
Yasuaki Hayashino, MD, 1 Shunichi Fukuhara, MD, 1 Yoshimi Suzukamo, PhD, 2 Tomonori Okamura, MD, 3 Taichiro Tanaka, MD, 3 Hirotugu Ueshima, MD, 3 for the HIPOP-OHP Research group*

1. Department of Epidemiology and Healthcare Research, Kyoto University Graduate School of Medicine, Kyoto, Japan
2. Department of Physical Medicine and Rehabilitation, Tohoku University Graduate School of Medicine, Sendai, Japan
3. Department of Health Science, Shiga University of Medical Science, Shiga, Japan

* The members of HIPOP-OHP Research group members were listed in the appendix.

Running title: quality and quantity of sleep and risk of diabetes

Word count: 3430
Abstract word count: 196
# of tables and figures: 2 tables and 1 figure

CORRESPONDING TO: Yasuaki Hayashino, MD, MPH
Department of Epidemiology and Healthcare Research
Kyoto University Graduate School of Medicine
Konoe-cho, Yoshida, Sakyō-ku, Kyoto 606-8501
ya-su@mvd.biglobe.ne.jp
Phone: +81-75-753-9467
FAX: +81-75-753-4644
E-mail: hayasino-y@umin.net
ABSTRACT

BACKGROUND

To investigate the impact of self-reported sleep duration and sleep quality on the risk of developing diabetes.

METHODS

Data were analyzed from the cohort of participants in a High-risk and Population Strategy for Occupational Health Promotion Study (HIPOP-OHP) conducted in Japan from the year 1999 onwards. Cox proportional hazard model was used to evaluate the association between sleep duration or sleep quality and the risk of diabetes.

RESULTS

Of 6509 participants, a total of 230 diabetes cases were reported over a median 4.2 years of follow-up. For participants who often experienced difficulty initiating sleep, the multivariate-adjusted hazard ratios for diabetes were 1.42 (95%CI, 1.05-1.91) in the case of participants with a medium frequency of difficulty initiating sleep, and 1.61 (95%CI, 1.00-2.58) for those with a high frequency, with a statistically significant linear trend. Significant association was not observed in the association between difficulty maintaining sleep or duration of sleep and risk of diabetes.
CONCLUSIONS

In conclusion, higher frequencies of difficulty initiating sleep, but not difficulty maintaining sleep and sleep duration, are associated with higher risks of diabetes in relatively healthy Asian workers, even after adjusting for a large number of possible confounders.
**Background**

Sleep quantity and quality has been reported to be associated with morbidity and mortality [1-4]. Experimental restriction of sleep to less than 4 hours per night for 6 nights resulted in impaired glucose tolerance in healthy young adults [5]. Because diabetes mellitus carries a high risk of cardiovascular mortality, the impact of sleep restriction on glucose regulation suggests a mechanism whereby short sleep time might increase mortality. Evidence is accumulating on the long-term effect of normal quality of sleep (e.g. difficulty initiating and maintaining sleep) or quantity of sleep (sleep duration) on the future risk of developing diabetes. However, most of these studies were done in the U.S. and Europe, and it is unclear whether the results are applicable to the Asian population. Evidence increasingly suggests that the epidemiology of type 2 diabetes depends on ethnicity, so that this finding might not be universal [6].

In the present study, objective of this study is to investigate the relationship between difficulty initiating or maintaining sleep, the self-reported typical sleep duration and quality of life and to reveal the effect of quality or quantity of sleep on the risk of developing incident diabetes in a large sample of healthy workers in Japan.
Methods

Participants and follow-up

We obtained the baseline and annual follow-up data during 1999-2004 from High-risk and Population Strategy for Occupational Health Promotion Study (HIPOP-OHP) for current analysis. The details of this study have been comprehensively described elsewhere [7-9]. Briefly, this 4-year worksite trial was begun in Japan in 1999 for the purpose of preventing cardiovascular disease.

Health promotion consisted of two kinds of approaches to intervention: health promotion intervention and minimization of high-risk conditions associated with cardiovascular diseases. The intervention areas included diet, physical activity, and cessation of smoking. A total of 7226 participants were assigned to twelve worksites, into an intervention group and a control group of six worksites each.

