history of diabetes mellitus at the time of the baseline survey, we calculated the incidence of new-onset hyperglycemia over the 2 years. Finally, we conducted logistic regression analyses to determine the association between sleep habits and the onset of hyperglycemia. We considered the incidence of new-onset hyperglycemia between 2005 and 2007 as the response variable, and used the following items as covariates: age of the subjects in 2005, gender, body mass index (BMI), smoking status, presence/absence of exercise habits, systolic blood pressure, difficulty in initiating sleep, difficulty in remaining alert, difficulty in maintaining sleep, use of hypnotic medication, use of the restroom during the night, experiencing pain, sleep duration, high-density lipoprotein level, triglyceride level, and CES-D score. We also performed gender-specific logistic regression analyses. SPSS 14.0J for Windows (SPSS, Chicago, IL, USA) was used for all statistical analyses.

Ethical considerations

We obtained approval from the ethics committee of our institution prior to initiation of the study. The survey details and the purpose of the study were explained both verbally and on a printed form to the participants, and they were instructed to sign the consent forms for participation. The privacy of the participants was strictly protected.

RESULTS

The number of participants in the baseline survey and the follow-up survey was 1067 and 814, respectively. Of these participants, 497 participated in both surveys. In the baseline survey, 68 participants had a fasting glucose level of ≥100 mg/dL or a medical or treatment history of diabetes mellitus, while 429 participants had a fasting glucose level of <100 mg/dL and had neither a medical nor a treatment history of diabetes mellitus (Table 1: Changes in the plasma glucose levels of the participants in 2005 and 2007). Among these 429 participants, the fasting glucose level in 12 increased to ≥100 mg/dL at the follow-up survey; the incidence of hyperglycemia was 2.8% during this time period (Table 2). No participants were diagnosed as having diabetes mellitus at any medical institution during these 2 years.

Table 1 Changes in the plasma glucose levels of the participants in 2005 and 2007

	In 2007 FPG < 100 mg/dL	In 2007 FPG ≥ 100 mg/dL	Total (%)
In 2005			
FPG <100 mg/dL and history of diabetes (–)	417 (83.9)	12 (2.4)	429 (86.3)
In 2005			
FPG ≥ 100 mg/dL or history of diabetes (+)	26 (5.2)	42 (8.5)	68 (13.7)
Total	443 (89.1)	54 (10.9)	497 (100.0)

FPG, fasting plasma glucose.

The results of logistic regression analyses are presented in Table 3. The results of univariate logistic regression analyses showed that the incidence of hyperglycemia was significantly associated with that of systolic blood pressure ($P = 0.02$), difficulty in initiating sleep ($P < 0.01$), and difficulty in maintaining sleep ($P = 0.02$). The results of multiple logistic regression analyses revealed a significant association between difficulty in initiating sleep and the incidence of hyperglycemia after 2 years ($P = 0.01$; adjusted odds ratio [OR], 5.27; 95% confidence interval [CI], 1.48–18.77).

The results of gender-specific analyses are presented in Table 4. The univariate analysis showed significantly high odds ratios between new onset of hyperglycemia and difficulty in initiating sleep for both men and women (males: $P = 0.04$; crude OR, 5.48; 95% CI, 1.04–28.83, females: $P = 0.01$; crude OR, 8.60; 95% CI, 1.53–48.27). However, the multivariate analysis showed a significantly high odds ratio only in women ($P = 0.02$; adjusted OR, 7.91; 95% CI, 1.38–45.42).

DISCUSSION

Many epidemiological studies of sleep disorders and impaired glucose tolerance have been conducted in Western countries.[14–17] However, only two large-scale epidemiological prospective studies – one by Kawakami *et al.*[27] and the other by Hayashino[28] – have been conducted with a Japanese cohort; the study populations in their studies were limited to employees. Our prospective study was significant in that it included residents of a local Japanese community, and our results suggested that difficulty in initiating sleep may be a risk factor for hyperglycemia, which might develop after 2 years of sleep disturbance.

Spiegel *et al.* demonstrated that insomnia could be a risk factor for impaired glucose tolerance on the basis of physiological experiments that measured the levels of various hormones such as catecholamines and cortisol.[21,22] In addition, it has been reported that adrenocorticotropic hormone (ACTH) and cortisol secretion were significantly higher in patients with chronic insomnia symptoms than in non-insomnia controls. As the severity of insomnia increased, the levels of hormones also increased; in addition, sympathetic nervous system activity increased, and a higher blood noradrenaline concentration was observed.[19,33] Such endocrinological changes accompanying insomnia are considered to induce an increase in the plasma glucose level. Recently, sleep and appetite-regulating hormones (leptin and ghrelin) were also reported to be closely associated with saccharometabolism: when sleep was prevented, the blood leptin concentration decreased and the blood ghrelin concentration increased, which led to an increase in appetite and a sense of hunger.[34–36] Furthermore, the melanin-concentrating hormone (MCH) system, which is considered to regulate these hormones, is reportedly involved in sleep as well as eating habits, energy metabolism, and stress responses such as depression and anxiety;[37] therefore, it was inferred that insomnia induces dysregulation of these hormones, which in turn increases insulin resistance, and consequently, an increase in blood glucose levels. Future epidemiological studies should include measurements of the blood concentrations of these hormones.

Nilsson *et al.* conducted a cohort study involving 6599 Swedish men and investigated the association between difficulty in initiating sleep and impaired glucose tolerance; they reported that glucose tolerance worsened in subjects with insomnia, including those having difficulty in initiating sleep and those who used hypnotic medication.[18] Large-scale prospective studies with Japanese subjects were conducted by Kawakami *et al.*[27] and Hayashino *et al.*[28] Kawakami *et al.* followed up 2649 employees over 8 years, and Hayashino *et al.* followed up 6509 employees over 4.2 years; the results of both studies indicated that difficulty in initiating sleep could be a risk factor for diabetes mellitus. The

Table 2 Incidence of hyperglycemia

		Incidence of hyperglycemia	
	n	%	95% CI
Overall	429	2.8	0.0–12.1
Gender			
Male	155	3.9	0.9–6.9
Female	274	2.2	0.5–3.9
Age classification (years)			
<50	112	0.9	0.0–2.6
50–59	109	1.8	0.0–4.3
60–69	134	4.5	1.0–8.0
70≤	74	4.1	0.0–8.6
BMI			
<25	311	2.6	0.8–4.4
≥25	118	3.4	0.1–6.7
Systolic blood pressure			
<130	246	1.2	0.0–2.6
≥130	183	4.9	1.8–8.0
Smoking			
No	358	2.8	1.1–4.5
Yes	71	2.8	0.6–6.6
Exercise			
No	334	2.1	0.6–3.6
Yes	95	5.3	0.8–9.8
Sleep disorder			
Difficulty initiating sleep			
No	346	1.4	0.2–2.6
Yes	80	8.8	2.6–15.0
Difficulty remaining alert			
No	404	2.7	1.1–4.3
Yes	23	4.3	0.0–12.6
Difficulty maintaining sleep			
No	331	1.8	0.4–3.2
Yes	95	6.3	1.4–11.2
Use of hypnotic medication			
No	407	2.7	1.1–4.3
Yes	20	5.0	0.0–14.6
Going to the restroom during night			
No	323	2.2	0.6–3.8
Yes	103	4.9	0.7–9.1
Having pain			
No	399	2.8	1.2–4.4
Yes	24	4.2	0.0–12.2
Sleep duration (h)			
<7	110	0.0	
7 to <8	124	1.6	0.0–3.8
8 to <9	129	5.4	1.5–9.3
9= or <	64	4.7	0.0–9.9
CES-D			
<16	349	2.0	0.5–3.5
≥16	80	6.3	1.0–11.6
High-density lipoprotein cholesterol level			
<40	411	2.7	1.1–4.3
≥40	18	5.6	0.0–16.2
Triglyceride level			
<150	389	2.3	0.8–3.8
≥150	40	7.5	0.0–15.7

BMI, body mass index; CES-D, Center for Epidemiologic Studies Depression Scale; CI, confidence interval.