We excluded 717 participants from the current analysis, those who had incident diabetes at the baseline survey conducted between 1999 and 2000, or those who did not report the quality or quantity of sleep (difficulty initiating sleep, difficulty maintaining sleep, and duration of sleep) at baseline. We therefore used a cohort of 6509 healthy male and female workers aged 19-69 at baseline for the current analysis.
Study variables and standardization

In 1999 or 2000, a baseline health check was performed on all participants. Data from the physical examinations, such as blood pressure, height, weight, and biological data including plasma glucose level and cholesterol, were measured at baseline and annual check-ups thereafter. History of diabetes and other lifestyle parameters, such as daily alcohol intake, smoking habits, use of medications, and exercise, were evaluated using a self-administered questionnaire [7-9]. BMI was calculated as weight (kilograms) divided by height (meters) squared. For recreational physical activities, a metabolic equivalent task (MET) score was assigned based on the energy cost of each activity [10], and then the equivalent energy expenditure in hours per week (MET-h/w) for each participant was estimated. Drinking habits were also assessed by a self-administered questionnaire; the frequency of alcohol consumption during a typical week and the total alcohol intake on each occasion was determined and used to calculate the alcohol intake per day.

Sleep duration and difficulty initiating sleep was evaluated at baseline using a self-administered questionnaire. Participants were asked the following questions: “Indicate the average hours of sleep you usually take on weekdays”, “How often do you experience difficulty initiating sleep? 1. Often, 2. Sometimes, 3.
None”, and “How often do you experience difficulty maintaining sleep? 1. Often, 2. Sometimes, 3. None”. Because the duration of sleep was not normally distributed, it was divided into the following four categories for the purpose of this analysis: < 6 hours; ≥ 6 hours and < 7 hours; ≥ 7 hours and < 8 hours; ≥ 8 hours.

To confirm if these questions regarding difficulty initiating sleep and difficulty maintaining sleep were accurately assessing the target qualities of sleep, we evaluated the construct validity of this question. Construct validity refers to the extent to which an instrument is consistent with the theoretically derived hypothesis of the construct of interest, and is distinct from other related and unrelated constructs. It has been reported that insomnia is associated with a low quality of life [11], and we thus hypothesized that people with difficulty initiating sleep or difficulty maintaining sleep may have a low quality of life, to the extent that this question accurately classified different degrees of difficulty initiating sleep. Therefore, we evaluated the association between difficulty initiating sleep and quality of life. Quality of life was evaluated using the Japanese version of the Short Form 36 health survey (SF-36) [12]. The SF-36 is a 36 item questionnaire which measures health functioning on eight scales and is among the most widely used measures of quality of life in studies of patients and the general population [13-18]. Cross-sectional data from population studies have shown that the SF-36
is reliable and able to detect differences between groups defined by age, sex, socioeconomic status, geographical region, and clinical conditions [12]. The SF-36 could therefore be a useful tool for evaluating the difference between different categories of difficulty initiating sleep. For HIPOP-OHP study, however, only data from a total of 22 items out of the 36 and from only 5 of the sub-domains (vitality, mental health, role limitations-physical, role limitations-emotional, and general health) were collected. From these, we derived summary scores (0-100) for these 5 sub-domains to evaluate the association with the different categories of difficulty initiating sleep. For the purpose of validating the questions, we also hypothesized that participants showed a shorter sleep duration if they had poor sleep quality, thus evaluated the association between difficulty initiating sleep, difficulty maintaining sleep, and sleep duration.

**Diagnosis of diabetes**

In accordance with the American Diabetes Association and World Health Organization, a case of diabetes was considered confirmed if at least the following was ascertained: 1) a fasting blood glucose level of 126 mg/dL or greater (>=7.0 mmol/L), 2) a random plasma glucose of at least 200mg/dl (11.1 mmol/L), 3) treatment with hypoglycemic medication (insulin or oral hypoglycemic agent). In
addition to the above criteria, a self-reported history of diabetes was also
considered as a case. Because self-reported diagnosis of diabetes has been reported
as reliable [19], and it has often been used as a measure of exposure or outcome in
many cohort studies[20, 21].

**Statistical Analyses**

We used direct standardization to compare categorical variables adjusted for
age, and the generalized linear model to compare age-adjusted continuous
measurements. To evaluate the validity of the question regarding difficulty
initiating sleep or difficulty maintaining sleep, we used the general linear model
and tested the trend of the quality of life scores across different categories of
difficulty initiating. We used the Cox-proportional hazard model to analyze the
association between difficulty initiating sleep, difficulty maintaining sleep, and
sleep duration, and incident diabetes cases. Person-time was calculated from the
return of the baseline questionnaire until the date of onset of diabetes, or the end
of follow-up, whichever occurred first. The association between difficulty initiating
sleep and difficulty maintaining sleep categories and sleep duration categories
was evaluated using the chi-square test. The general linear model was used to
test the linear trend between the SF-36 sub-domain scores and the difficulty
We evaluated the effect of difficulty initiating sleep, difficulty maintaining sleep, and sleep duration on the risk of developing diabetes in separate age-adjusted and multivariable-adjusted models. For the evaluation of sleep quality, the first multivariable model (model 1) controlled for variables considered to be potential confounders of the association between the aimed categories and incident diabetes cases. This model controlled for age (in 5-year increments), gender, physical activity (MET-h/w) quartiles, body mass index quartiles, history of smoking (never, past, current), history of hypertension, history of high cholesterol, parental history of diabetes, alcohol use (mg/week) quartiles, and assigned intervention (health promotion) of original study. The second multivariable model (model 2) controlled for duration of sleep categories for the purpose of evaluating the association between difficulty initiating or maintaining sleep and the risk of developing diabetes. For the evaluation of sleep duration, we used slightly different models: BMI was not a factor in model 2, but was a factor in model 3, while the sleep duration categories were not included as an independent variable in any of the models for the nature of the analysis. We calculated age- and multivariable-adjusted hazard rates as a measure for the hazard ratio (HR) and the corresponding 95% confidence intervals (CIs). All analyses were
performed using commercially available statistical software packages (Intercooled STATA 8.2, Stata Corp., College Station, Tex).
Results

Of the 6509 participants included in the current analysis, the average age and body-mass index at baseline were 38.2 years and 22.6 kg/m$^2$ respectively, suggesting that the studied population consisted of relatively young and lean workers. The baseline frequencies of participants’ difficulty initiating sleep are shown in Table 1. At baseline, 61.3% of participants reported that they do not experience difficulty initiating sleep, 30.7% reported sometimes, and 8.0% reported often. At baseline, a high frequency of difficulty initiating sleep was associated with a higher occurrence of diabetes in the family history, a higher occurrence of a history of hypertension. Also, participants who reported often experiencing difficulty initiating sleep consumed more alcohol, and exercised less, but were less likely to be current smokers.

The primary task of this analysis was the ascertainment of incident diagnoses of diabetes during the study period. Over a median 4.2 years of follow-up, a total of 230 diabetes cases were reported. After adjustment for age, the risk of developing diabetes proved similar among the various sleep duration categories (<6, 6-7, 7-8, >=8) (Table 2). These associations remained unchanged even after adjusting for large number of possible confounding factors.

A higher frequency of difficulty initiating sleep was associated with a
significantly increased risk of developing incident diabetes in the age-adjusted model (Table 2). For participants who often experience difficulty initiating sleep, the age-adjusted hazard ratio (HR) for developing diabetes was 1.65 (95%CI, 1.07-2.54), with a significant linear trend being seen between the self-reported frequency of difficulty initiating sleep and the risk of diabetes (p=0.007). After adjusting for possible confounding factors in the relationship between difficulty initiating sleep and diabetes, the positive associations with diabetes were not attenuated. In model 1, the multivariate adjusted HR for diabetes was 1.39 (95%CI, 1.04-1.88) for participants with a moderate frequency of difficulty initiating sleep, and 1.63 (95%CI, 1.04-2.59) for high frequency, with the linear trend remaining significant (p=0.011). Adjusting for sleep duration (model 2) did not attenuate hazard ratios. Contrary to difficulty initiating sleep, a higher frequency of difficulty maintaining sleep was not significantly associated with risk of developing incident diabetes even after adjusting for a large number of confounders (Table 2).