Table 3 Results of logistic regression analyses

	Crude OR	95% CI	*P*-value	Adjusted OR	95% CI	*P*-value
Gender			0.31			
Male	1.00					
Female	0.56	0.18–1.75				
Age classification (years)			0.37			
<50	0.62	0.06–6.19				
50–59	0.44	0.07–2.71				
60–69	1.11	0.27–4.57				
70≤	1.00					
BMI			0.65			
<25	1.00					
≥25	1.33	0.39–4.50				
Systolic blood pressure			0.02			0.07
<130	1.00			1.00		
≥130	4.19	1.12–15.70		3.64	0.91–14.61	
Smoking			0.10			
No	1.00					
Yes	1.01	0.22–4.71				
Exercise			0.99			0.08
No	2.60	0.81–8.37		3.20	0.87–11.79	
Yes	1.00			1.00		
Sleep disorder						
Difficulty initiating sleep			<0.01			0.01
No	1.00			1.00		
Yes	6.54	2.02–21.18		5.27	1.48–18.77	
Difficulty remaining alert			0.65			
No	1.00					
Yes	1.62	0.20–13.15				
Difficulty maintaining sleep			0.02			
No	1.00					
Yes	3.65	1.15–11.60				
Use of hypnotic medication			0.54			
No	1.00					
Yes	1.90	0.23–15.45				
Going to the restroom during night		0.15				
No	1.00					
Yes	2.30	0.72–7.42				
Having pain			0.69			
No	1.00					
Yes	1.53	0.19–12.40				
Sleep duration (h)			0.10			0.56
<8	1.00			1.00		
8 to <9	3.50	0.71–17.19		4.30	0.81–22.88	
≥9	3.50	0.49–18.43		2.53	0.36–17.74	
CES-D			0.05			0.08
<16	1.00			1.00		
≥16	3.26	1.01–10.54		3.28	0.86–12.46	
High-density lipoprotein cholesterol level			0.47			
<40	1.00					
≥40	2.14	0.26–17.53				
Triglyceride level			0.06			
<150	1.00					
≥150	3.42	0.89–13.20				

BMI, body mass index; CES-D, Center for Epidemiologic Studies Depression Scale; CI, confidence interval; OR, odds ratio. Variables excluded by the process of backward elimination analysis are represented by an empty column.

Table 4 Results of logistic regression analyses by gender

	Crude OR	95% CI	*P*-value	Adjusted OR	95% CI	*P*-value
Males						
Difficulty initiating sleep			0.04			
No	1.00					
Yes	5.48	1.04–28.83				
Females						
Difficulty initiating sleep			0.01			0.02
No	1.00			1.00		
Yes	8.60	1.53–48.27		7.91	1.38–45.42	

CI, confidence interval; OR, odds ratio. Males: Multivariate logistic regression analyses were conducted with adjustment for age, body mass index, systolic blood pressure, smoking, exercise, difficulty initiating sleep, difficulty maintaining sleep, going to the restroom during night, having pain, sleep duration, Center for Epidemiologic Studies Depression Scale (CES-D), triglyceride level. Females: Multivariate logistic regression analyses were conducted with adjustment for age, body mass index, smoking, exercise, difficulty initiating sleep, difficulty remaining alert, difficulty maintaining sleep, use of hypnotic medication, going to the restroom during night, sleep duration, Center for Epidemiologic Studies Depression Scale (CES-D), high-density lipoprotein cholesterol level, triglyceride level. Variables excluded by the process of backward elimination analysis are represented by an empty column.

results of our study are in agreement with those previous studies. Moreover, gender-specific analyses revealed significantly high odds ratios between new onset of hyperglycemia and difficulty in initiating sleep for both men and women in univariate analysis, and a significantly high odds ratio only for women in multivariate analysis. It is unclear why no significant association was observed in men in the multivariate analysis. This may be attributed to a small sample size, as a result of dividing the samples by gender, which may have lowered the statistical power. There is no medical consensus on whether there are gender-based differences with regard to associations between insomnia symptoms and impaired glucose tolerance. However, there may be gender-based differences with regard to endocrine metabolic functions for sleep.

Recent studies[38,39] have revealed that depression could be a confounding factor in the association between hyperglycemia and sleep disorders. However, the above-mentioned studies did not adjust for the depression status in their analyses; in contrast, in the present study, depression status was used as a covariate. Our results suggest that difficulty in initiating sleep is a risk factor for high fasting plasma glucose levels. We believe that the results of our study, which were obtained after adjustment for depression status, further support those of previous studies.

In our follow-up survey, we used a fasting plasma glucose level of ≥100 mg/dL as the reference level for impaired glucose tolerance, instead of using the one used as a diagnostic criterion for diabetes mellitus. A fasting plasma glucose level of ≥100 mg/dL indicated that the patient was in a prediabetic state. The results of our study suggest that sleeping disorders such as difficulty in initiating sleep affect plasma glucose levels in some people who are in a prediabetic state.

The present study results showed that compared to other insomnia symptoms and short sleep duration, difficulty in initiating sleep had a stronger association with impaired glucose tolerance. To date, associations between difficulty in initiating sleep and onset of impaired glucose tolerance have not been sufficiently examined either epidemiologically or physiologically in previous studies. Thus, the mechanism cannot be fully explained at this point. For further clarification of the association between insomnia and impaired glucose tolerance, more epidemiological studies must be conducted with different study populations, and meta-analyses of the results must be performed. We expect that such studies will help in determining good sleep habits and contribute to the prevention and treatment of diabetes mellitus. In addition, such findings will be conducive to healthcare and prevention activities and clinical practice in general.

There were several limitations to the present study. First, self-reported questionnaires were used to obtain data on sleep duration. Therefore, the data obtained were not objective. However, some studies have reported that self-reported data on sleep status do concur, to a certain extent, with physiologic data.[40,41] Second, although consumption of beverages such as alcohol and coffee, improper eating habits, and family history[12,13,42,43] are considered to be risk factors for diabetes mellitus, this study did not adjust for these factors.

Third, we only analyzed the cumulative incidence of hyperglycemia at 2 years among subjects who experienced difficulty in initiating sleep at the baseline survey; therefore, the changes in the plasma glucose levels during the period between the baseline and follow-up surveys could not be determined. Fourth, residents of a particular local community in Japan were used as samples in this study, and the sample size was small; the distributions of gender and age were not considered. Thus, the representativeness of the sampling was not ensured. Additionally, the small sample size made it impossible to use commonly used classifications for routine exercising and sleep duration. Fifth, because data on restless legs syndrome and sleep apnea were not collected, these were not considered in the analyses. Sixth, the possibility of a difference between the groups of participants and non-participants in the follow-up survey cannot be ruled out. However, a comparison between people who had participated only in the baseline survey and those who participated in both baseline and follow-up surveys showed no statistically significant difference in gender composition and the average age of participants in the baseline survey. This may signify that people who dropped out did not belong to any particular age group or gender.

Conclusions

The results of our prospective study conducted on residents of a local Japanese community suggest that difficulty in initiating sleep might be a risk factor for hyperglycemia 2 years after first experiencing sleep disturbance. These results will help in the formulation of guidelines for future preventive medicine practices such as healthcare education and guidance for local communities.

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SCIENTIFIC INVESTIGATIONS

Non-Pharmacological Self-Management of Sleep Among the Japanese General Population

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Study Objectives: The present study was conducted to clarify the prevalence of non-pharmacological self-management (nPSM) practices for obtaining good sleep and to identify favorable nPSM practices that could be applied for reducing excessive daytime sleepiness (EDS). We analyzed epidemiological data for an authentic representative sample of the Japanese population.

Methods: Data obtained from 24,686 adults via a self-administered questionnaire completed in the Active Survey of Health and Welfare 2000 were used for analyses. The prevalence of individual nPSM practices was calculated by gender. Subsequently, the associations between such practices and EDS were examined using logistic regression analyses.

Results: "Having a bath" was the most prevalent nPSM practice for both men (59.0%) and women (64.4%), followed by "maintaining a regular schedule" (men: 49.0%, women: 58.6%), "reading or listening to music" (men: 43.4%, women: 49.4%), "snacking on food and/or beverages" (men: 36.1%, women: 27.9%), and "exercising" (men: 26.2%, women: 29.4%). The prevalence of "maintaining a regular schedule" increased with age. Multiple logistic regression analyses revealed that having a bath and maintaining a regular schedule had negative associations with EDS, whereas snacking on food and/or beverages had a positive association.

Conclusions: Having a bath and maintaining a regular schedule were identified as favorable nPSM practices for reducing EDS, whereas snacking on food and/or beverages was considered to be an unfavorable nPSM practice.

Keywords: Self-management, sleep, Japan, epidemiology, excessive daytime sleepiness, prevalence

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Sleep disturbance is known to be associated with the onset of mental disorders such as depression. It is also well known that sleep disturbance is an eventual risk factor for various somatic disorders such as diabetes mellitus, obesity, and cardiovascular disease.[1-5] In addition, excessive daytime sleepiness (EDS) resulting from sleep disturbance may lead to industrial and traffic accidents.[6-8] Thus, in developed countries, employing pertinent measures to prevent sleep disturbance is widely recognized as an important issue in promoting industrial hygiene and public health.