To assess the construct validity of the question evaluating the frequency of difficulty initiating and maintaining sleep, we first evaluated the association between these questions and sleep duration (Table 1). The more often participants experienced difficulty initiating or maintaining sleep, the shorter sleep duration
was reported. Of those who reported difficulty initiating sleep, the proportions whose sleep duration was less than 6 hours were 14.2%, 16.0%, and 18.2% for none, sometimes, and often, respectively, and a significant association was observed (p<0.001). Similarly, for those who reported difficulty maintaining sleep, the proportions whose sleep duration was less than 6 hours were 14.3%, 16.9%, and 16.4% for none, sometimes, and often, respectively, and a significant association was observed (p<0.001) (results not shown in the table). Next, we evaluate the association with SF-36 sub-domain scores. The reported frequency of difficulty initiating sleep was significantly associated with all five of the SF-36 domains measured at baseline (Figure 1). The average SF-36 scores for the general health domain were 63.1 for participants who did not experience difficulty initiating sleep, 55.8 for those with a moderate frequency, and 48.8 for those with a high frequency of difficulty initiating sleep. There was a statistically significant linear inverse association between the frequency of difficulty initiating sleep and the SF-36 scores (p for trend <0.001 for all measures).
DISCUSSION

We observed a modest, but significant, positive association between a high self-reported frequency of difficulty initiating sleep and a higher risk of developing diabetes even after adjusting for large number of possible confounders in the association between sleep and incident diabetes. This effect was not attenuated by BMI or duration of sleep. Contrary to previous reports [22-24], a shorter sleep duration and difficulty maintaining sleep was not associated with a higher risk of diabetes mellitus in the case of healthy Asian workers.

Habitual snoring and sleep apnea have been reported to be associated with abnormal levels of fasting glucose and insulin resistance. However, a recent study has suggested that quality or quantity of sleep is an important determinant of glucose metabolism, independent of snoring and sleep apnea [5, 25, 26]. Short-term physiologic studies have shown that restriction of sleep results in abnormalities of endocrine function that could predispose to the development of diabetes. In a recently published study, Spiegel et al. restricted sleep in 11 healthy young men to 4 hours per night for 6 nights, and then allowed them to have a sleep recovery period of 6 nights [5]. Despite the short duration of partial sleep deprivation, the subjects in that study demonstrated impaired glucose tolerance, higher evening cortisol levels, and increased sympathetic nervous system activity
in the sleep deprived state, as compared with the recovery state.

Epidemiological studies have evaluated the association between sleep and the risk of developing diabetes mellitus. It has been shown that a short sleep duration was associated with a higher risk of developing diabetes, but the association with longer sleep durations was inconsistently reported [22-24]. Mallon et al. reported that difficulty maintaining sleep, but not difficulty initiating sleep, was associated with the risk of diabetes. Contrarily, Nilsson et al. revealed those who had difficulty falling asleep or regularly used hypnotics showed an association with the development of diabetes in a cohort of 6599 middle-aged men in Sweden [27]. In spite of the above studies, our results suggested that sleep duration was not associated with the risk of developing diabetes. Our study is also inconsistent with other earlier studies. There are some possible reasons why this kind of discrepancy was seen. Firstly, our study population is relatively lean (mean BMI, 22.6 kg/m$^2$) compared to that reported by Ayas et al. (mean BMI, 24.6 kg/m$^2$). As pointed out in their report, short sleep duration per se may not be a risk factor for diabetes, and instead a high BMI may worsen sleep quality. In fact, in their report, the relative risk of diabetes was no longer significant for short sleepers after adjustment for BMI, and this may explain the discrepancy between the two studies. Secondly, most subjects in previous studies were not of an Asian
population, whereas all of our study participants were Asian. Therefore the effect of short sleep time on the increased risk of diabetes may vary among different ethnicities. Thirdly, in our study, very few people had a sleep duration of less than 5 hours or more than 9 hours. This low variation of sleep duration in our study limited our ability to detect any positive relation between short sleep duration and a higher risk of developing diabetes mellitus. Finally, the participants' normal sleep duration was self-reported. It has been reported that self-reported sleep duration has a moderate degree of variation over time [28], and misclassification bias might lead the result of the current study toward the null.