People in general use various non-pharmacological self-management (nPSM) strategies to obtain good sleep. However, most previous studies have focused on so-called pharmacological management practices such as the use of alcohol or hypnotic medications, and many epidemiological findings regarding such practices have been reported. For example, a study in the US reported that the prevalence of using hypnotic medications to improve the quality and quantity of sleep ranged from 10% to 18%, while that of consuming alcohol ranged from 10% to 13%, with the use of hypnotic medications being more prevalent among women and the consumption of alcoholic beverages more prevalent among men.[9] A study in Japan obtained similar findings with respect to the use of hypnotics (women: 5.9%, men: 4.3%),[10] and to the larger proportion of men consuming alcoholic beverages to induce sleep one or more times a week compared to women (48.3% and 18.3%, respectively).[10] Although physiological data associated with nPSM practices such as exercising, having a bath, reading, or snacking on food and/or beverages have been reported, few findings of epidemiological studies are available. In a survey of self-management practices employed by Americans to obtain sleep, Ancoli-Israel et al. found that the prevalence of exercising was higher among non-insomniacs than among insomniacs.[9] Morin et al. conducted a similar study of Americans and reported that the prevalence of reading was the highest, followed by listening to music.[11] However, no epidemiological study of nPSM practices for obtaining good sleep has been conducted in any Asian

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country to date. Therefore, in this study, we examined nPSM practices employed by the Japanese by examining data from an authentic, substantially large, representative sample of the Japanese population. We also analyzed the associations between each nPSM practice and EDS in order to identify those nPSM practices reported to be most effective.

METHODS

Selection of Participants

The present study was part of a national survey (Active Survey of Health and Welfare) organized by the Statistics and Information Department of the Ministry of Health, Labour and Welfare of Japan. This national survey was planned in order to collect basic information on health and welfare, and included questions concerning symptoms of depression and sleep. The survey was conducted through health centers across Japan.

The survey was administered to subjects from 300 census precincts in Japan selected randomly from among some 824,000 precincts, which had been apportioned for equal population size. Each census precinct was numbered from north to south, and 300 precincts were selected by choosing precinct numbers at certain intervals. As a result, the sample represented the entire country. A health center with jurisdiction for each precinct was designated. Investigators sent by these health centers visited all households to distribute the questionnaires, and collected them a few days later. The survey targets were all individuals aged 12 years or older in the 300 sampled precincts. The survey was conducted simultaneously throughout Japan in June 2000. Oral informed consent was obtained from the participants, and their privacy was protected in accordance with Declaration of Helsinki guidelines.

Measures

A self-administered questionnaire was devised by 2 of the authors (M.U. and T.O.) together with an appropriate official of the Ministry of Health, Labour and Welfare. The questionnaire comprised 44 items, including items on (1) sociodemographic information such as age, gender, and community size; (2) general health status; (3) physical and psychological complaints; (4) information on mental stress; and (5) sleep habits and sleep problems, as well as (6) the Japanese version of the Center for Epidemiologic Studies Depression Scale (CES-D). The CES-D, which is a 20-item inventory designed specifically to assess symptoms of depression in the general population, was used to screen for current depressive states during the one week leading up to the survey. This questionnaire is adequately reliable and valid for use in a general population. The CES-D yields an item score (range, 0–3) and the sum of the 20-item scores (range 0–60). Higher scores indicate increasing severity of depressive symptoms. Although this scale is designed to screen, but not diagnose, major depression, a score $\geq$ 16 is highly suggestive of depressive symptoms. Shima et al. developed the Japanese version of the CES-D, examined its reliability and validity, and recommended that the cut-off point be set at 16, as is the case for the American version of the CES-D.[12]

The following questions regarding sleep experienced during the previous month (listed here followed by the variables they targeted) were embedded in the questionnaire:

Question: Did you indulge in any of the following practices in the past month in order to sleep efficiently?

(1) I consumed alcoholic beverages. [1 = No; 2 = 1-2 times a month; 3 = 1-2 times a week; 4 = 3 or more times a week]
(2) I used medications such as hypnotic drugs. [1 = No; 2 = 1-2 times a month; 3 = 1-2 times a week, 4 = 3 or more times a week]
(3) I snacked on food and/or beverages. [1 = No; 2 = Yes]
(4) I performed light exercise. [1. No, 2. Yes]
(5) I had a bath. [1. No, 2. Yes]
(6) I read or listened to music. [1. No, 2. Yes]
(7) I tried to maintain a regular schedule. [1. No, 2. Yes]

With regard to (1) and (2), participants who consumed alcohol and who used medications one or more times a week were categorized as participants who "consumed alcohol" and "used medication," respectively.

With regard to sleep duration, we posed the question, "What was your average sleep duration per night?" Those who answered "less than 6 hours" were categorized as participants with "short sleep duration."

For subjective sleep insufficiency, participants were asked to respond to the question, "Have you had sufficiently restful sleep?" by selecting one of the following 4 options: "Sufficient," "Fairly sufficient," "Rather insufficient," and "Completely insufficient." Those who selected the latter 2 options were categorized as participants with "subjective insufficient sleep".

For excessive daytime sleepiness, we posed the question, "Have you experienced any difficulty in staying awake at times when you should not fall asleep (e.g., while you are driving)?" Those who responded affirmatively were classed as participants with "excessive daytime sleepiness."

Statistical Analyses

Questionnaires were returned by 32,729 participants. The Ministry of Health, Labour and Welfare did not publish the number of residences contacted in the target communities, and therefore the return rate could not be calculated. However, the collection rates of similar investigations carried out 3, 4, and 6 years previously were 87.1%, 89.6%, and 87.3%, respectively. It can be assumed that since the present study was performed using similar methods, the collection rate is likely to have been similar to the previous investigations. The Minister of Health, Labour and Welfare granted permission for us to use the survey data. Before analysis, 707 participants who submitted blank answer forms were excluded from the study. Participants under 20 years of age (N = 3086) were also excluded since this study was aimed at adults. In addition, participants who had not responded to the questions on gender and/or age were excluded (N = 222), as were participants who omitted 6 or more answers on the CES-D (N = 4028). Thus, data for a total of 24,686 participants (11,752 men and 12,934 women) were analyzed statistically.

For statistical analysis, the prevalence of each nPSM practice (snacking on food and/or beverages, exercising, having a bath, reading or listening to music, and maintaining a regular schedule) used as a sleep aid was calculated by gender and by age class. The significance of the categorical data, such as the prevalence of each nPSM strategy used as a sleep aid, was analyzed using the χ^2 test. Finally, logistic regression analyses were conducted to examine the factors associated with EDS by using 4 models with different adjustment factors. Model 1 was nonadjustable. Model 2 was adjustable, using gender, age class, place of residence, and severity of depression as covariates. In Model 3, short sleep duration and subjective insufficient sleep were added to the covariates of Model 2. In Model 4, consumption of alcohol and use of medication were further added to the covariates of Model 3.

Odds ratios were calculated from the univariate and multivariate logistic regression analyses with 95% confidence intervals. All analyses were performed using SPSS 12.0 for Windows (SPSS Inc., Chicago, IL)

RESULTS

Characteristics of the Participants

The demographic characteristics of the total 24,686 participants are shown in Table 1. Although the percentages of the men and women aged 70 years or older are slightly lower than those revealed by the census, the percentages of other groups are similar.

Prevalence of Non-pharmacological Self-management Practices

The prevalence of each of the 5 nPSM practices classified by gender is shown in Table 2; the prevalence of "having a bath" was highest among both men (59.0%) and women (64.4%), followed by "maintaining a regular schedule" (men: 49.0%, women: 58.6%), "reading or listening to music" (men: 43.4%, women: 49.4%), "snacking on food and/or beverages" (men: 36.1%, women: 27.9%) and "exercising" (men: 26.2%, women: 29.4%). For all the nPSM practices, age-related differences were identified among both men and women ($p < 0.001$). In particular, the prevalence of maintaining a regular schedule increased with age, with respective prevalence in men and women in their 20s at 35.6% and 46.1% compared with that in men and women in their 70s at 68.1% and 69.8%. In terms of gender-based differences, the prevalence of snacking on food and/or beverages was significantly higher among men than women ($p < 0.001$). However, the prevalences of other nPSM practices were significantly higher among women than men ($p < 0.001$).

Table 1—Demographic Characteristics of Analyzed Subjects in a Sample of the Japanese Adult General Population (N = 24,686)[a]

	Percentage in Age Group					
Data Set	**20-29 y**	**30-39 y**	**40-49 y**	**50-59 y**	**60-69 y**	**70+ y**
Present study						
Male (N = 11,752)	18	18	19	21	15	9
Female (N = 12,934)	18	18	18	20	14	12
Census						
Male	19	18	17	20	15	12
Female	17	16	16	19	15	17

[a]Data for both the present study and the census were obtained in 2000.

Table 2—Non-Pharmacological Self-Management by Gender and Age Expressed as Percentage

Age, y	N	Snacking on food and/or beverage,%	Exercising,%	Having a bath,%	Reading or listening to music,%	Maintaining a regular schedule,%
Male						
20-29	2151	35.8	26.1	50.7	55.5	35.6
30-39	2157	36.5	21.0	50.1	41.9	38.3
40-49	2251	39.6	25.2	58.9	37.7	49.1
50-59	2468	40.4	29.4	69.5	40.3	59.3
60-69	1712	29.8	31.8	69.1	39.2	64.3
70+	1013	23.0	27.6	66.4	40.0	68.1
Total	11752	36.1	26.2	59.0	43.4	49.0
Sig.1		$\chi^2 = 69.07$*	$\chi^2 = 45.84$*	$\chi^2 = 229.35$*	$\chi^2 = 141.36$*	$\chi^2 = 431.76$*
Female						
20-29	2329	28.8	26.7	56.7	56.5	46.1
30-39	2362	29.3	25.4	55.9	47.0	53.5
40-49	2368	31.4	30.9	69.4	50.0	61.0
50-59	2592	29.2	34.8	74.9	50.0	66.4
60-69	1766	21.1	37.4	68.9	49.7	65.8
70+	1517	20.2	23.3	64.5	35.4	69.8
Total	12934	27.9	29.4	64.4	49.4	58.6
Sig.1		$\chi^2 = 58.69$*	$\chi^2 = 87.67$*	$\chi^2 = 220.92$*	$\chi^2 = 113.49$*	$\chi^2 = 260.20$*
Sig.2		$\chi^2 = 127.85$*	$\chi^2 = 21.77$*	$\chi^2 = 52.75$*	$\chi^2 = 60.65$*	$\chi^2 = 160.15$*

Sig.1: χ^2 test, 2 (Each non-pharmacological self-management-Yes or No; Snacking on food and/or beverage, Exercising, Having a bath, Reading or listening to music and Maintaining a regular schedule) × 6 (age effect; 20-29, 30-39, 40-49, 50-59, 60-69, 70+)
Sig.2: χ^2 test, 2 (Each non-pharmacological self-management-Yes or No; Snacking on food and/or beverage, Exercising, Having a bath, Reading or listening to music and Maintaining a regular schedule) × 2 (gender effect; male, female)
*$p < 0.001$

Table 3—Logistic Regression Results for Prediction of Excessive Daytime Sleepiness (EDS) Among the General Adult Population (N = 24,686)

	Prevalence of EDS (%)	Model 1			Model 2			Model 3			Model 4		
		Crude OR	95% CI	P-value	Adjusted OR	95% CI	P-value	Adjusted OR	95% CI	P-value	Adjusted OR	95% CI	P-value
Snacking on food and/or beverage													
No	2.7												
Yes	4.0	1.50	1.26-1.80	< 0.01	1.36	1.11-1.67	< 0.01	1.34	1.09-1.65	0.01	1.42	1.15-1.76	< 0.01
Exercising													
No	3.1												
Yes	3.1	1.00	0.82-1.21	0.96	1.08	0.86-1.37	0.50	1.11	0.88-1.41	0.37	1.15	0.90-1.45	0.26
Having a bath													
No	3.6												
Yes	2.8	0.77	0.65-0.92	< 0.01	0.76	0.61-0.94	0.01	0.75	0.61-0.93	0.01	0.76	0.61-0.95	0.01
Reading or listening to music													
No	2.9												
Yes	3.4	1.20	1.01-1.42	0.04	1.17	0.95-1.44	0.13	1.13	0.92-1.39	0.24	1.12	0.91-1.38	0.28
Maintaining a regular schedule													
No	4.0												
Yes	2.2	0.54	0.45-0.64	< 0.01	0.62	0.51-0.77	< 0.01	0.71	0.57-0.88	< 0.01	0.71	0.57-0.88	< 0.01

Other Adjustment factors
Model 1: non-adjustment.
Model 2: sex, age, size of community and depression status.
Model 3: sex, age, size of community, depressive status, short sleep duration and subjective insufficient sleep.
Model 4: sex, age, size of community, depressive status, short sleep duration, subjective insufficient sleep, alcohol use and hypnotic medication use.
OR: odds ratio
CI: confidence interval

Logistic Regression Analyses

The results of the logistic regression analyses are shown in Table 3. In Model 1, snacking on food and/or beverages and reading or listening to music showed significant positive associations with EDS. In contrast, having a bath and maintaining a regular schedule showed significant negative associations with EDS. In Models 2-4, reading or listening to music showed no association with EDS, and snacking on food and/or beverages showed a positive association, while having a bath and maintaining a regular schedule showed negative associations with EDS.

DISCUSSION

In the present study, we examined the prevalence of nPSM practices to obtain good sleep and the associations between each nPSM practice and EDS. This study was of epidemiological significance in that the participants were randomly selected from a nationwide population and the sample size was large. In effect, the age structure of the participants (shown in Table 1) was very close to that found in the national census, which had been conducted during the same period. This indicates that the study population represents the general population of Japan. To our knowledge, no similar epidemiological study has been reported to date.

Among the nPSM practices examined in this study, the prevalence of having a bath was highest among both men and women, followed by maintaining a regular schedule. In the U.S., Ancoli-Israel et al. found that the prevalence of exercising was highest (75%) among three nPSM practices in subjects without sleep disturbance, followed by reading (9%) and relaxing.[9] The survey of Morin et al. of the general population in Canada demonstrated that among reading, receiving acupuncture, getting a massage, relaxing, and listening to music, the prevalence of reading was highest (32.5%), followed by listening to music (25.2%).[11] In the present study, exercising and reading were included among the choices of nPSM practices, although the prevalence of exercising (approximately 30%) was the lowest among the 5 practices. Exercising and reading were actively adopted as self-management practices for sleeping by participants in studies conducted outside Japan, and thus the selection of self-management practices for sleep appear to differ across countries. The practice of having a bath, the prevalence of which was the highest in the present study, was not an identified practice in the previous studies outside Japan. This may be attributable to the unique habit of the Japanese taking a nightly hot bath.

In the present study, the prevalence of maintaining a regular schedule increased with age, the highest prevalence being evident among participants in their 70s. This result coincides with those of previous studies conducted in the US.[13,14] It is inferred that with age, people tend to become more health conscious and prefer a good sleep at night and lively daytime activities.

In this study, we attempted to classify the examined nPSM practices into favorable and unfavorable types by calculating the odds ratios with regard to EDS. Given our findings, we propose the theory that by employing an nPSM practice showing a statistically and significantly low odds ratio with regard to EDS, a night-sleep problem could be resolved, in turn leading to a decrease in EDS. Moreover, we considered that such a practice would be a favorable one. Conversely, we considered an nPSM practice showing a significantly high odds ratio with regard to EDS could lead to a higher possibility of EDS, and hence would be an unfavorable nPSM. However, there may be cases where a person with a sleep disorder might employ an nPSM practice to prevent EDS, but not benefit from it. In such a scenario, the sleep disorder would be a confounding factor affecting the association between the nPSM practice and EDS. Furthermore, there may be other confounding factors besides sleep. Therefore, in this study, several logistic regression models were set up for inputting various covariates, including sleep duration and subjective sleep insufficiency, to adjust for the possible confounding factors. Despite this attempt, causal relationships can not be thoroughly discussed because this study was cross-sectional; however, since this study was conducted with an authentic, representative sample of the Japanese population, the results obtained may be beneficial for the design of future public health measures for achieving good sleep.

In relation to the above-mentioned theory, the results indicate that having a bath and maintaining a regular schedule are favorable nPSM practices, and that snacking on food and/or beverages is an unfavorable nPSM practice. These results are supported by those of other previous physiological studies. It has been reported that having a bath not only leads to an increase in body temperature, but also stimulates the thermoregulatory center, which promotes the lowering of body temperature and induces slow wave sleep.[15,16] Having a bath is also reported to shorten significantly subjective and objective sleep latency and wake time after sleep onset, and increase the duration of slow wave sleep.[17-19] A previous study revealed that greater distal vasodilatation, as indicated by the distal-proximal skin temperature gradient, could predict shorter sleep latency in healthy subjects.[20] Moreover, Pache et al. have reported that patients with vasospastic syndrome suffer prolonged sleep onset latency due to impaired capacity for distal vasodilation.[21,22] Furthermore, it has been reported that subjective sleep sufficiency is better in individuals when they take a bath before going to bed than when they do not.[19] Based on the results of these physiological studies, it is inferred that "having a bath" is a favorable nPSM practice that could improve the quality of night sleep and reduce EDS.

Although it is difficult to define maintaining a regular schedule, this practice would include waking up at a regular time in the morning, performing specific activities at specific times, and not staying up late at night. For an individual who has adopted this practice, the sleep-wakefulness rhythm related to daytime activities and rest at night is maintained. In addition to this sleep-wakefulness rhythm, biodynamic rhythms such as autonomic rhythms (including periodic changes in body temperature and blood pressure) and endocrinological rhythms (including the melatonin and cortisol secretory cycles) are maintained in an orderly manner.[23] However, when a person's schedule is irregular, these biodynamic rhythms are disrupted, ultimately affecting sleep.[13,24-26] Monk et al. reported that the quality of sleep was lower in individuals with irregular schedules than in those with regular schedules.[13,24] Manber et al. also reported that subjects who maintained a regular daily rhythm for 4 weeks showed improvement in their night sleep and significant reduction of subjective daytime sleepiness, as compared with controls who had irregular rhythyms.[25] The results of these previous studies are in accord with those of the present study, in which the odds ratio of maintaining a regular schedule with regard to EDS was low. Hence, these previous results support our theory that maintaining a regular schedule is a favorable nPSM practice.