Although the mechanism behind the positive association between difficulty initiating sleep and diabetes is not clear, there are some possible candidates. First, there are some reports that sleep disorders are associated with increased activity of the sympathetic nervous system [29, 30], which in turn is associated with increased glycogen breakdown and gluconeogenesis, and thus induces insulin resistance. Second, it has been reported that psychological distress is associated with poor glycemic control [31-35]. In the current study, difficulty initiating sleep was significantly associated with a lower mental health sub-domain score in the SF-36 questionnaire, and this might be an intermediate mechanism in the association between quality of sleep and risk of diabetes.
The prospective design of this study minimized the possibility that reporting of sleep duration or quality of sleep was biased by the diagnosis of diabetes, which could occur in case-control studies. Other strengths of the present study include the long follow-up and the relative homogeneity of socioeconomic status and ethnicity among subjects. Furthermore, we evaluated the construct validity of the sleep quality questionnaire, validating this tool for the purpose of evaluating the association with the risk of diabetes.

There may be several limitations to this study. Firstly, sleep duration and difficulty initiating sleep measurements were self-reported. While some misclassification of these measurements is likely, the bias of the effect on the risk of diabetes should tend towards the null, and thus our results for the association between difficulty initiating sleep and the risk of diabetes can not be dismissed. Secondly, because this is an observational study, confounding factors could be a plausible explanation for the findings, but this likelihood is limited by the prospective design for data collection and the adjustments made for the many covariates that could be confounders in the association of sleep problems and incident diabetes cases. Thirdly, because our study population consisted of a relatively lean and young Asian population, caution should be used in extrapolating our results to more obese, non-Asian, or older age groups.
Conclusions

In conclusion, these prospective data from the HIPOP-OHP suggested that difficulty initiating sleep, but not sleep duration or difficulty initiating sleep, was associated with a higher risk of diabetes in relatively healthy Asian workers even after adjusting for a large number of possible confounders. These findings may have important implications for the prevention of diabetes.
Competing interests

None for all authors.
Authors' contributions

YH, SF, YS, TO, TT, and HU conceived the study, and participated in the study design. YH performed statistical analysis. YH and YS drafted the initial manuscript for journal submission and participated in revisions. TO, TT, and HU coordinated data collection. All authors read and approved the final manuscript.
Acknowledgement

The High-risk and Population Strategy for Occupational Health Promotion (HIPOP-OHP) Study was funded by research grants from the Ministry of Health and Welfare, Japan (H10-12, No.063, Research on Health Services, Health Sciences Research Grants, H13, No.010 Medical Frontier Strategy Research, Health Sciences Research Grants), from the Ministry of Health, Labor and Welfare, Japan (H14-16, No.010 Clinical Research for Evidenced-Based Medicine, Health and Labor Sciences Research Grants) and from the Japan Arteriosclerosis Prevention Fund 2000 and 2004. We thank Toshimi Yoshida, Department of Health Sciences, Shiga University of Medical Science, for her excellent clerical support in this research.
Competing interests

None for all authors.
Appendix

HIPOP-OHP Research group:

Chairman: Hirotsugu Ueshima (Department of Health Science, Shiga University of Medical Science, Otsu, Shiga).