In this study, we noted a significantly high odds ratio for snacking on food and/or beverages with regard to EDS, suggesting that it was an unfavorable nPSM practice. A previous epidemiological study reported that irregular eating habits and subjective sleep insufficiency were closely associated,[27] and eating before going to bed was reported elsewhere to activate the digestive system and impede the body and brain from preparing to have a good rest; thus, this practice eventually hampered good sleep.[28] Therefore, the practice of snacking on food and/or beverages may actually lead to hampered sleep and consequently induce EDS.

The results of the present study provide suggestions on the appropriate self-management practices that should be employed for obtaining good sleep and preventing EDS. Performing such favorable self-management practices is vital for preventing various mental and somatic disorders since sleep disturbance is a risk factor for such disorders. Therefore, the identification of such favorable and unfavorable self-management practices in this study will contribute not only to the prevention of EDS, but also to the planning of public health policies and measures.

This study had a few limitations. First, because the study was cross-sectional, a causal relationship could not be established. A follow-up study will be required to verify the results. Second, excessive sleepiness was evaluated by only one questionnaire item. In our future studies we plan to use epidemiological tools such as the Epworth Sleepiness Scale. Third, all data used were subjective and obtained from a self-administered questionnaire. Because we preferred data accumulation from a larger number of participants nationwide, physiological measurements could not be obtained. However, several studies have reported that self-reported data on sleeping habits coincide with physiological data to a certain extent.[29,30] Fourth, due to the limitation of space on our self-administered questionnaire, we could not adopt the social demographic items of confounding factors such as marital status, education, occupation, and income, and these remain the subject for further study.

To conclude, having a bath and maintaining a regular schedule appear to be favorable nPSM practices for obtaining good sleep, while snacking on food and/or beverages is an unfavorable practice, findings which can contribute to the planning of public health measures with respect to sleep.

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DISCLOSURE STATEMENT

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Associations of Usual Sleep Duration with Serum Lipid and Lipoprotein Levels

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Study Objectives: We examined the individual association between sleep duration and a high serum triglyceride, low HDL cholesterol, or high LDL cholesterol level.

Design and Setting: The present study analyzed data from the National Health and Nutrition Survey that was conducted in November 2003 by the Japanese Ministry of Health, Labour and Welfare. This survey was conducted on residents in the districts selected randomly from all over Japan.

Participants: The subjects included in the statistical analysis were 1,666 men and 2,329 women aged 20 years or older.

Intervention: N/A

Measurements and Results: Among women, both short and long sleep durations are associated with a high serum triglyceride level or a low HDL cholesterol level. Compared with women sleeping 6 to 7 h, the relative risk of a high triglyceride level among women sleeping <5 h was 1.51 (95% CI, 0.96-2.35), and among women sleeping ≥8 h was 1.45 (95% CI, 1.00-2.11); the relative risk of a low HDL cholesterol level among women sleeping <5 h was 5.85 (95% CI, 2.29-14.94), and among women sleeping ≥8 h was 4.27 (95% CI, 1.88-9.72). On the other hand, it was observed that the risk of a high LDL cholesterol level was lower among men sleeping ≥8 h. These analyses were adjusted for the following items: age, blood pressure, body mass index, plasma glucose level, smoking habit, alcohol consumption, dietary habits, psychological stress, and taking cholesterol-lowering medications.

Conclusions: Usual sleep duration is closely associated with serum lipid and lipoprotein levels.

Keywords: Dyslipidemia; triglyceride; high density lipoprotein cholesterol; low density lipoprotein cholesterol; sleep duration

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IN THE LATE 1960S, IT WAS REVEALED THAT SHORTER OR LONGER SLEEP DURATION RESULTED IN AN INCREASED RISK OF MORTALITY IN HUMANS, AND that there was a U-shaped association between sleep duration and mortality risk.[1] Subsequently, several large-scale studies demonstrated similar findings.[2-4] In recent years, U-shaped associations have been demonstrated between sleep duration and morbidity risk for diabetes mellitus,[5-7] obesity,[8] hypertension,[9] coronary heart disease (CHD),[10] and atherosclerosis.[11] It has been increasingly recognized that sleep habits, along with other lifestyle habits, such as eating, exercising, smoking, and drinking, are potential risk factors for diabetes mellitus, obesity, hypertension, and cardiovascular disease (CVD).

Dyslipidemia, such as an increase in the level of triglyceride, a decrease in the level of high-density-lipoprotein (HDL) cholesterol, and an increase in the level of low-density-lipoprotein (LDL) cholesterol, increases the risk of CVD morbidity.[12-14] In order to prevent CVD, it is important to identify and change lifestyles that are associated with serum triglyceride, HDL cholesterol or LDL cholesterol level. It is well known that these serum lipid and lipoprotein levels are strongly influenced by lifestyles. Smoking decreases the level of HDL cholesterol and increases the level of triglyceride in blood, whereas alcohol consumption increases the levels of both.[15] Exercise increases the HDL cholesterol level and decreases the triglyceride level in blood.[15] In addition, alcohol consumption is reported to decrease the level of LDL cholesterol.[16,17]

In 1999, Nakanishi et al. indicated that there was no significant association between sleep duration and serum lipid and lipoprotein levels among men.[18] However, their sample was comprised of male office workers from a single company and these findings cannot reasonably be extrapolated to the general Japanese population. To clarify this issue, the present study examined the individual associations of sleep duration with the levels of serum triglyceride, HDL cholesterol and LDL cholesterol.

METHODS

Study Subjects and Data Collection

The present study was performed using data collected by the National Health and Nutrition Survey that was conducted in November 2003 by the Japanese Ministry of Health, Labour and Welfare. The National Health and Nutrition Survey is a cross-sectional survey that is conducted annually in order to obtain epidemiological data for national health promotion.[19] The subjects of this national survey comprised approximately 15,000 residents aged 1 year or more in the 300 districts randomly selected from the national census unit districts.

The survey comprised three parts: (1) examination of physical status, (2) dietary intake survey, and (3) questionnaire on lifestyles. Actual data collection was performed by the staff of the local public health centers that exercised jurisdiction over the selected districts.

Disclosure Statement

This was not an industry supported study. The authors have indicated no financial conflicts of interest.

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For the physical status examination, the subjects were invited to public facilities within the districts. The heights and weights of all the participants aged 1 year or older, abdominal circumference, and blood pressure of all participants aged 15 years or older were measured. In addition, participants aged 20 years or older were interviewed with regard to any medications taken on a regular basis, and blood samples were taken from each subject for subsequent analysis.

For dietary assessment, the staff of the public health centers visited the subjects' households, distributed the recording sheets, and explained how to complete them. The subjects were requested to record the name and amount of all food consumed by each household member aged 1 year or older on a selected weekday.

The lifestyle questionnaire, which was self-administered, was issued to all participants older than 15 years of age, with instructions on how to complete it. The lifestyle questionnaire included items related to diet, smoking, drinking, exercise, sleep, and dental hygiene. When the staff of the public health centers visited the subjects' households, the subjects were informed of the due consideration given to confidentiality of all personal data based on the Health Promotion Law.

Measures and Definitions

According to criteria determined by the Japan Society for the Study of Obesity, a BMI of 25 kg/m^2 or higher was considered to indicate overweight.[20] Before recording the blood pressure, activities that might potentially affect the blood pressure readings (blood sampling, exercise, eating, and smoking) were prohibited. Each participant was instructed to urinate prior to recording the blood pressure. After 5 min of rest, blood pressure was measured in the right upper arm with the participant seated on a chair. Blood pressure was measured twice with an interval of 1 minute between the 2 measurements, and the 2 measurements were used for statistical analyses.

In accordance with criteria determined by the World Health Organization, International Society of Hypertension, and Japanese Society of Hypertension, a mean systolic blood pressure of 140 mm Hg or higher or a mean diastolic blood pressure of 90 mm Hg or higher was considered to indicate hypertension.

Blood tests included the following items: white blood cell count, red blood cell count, platelet count, hemoglobin concentration, ferritin level, total protein level, albumin level, total cholesterol level, HDL cholesterol level, triglyceride level, glucose level, and hemoglobin A1c level. The serum triglyceride and HDL cholesterol levels were measured using the enzyme and direct methods, respectively. In the participants whose serum triglyceride level was lower than 400 mg/dL, the level of LDL cholesterol was calculated from total cholesterol, HDL cholesterol and triglyceride levels using Friedewald's formula.[21] The serum triglyceride level was 400 mg/dL or more in 93 participants (2.3%), and we excluded cases showing this value from statistical analysis involving LDL cholesterol. In accordance with the criteria determined by the Japan Atherosclerosis Society, a serum triglyceride level $\geq$150 mg/dL was considered to be high, an HDL cholesterol level <40 mg/dL was defined as low, and an LDL cholesterol level $\geq$140 mg/dL was considered to be high. Furthermore, in accordance with the criteria determined by the Japan Diabetes Society, a fasting glucose level $\geq$126 mg/dL was considered to represent hyperglycemia.

The questionnaire on lifestyles included the question: "What was your daily average sleep duration during the past month?" The 6 options provided as responses to this question were: (a) less than 5 h, (b) 5 h or more but less than 6 h, (c) 6 h or more but less than 7 h, (d) 7 h or more but less than 8 h, (e) 8 h or more but less than 9 h, and (f) 9 h or more. Categories (e) and (f) were integrated for the purpose of statistical analysis. Subjects who answered "every day" and "sometimes" to the question "Do you smoke currently? (*within one month*)" were categorized as current smokers. Those who answered "3 days or more per week" to the question "How many days per week do you consume alcoholic beverages?" were categorized as habitual drinkers. Those who had exercised twice or more per week for $\geq$30 min over the past one year or more were categorized as habitual exercisers. Questions regarding the frequencies of skipping meals, eating between meals, and eating out were asked separately. If the frequency of any of the above eating patterns was once or more per week, it was considered to be a habit. The questionnaire also included a question on psychological stress levels. To the question "Have you felt stress caused by dissatisfaction, worries, or troubles during the past month?" the following 4 options were provided: definitely, occasionally, not much, and never. The participants who selected "definitely" as the answer to this question were regarded as those "Definitely feeling psychological stress."

Statistical Analyses

After seeking permission from the Ministry of Health, Labour and Welfare, we performed statistical analysis of the anonymized dataset obtained from the National Health and Nutrition Survey.

A total of 11,630 individuals participated in at least one of the three parts of the National Health and Nutrition Survey, and the response rate was approximately 77.5%. Of these participants, the following were sequentially excluded from the dataset; those aged 20 years or younger (2,199); those who did not participate in a blood test (4,124); pregnant women or women who had given birth in the last 6 months (43); those from whom blood was collected within 4 h after a meal (1,234); those for whom the serum triglyceride and HDL cholesterol levels could not be measured due to technical errors such as an insufficient quantity of collected blood (8); and those who did not answer the question on sleep duration (27). The data for the remaining 3,995 cases (men: 1,666, women: 2,329) were used for statistical analyses.

All statistical analyses were conducted separately by gender. Unadjusted differences in continuous and categorical variables across sleep duration categories were assessed for significance using single-factor analysis of variance or contingency table analysis, as appropriate. Logistic regression analyses were conducted to assess the relation of usual sleep duration to a high triglyceride, low HDL cholesterol or high LDL cholesterol level, adjusting for relevant covariates. Covariates included in the model were age, blood pressure, BMI, fasting plasma glucose level, smoking habit, alcohol consumption, dietary habits, psychological stress, and taking cholesterol-lowering medications.

Table 1—Characteristics of the Male Participants According to Reported Usual Sleep Duration

Characteristic	Reported Usual Sleep Duration, h/night					P value
	<5	5 to <6	6 to <7	7 to <8	≥8	
No. of participants	70	318	596	455	227	
Age, y	52.7 (19.9)	52.4 (16.8)	53.6 (15.6)	56.3 (16.1)	64.1 (15.2)	<0.001
BMI	22.9 (3.2)	23.9 (3.5)	23.6 (3.1)	23.2 (3.2)	23.1 (3.4)	0.008
Systolic blood pressure, mm Hg	133.4 (17.1)	134.0 (21.3)	134.3 (19.6)	136.4 (19.1)	136.7 (18.1)	0.181
Diastolic blood pressure, mm Hg	78.5 (10.4)	81.3 (13.0)	82.2 (11.5)	82.7 (11.0)	80.6 (11.2)	0.015
Drinking alcohol ≥3 days/week, %	44.3	50.8	57.0	61.3	59.5	0.009
Current smoking, %	43.3	47.9	42.5	46.9	45.9	0.515
Exercising at least twice per week, %	40.0	28.6	29.8	29.3	29.2	0.433
Skipping meal ≥1 time/day, %	21.4	5.4	7.9	7.7	3.5	<0.001
Eating between meals ≥1 time/day, %	28.6	31.6	27.7	28.1	34.8	0.273
Eating out ≥1 time/day, %	22.9	12.6	9.7	5.5	2.6	<0.001
Definitely feeling psychological stress, %	37.1	18.6	9.2	7.0	4.0	<0.001
Fasting plasma glucose, mg/dL	101.6 (26.6)	104.8 (32.3)	104.5 (29.5)	108.8 (43.9)	112.6 (44.8)	0.021
Hemoglobin A1c, %	5.41 (0.97)	5.33 (0.78)	5.40 (0.86)	5.47 (1.07)	5.55 (1.03)	0.069
Triglyceride, mg/dL	134.5 (70.9)	159.0 (110.3)	155.3 (120.6)	157.7 (115.4)	141.7 (94.1)	0.198
HDL cholesterol, mg/dL	57.8 (16.2)	56.1 (14.6)	56.1 (14.4)	56.5 (15.7)	56.1 (15.6)	0.915
LDL cholesterol, mg/dL	109.0 (29.0)	113.1 (31.7)	116.4 (32.3)	112.7 (31.1)	107.2 (29.6)	0.004
Total cholesterol, mg/dL	193.7 (33.9)	199.5 (34.2)	202.1 (37.0)	199.3 (33.4)	191.8 (35.2)	0.003

Data are presented as mean (SD) or percentages.
Significance tests for the unadjusted difference across categories of sleep duration are based on the contingency table analysis for categorical variables and single-factor analysis of variance for continuous variables.

Odds ratios were calculated from logistic regression analyses with 95% confidence intervals. Finally, participants who were taking cholesterol-lowering medications were excluded, and the same analyses as described above were performed. All analyses were performed using SPSS 12.0 for Windows.

RESULTS

Among men, the percentages of subjects who slept <6 h and ≥8 h per night were 23.3% and 13.6%, respectively. Among women, the corresponding percentages were 31.2% and 8.2%, respectively. The number of subjects with shorter sleep duration was greater for women than for men, and the number of subjects with longer sleep duration was smaller for women than for men ($P < 0.001$). The mean (standard deviation [SD]) serum triglyceride level was 153.9 (112.2) mg/dL for men and 123.2 (86.5) mg/dL for women, and was thus significantly higher among men ($P < 0.001$). The mean (SD) serum HDL cholesterol level was 56.3 (15.0) mg/dL for men and 64.8 (15.6) mg/dL for women, and was thus significantly lower among men ($P < 0.001$). The mean (SD) serum LDL cholesterol level was 113.2 (31.5) mg/dL for men and 118.6 (32.0) mg/dL for women, and was thus significantly higher among women ($P < 0.001$). The prevalence of a high triglyceride level was 36.5% among men and 24.0% among women, and was thus significantly higher among men ($P < 0.001$). The prevalence of a low HDL cholesterol level was 12.1% among men and 3.4% among women, and was thus significantly higher among men ($P < 0.001$). The prevalence of a high LDL cholesterol level was 17.6% among men and 23.9% among women, and was thus significantly higher among women ($P < 0.001$).

Among men with shorter sleep duration, the number of men who answered that they skipped meals or ate out once or more per day was observed to be high (Table 1). Additionally, a high number of men in this group answered that they experienced high levels of psychological stress. A significant association was observed between serum LDL cholesterol levels and sleep duration among men. The mean serum LDL cholesterol level of those who slept ≥8 h was approximately 9.2 mg/dL lower than that of those who slept for 6 to 7 h. Among men, there were no evident significant associations between sleep duration and serum triglyceride or serum HDL cholesterol level.

Similarly, among women with shorter sleep duration, the number of subjects who skipped meals, ate out, or experienced heavy psychological stress was large (Table 2). The mean serum triglyceride level was lowest in women who slept 6 to 7 h and

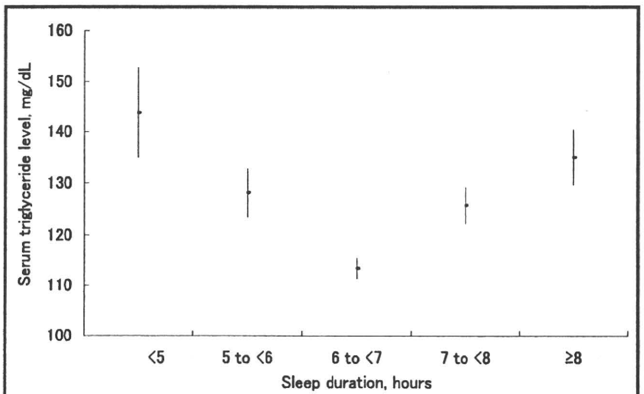

Figure 1—The relationship between serum triglyceride level and sleep duration. The mean value (point) and standard error (bar) of the serum triglyceride level for different sleep duration groups are shown. A U-shaped association is observed between serum triglyceride level and sleep duration.

Table 2—Characteristics of the Female Participants According to Reported Usual Sleep Duration

Characteristic	Reported Usual Sleep Duration, h/night					P value
	<5	5 to <6	6 to <7	7 to <8	≥8	
No. of participants	125	601	919	493	191	
Age, y	56.6 (16.7)	53.2 (15.1)	53.2 (15.3)	57.1 (17.2)	65.0 (16.9)	<0.001
BMI	23.3 (4.2)	22.8 (3.6)	22.7 (3.4)	22.8 (3.3)	22.6 (3.6)	0.457
Systolic blood pressure, mm Hg	133.9 (21.7)	128.4 (20.7)	128.6 (20.6)	131.0 (22.0)	134.9 (19.3)	<0.001
Diastolic blood pressure, mm Hg	77.9 (11.6)	76.8 (11.4)	77.5 (11.2)	77.2 (12.1)	77.9 (12.0)	0.691
Drinking alcohol ≥3 days/week, %	8.0	15.5	15.3	12.4	13.1	0.127
Current smoking, %	12.8	12.5	10.2	6.9	7.9	0.023
Exercising at least twice per week, %	21.8	26.1	25.5	25.3	20.6	0.535
Skipping meal ≥1 time/day, %	11.2	3.7	4.0	4.3	6.8	0.002
Eating between meals ≥1 time/day, %	40.8	52.8	49.0	47.6	52.9	0.086
Eating out ≥1 time/day, %	5.6	4.3	2.1	1.6	0.5	0.001
Definitely feeling psychological stress, %	29.6	18.1	11.6	7.3	4.7	<0.001
Fasting plasma glucose, mg/dL	105.0 (35.0)	103.3 (25.3)	102.2 (26.3)	104.7 (25.7)	110.9 (36.9)	0.002
Hemoglobin A1c, %	5.39 (0.72)	5.34 (0.77)	5.30 (0.74)	5.34 (0.68)	5.39 (0.83)	0.427
Triglyceride, mg/dL	143.9 (100.0)	128.1 (115.7)	113.4 (66.0)	125.8 (77.2)	135.0 (74.1)	<0.001
HDL cholesterol, mg/dL	63.2 (17.4)	65.3 (16.2)	66.3 (14.8)	63.4 (15.5)	60.2 (15.4)	<0.001
LDL cholesterol, mg/dL	117.4 (31.4)	116.7 (31.8)	118.1 (32.3)	120.7 (31.4)	122.6 (32.9)	0.114
Total cholesterol, mg/dL	209.6 (38.4)	207.0 (37.1)	207.1 (35.9)	208.8 (34.8)	209.5 (34.5)	0.770

Data are presented as mean (SD) or percentages.
Significance tests for the unadjusted difference across categories of sleep duration are based on the contingency table analysis for categorical variables and single-factor analysis of variance for continuous variables.

became higher as the sleep duration became shorter than 6 h or longer than 7 h. Compared with those who slept for 6 to 7 h, the mean serum triglyceride level in those who slept <5 h, and in those who slept ≥8 h, was approximately 30.5 mg/dL and 21.6 mg/dL higher, respectively. Thus, a U-shaped association was observed between sleep duration and serum triglyceride level (Figure 1). In contrast, the mean serum HDL cholesterol level was highest for sleep durations of 6 to 7 h, and became lower as the sleep duration became shorter than 6 h or longer than 7 h. Compared with those who slept for 6 to 7 h, the mean serum HDL cholesterol level in those who slept <5 h, and in those who slept ≥8 h was approximately 3.1 mg/dL and 6.1 mg/dL lower, respectively. Thus, an inverted U-shaped association was

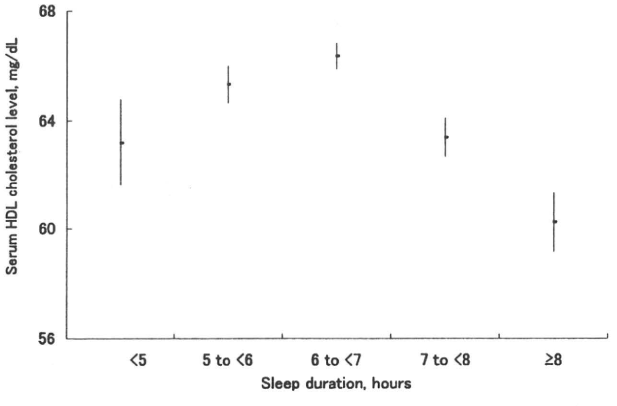

Figure 2—The relationship between serum HDL cholesterol level and sleep duration. The mean value (point) and standard error (bar) of serum HDL cholesterol level for different sleep duration groups are shown. An inverted U-shaped association is observed between serum HDL cholesterol level and sleep duration.

observed (Figure 2). Furthermore, U-shaped associations were observed between sleep duration and systolic blood pressure, and sleep duration and fasting plasma glucose. Among women, there was no significant association between sleep duration and serum LDL cholesterol level.

Among women, both univariate and multivariate logistic models showed statistically significant associations between sleep duration and a high triglyceride level and sleep duration and a low HDL cholesterol level (Table 3). Both the associations were U-shaped. The ORs for a high triglyceride and a low HDL cholesterol levels were the lowest for sleep durations of 6 to 7 h and became higher as the sleep duration became shorter or longer than 6 to 7 h. Among men, no statistically significant association was observed between sleep duration and a high triglyceride level, or sleep duration and a low HDL cholesterol level.

A significant association was observed among men with regard to LDL cholesterol level and sleep duration. Specifically, the OR with regard to a high LDL cholesterol level among those who slept ≥8 h was significantly lower than for those who slept for 6 to 7 h. On the other hand, there was no significant association between sleep duration and LDL cholesterol level among women.

Finally, 370 participants (9.3%) who took cholesterol-lowering medications were excluded, and the same analyses as those described above were performed. There were no substantial differences between the results of those analyses and the above-mentioned analyses.

DISCUSSION

In the present study, we found U-shaped associations between sleep duration and a high triglyceride or a low HDL cho-

Table 3—Odds Ratios for Dyslipidemia by Reported Sleep Duration

Reported Usual Sleep Duration, h/night	High triglyceride Crude odds ratio	95% CI	P value	Adjusted odds ratio*	95% CI	P value
Male			0.364			0.229
<5	1.02	0.61-1.71		1.52	0.85-2.70	
5 to <6	1.25	0.95-1.66		1.36	1.00-1.84	
6 to <7	1.00	referent		1.00	referent	
7 to <8	1.10	0.85-1.41		1.24	0.94-1.63	
≥8	0.89	0.64-1.23		1.09	0.76-1.56	
Female			<0.001			0.048
<5	1.82	1.21-2.75		1.51	0.96-2.35	
5 to <6	1.41	1.10-1.80		1.42	1.09-1.84	
6 to <7	1.00	referent		1.00	referent	
7 to <8	1.28	0.98-1.66		1.15	0.87-1.53	
≥8	1.98	1.41-2.79		1.45	1.00-2.11	
Reported Usual Sleep Duration, h/night	**Low HDL cholesterol**					
Male			0.951			0.694
<5	1.15	0.54-2.41		1.35	0.60-3.03	
5 to <6	1.02	0.67-1.57		0.95	0.60-1.50	
6 to <7	1.00	referent		1.00	referent	
7 to <8	1.16	0.80-1.68		1.19	0.80-1.77	
≥8	1.09	0.68-1.75		0.87	0.51-1.46	
Female			<0.001			0.001
<5	6.40	2.60-15.78		5.85	2.29-14.94	
5 to <6	3.14	1.51-6.52		3.25	1.55-6.85	
6 to <7	1.00	referent		1.00	referent	
7 to <8	3.86	1.85-8.02		3.15	1.49-6.65	
≥8	7.04	3.18-15.57		4.27	1.88-9.72	
Reported Usual Sleep Duration, h/night	**High LDL cholesterol**					
Male			0.005			0.048
<5	0.49	0.23-1.06		0.66	0.29-1.48	
5 to <6	0.90	0.64-1.28		0.91	0.62-1.31	
6 to <7	1.00	referent		1.00	referent	
7 to <8	0.80	0.59-1.11		0.80	0.57-1.13	
≥8	0.42	0.26-0.68		0.45	0.27-0.76	
Female			0.333			0.515
<5	1.28	0.84-1.96		1.24	0.78-1.97	
5 to <6	0.87	0.68-1.12		0.88	0.67-1.14	
6 to <7	1.00	referent		1.00	referent	
7 to <8	1.10	0.85-1.42		1.10	0.84-1.45	
≥8	1.11	0.78-1.59		0.98	0.66-1.45	

*Multivariate logistic regression analyses were conducted with adjustment for age, blood pressure, body mass index, fasting plasma glucose level, smoking habit, alcohol consumption, dining habits, psychological stress, and using anti-cholesterol medicine.

lesterol level among women. Using the data of a cohort study conducted on 71,617 women in the USA, Ayas et al. examined the associations between sleep duration and CHD.[10] They reported that the relative risk of CHD was significantly higher among those with shorter or longer sleep durations, and that the association was U-shaped.[10] Recently, in a study comprising 2,437 participants from the general population in Germany, Wolff et al. reported that the carotid intima-media thickness was greater among those with short and long sleep durations.[11] From these study results, it is suggested that both short and long sleep durations can be regarded as individual risk factors of CVDs such as CHD and atherosclerosis. Since an increase in the triglyceride level or a decrease in the HDL cholesterol level in blood are risk factors for the onset of CVD,[12-14] the present results are important for explaining the association between sleep duration and CVD. It is logical to consider that the incidence or prevalence of a high triglyceride or a low HDL cholesterol level are high among individuals with short and long sleep durations, predisposing them to a higher relative risk of CVD. There are associations between two of the three elements (sleep duration, dyslipidemia, and CVD) and each element can produce a confounding effect on the association between the other two elements. These associations must be examined individually in the future using a study design that can account for the confounding effects of all the above elements.

While we were preparing the present report, a study on the associations between sleep duration and dyslipidemia was published by another group.[22] Williams et al. examined the associations between sleep duration and biomarkers that could be risk factors for CVDs in 935 women with type 2 diabetes. They indicated that among the subjects whose blood pressure was within the normal range, the serum HDL cholesterol level was low among those with both short and long sleep durations. They stated that the result partially explained how sleep habit could become a risk factor for CVDs. A simple comparison between their study and ours is not warranted because in their study the subjects were limited to women with type 2 diabetes. However, the data are helpful for clarifying the associations between dyslipidemia and sleep duration, i.e., an inverted U-shaped association was observed between serum HDL cholesterol levels and sleep duration in both studies.

Recently, it has become increasingly clear that sleep has a strong influence on the metabolic hormones that regulate energy balance. Sleep restriction lowers the blood concentration of leptin, which acts to suppress appetite, and increases the blood concentration of ghrelin, which promotes appetite.[8,23-25] In addition, it is known that administration of leptin decreases serum triglyceride level.[26,27] In addition, it was recently reported that short sleep duration was associated with a reduced leptin level and being overweight.[28] Mechanisms such as a decrease in the blood concentration of leptin or an increase in the blood concentration of ghrelin due to sleep restriction may be involved in the biological mechanisms responsible for the associations between short sleep duration and dyslipidemia: associations that were observed among women.

Meanwhile, it is not easy to explain the biological mechanism responsible for the association between long sleep duration and a high triglyceride or a low HDL cholesterol level. Existing knowledge of metabolic hormones and sleep duration cannot explain this association. Certain metabolic endocrinological changes caused by long sleep duration may result in increased triglyceride level and decreased HDL cholesterol level. However, because it is difficult to experimentally induce individuals to sleep for long periods, data related to this field are sparse. Meanwhile, there is a possibility that a specific factor may be associated separately with long sleep duration and a high triglyceride or a low HDL cholesterol level, and that through this unidentified confounding factor, an apparent association between long sleep duration and these dyslipidemia becomes evident. In this study, as age, overweight, hypertension, and glucose intolerance could have been potential confounding elements, various covariates, including the above factors, were fed into multivariate logistic models to study the association between long sleep duration and serum lipid and lipoprotein levels. However, the associations were independent of these factors, and could not be justified using them. Several previous studies have reported that various pathologic features such as obesity, hypertension, and glucose intolerance are associated with long sleep duration.[5-9] However, in those studies, biological mechanisms responsible for such associations were not completely elucidated. Therefore, studies on the physiological characteristics of long sleep must be conducted in the future.

Previous studies have reported that the relative risk of death or CHD was lowest among those who slept for 7 to 8 h.[1-4,10,29] Meanwhile, in the present study, the relative risk of a high triglyceride level or a low HDL cholesterol level was lowest among women who slept for 6 to 7 h. Thus, the optimal sleep duration suggested in the present study was not in accord with those indicated by previous studies. However, the results of the present and the previous studies are similar in that the relative risks were lowest among the categories of sleep duration to which the largest numbers of participants belonged. In an attempt to interpret the optimal sleep durations for disease prevention based on epidemiological data, it is inferred that the optimal sleep durations vary with the target population. In addition, when considering optimal sleep duration, bidirectional causal relationships must be taken into consideration from a biological viewpoint. In other words, sleep duration may affect physical status, but conversely, physical status may also affect sleep duration. It must be recognized that according to the type of disease being examined, the optimal sleep duration may differ.

With regard to the associations between sleep duration and mortality among Japanese, 3 cohort studies have been reported so far, but their results were discordant.[4,29,30] Kojima et al. reported that a U-shaped association was observed among male subjects,[29] whereas Tamakoshi et al. reported that a U-shaped association was observed among women.[4] Conversely, Amagai et al. reported that a U-shaped association was not observed among either men or women.[30] The reason for these gender-based differences in the associations between sleep duration and mortality among the studies is unclear. In the present study, a U-shaped association between sleep duration and dyslipidemia was recognized among women. Our data support the results of Tamakoshi et al. Further studies will be necessary to clarify the associations of sleep duration with dyslipidemia and mortality among Japanese.

In this study, unlike the situation in women, no significant associations were observed between sleep duration and serum triglyceride or HDL cholesterol level among men. However, the risk of a high LDL cholesterol level was lower among men who slept ≥8 h. From the viewpoint of CVD prevention, it was suggested that long sleep duration was not favorable for women, whereas it was favorable for men. Many previous studies have already reported that there is a gender-specific difference in the prevalence of dyslipidemia because sex hormones (estrogen, in particular) strongly affect lipoprotein metabolism.[31-33] It has also been reported that certain gender-specific differences in sleep habits are influenced by differences in social or household roles,[34] or in sex hormones.[35] Since there are gender-based differences in the onset of dyslipidemia and sleep habits, it is not unusual to observe a gender-specific difference in the association between them. In any event, until the biological mechanisms associated with the relationship between sleep duration and dyslipidemia are elucidated, the reasons for the gender-specific difference in these associations will remain unclear. This issue should be addressed in future epidemiological and physiological investigations.

Several studies have reported U-shaped associations between sleep duration and various diseases. On the other hand, several studies have reported that the associations were negative linear, and not U-shaped (i.e., the risk was higher only among those with short sleep durations).[36-39] In the present study, adjusted analyses failed to detect any significant associations of BMI, blood pressure, and fasting plasma glucose level with sleep duration; this was despite the fact that significant associations were recognized during unadjusted analyses (data not shown). Thus, the results of the present study did not always agree with those of previous ones. It is inferred that these differences were due to firstly, differences in the sampling of subjects, and secondly, differences in adjustment factors. It is important that future epidemiological studies regarding the associations between sleep duration and diseases are carefully designed to minimize the selection bias and are adjusted for confounding factors. Subsequently, the results from such studies should be integrated through a meta-analysis, and a consensus should be reached. Future development of studies along these lines is expected.

The present study had several limitations. First, as this was a cross-sectional study, causal relationships could not be determined, even for items between which an association was indicated. When examining a causal relationship, a longitudinal study such as a cohort study is required, and such a study will be required in the future. Second, there may have been a non-response bias. Since the subjects were asked to come to public facilities in each district on a particular day during the survey period for examination of physical status, many of them may not have been able to participate because they had to go to work. The percentage of subjects who did not participate in the survey of physical status is estimated to have been approximately 37%. Among the cases analyzed, the number of subjects in the 20 to 49-yr age group and that of male participants were relatively small. Third, objective data could not be used for the present evaluation of sleep habits. Lauderdale et al. showed that the self-reported sleep duration was systematically biased along gender and race line when compared to measured sleep duration.[40] Therefore, the bias due to the use of self-reported data on sleep duration in this study remains to be resolved. Hereafter, the advantages of using measured data, such as those obtained with an actigraph, should be examined in a future study.

In conclusion, the results of this study indicate that both short and long sleep durations are associated with a high serum triglyceride level or a low HDL cholesterol level among women. Conversely, it was observed that the risk of a high LDL cholesterol level was lower among men who slept $\geq$8 h. Usual sleep duration is closely associated with serum lipid and lipoprotein levels.

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