Participants: Akira Okayama (Department of Preventive Cardiology, National Cardiovascular Center, Osaka); Kiyomi Sakata and Keiko Tsuji (Department of Hygiene and Public Health, Iwate Medical University, School of Medicine, Iwate); Katsushi Yoshita (Department of National Nutrition Survey and Health Informatics, National Institute of Health and Nutrition); Toru Takebayashi and Yuriko Kikuchi (Department of Preventive Medicine and Public Health, School of Medicine, Keio University); Hideaki Nakagawa and Katsuyuki Miura (Department of Epidemiology and Public Health, Kanazawa Medical University); Hiroshi Yamato (Institute of Industrial Ecological Science, University of Occupational and Environmental Health); Nagako Chiba (Department of Human-Life, Tsukuba International Junior College); Masahiko Yanagita (Department of Nursing Science, Fukui Prefectural University); Kazunori Kodama, Fumiyoshi Kasagi and Nobuo Nishi (Department of Epidemiology, Radiation Effects Research Foundation), Yukinori Kusaka (Department of Environmental Health, Faculty of Medical Sciences, University of Fukui);
Shigeyuki Saitoh (Second Department of Internal Medicine School of Medicine, Sapporo Medical University); Hideo Tanaka (Department of Cancer Control and Statistics, Osaka Medical Center for Cancer and Cardiovascular Diseases); Masakazu Nakamura (Cholesterol Reference Method Laboratory Network at Osaka Medical Center for Health Science and Promotion); Masakazu Nakamura and Yoshihiko Naito (Osaka Medical Center for Health Science and Promotion); Yasuyuki Nakamura (Cardiovascular Epidemiology, Faculty of Home Economics, Kyoto Women’s University); Makoto Watanabe and Yoshikazu Nakamura (Department of Public Health, Jichi Medical School); Akira Babazono (Institute of Health Science, Kyushu University), Unai Tamura, Junko Minai, Zentaro Yamagata (Department of Health Sciences, School of Medicine, University of Yamanashi); Sumio Urano (Matsushita Health Care Center), Fujihisa Kinoshita (Wakayama Wellness Foundation); Isao Saitoh (Department of Public Health, Nara Medical University); Shinichi Tanihara (Department of Public Health, School of Medicine, Shimane University, Japan); Junko Tamaki (Department of Public Health, Kinki University School of Medicine); Osamu Tochikubo (Department of Public Health, Yokohama City University School of Medicine); Takeo Nakayama (Department of Medical System Informatics, Graduate School of Medicine and Faculty of Medicine, Kyoto University); Shunichi Fukuhara
(Department of Epidemiology and HealthCare Research, Graduate School of Medicine and Faculty of Medicine Kyoto University), Yoshiharu Fujieda

(Department of Health and Sport Sciences, Tokyo Gakugei University); Mariko Naito (Department of Preventive Medicine/Biostatistics and Medical Decision Making, Nagoya University Graduate School of Medicine); Shunsaku Mizushima (Department of Human Resources Development, National Institute of Public Health); Yuji Miyoshi (Tokyo central Clinic, Health Insurance Society of Meiji Yasuda Life Insurance Company); Takayo Tada (Department of Food Science, Faculty of Human Life Science, Mimasaka University); Taichiro Tanaka, Takashi Kadowaki, Toshimi Yoshida, Mami Ide and Tomonori Okamura (Department of Health Science, Shiga University of Medical Science, Otsu, Shiga).
REFERENCES


13. Greenfield S, Rogers W, Mangotch M, Carney MF, Tarlov AR: Outcomes of patients with hypertension and non-insulin dependent diabetes mellitus treated by different systems
and specialties. Results from the medical outcomes study. *Jama* 1995, **274**(18):1436-1444.


Table 1. Baseline characteristics of the study participants according to difficulty initiating sleep categories, 1999-2000, HIPOP-OHP, Japan

<table>
<thead>
<tr>
<th>Difficulty initiating sleeping</th>
<th>Non</th>
<th>Sometimes</th>
<th>Often</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of subjects (%)</td>
<td>3993 (61.3)</td>
<td>1996 (30.7)</td>
<td>520 (8.0)</td>
</tr>
<tr>
<td>Age *</td>
<td>38.4±9.5</td>
<td>38.3±9.5</td>
<td>36.2±9.5</td>
</tr>
<tr>
<td>Gender (male, %)</td>
<td>77.7</td>
<td>78.6</td>
<td>83.0</td>
</tr>
<tr>
<td>BMI (kg/m$^2$) †‡</td>
<td>22.7±0.05</td>
<td>22.7±0.07</td>
<td>22.8±0.14</td>
</tr>
<tr>
<td>Physical activity (MET-h/week) † §</td>
<td>5.5±0.17</td>
<td>4.3±0.24</td>
<td>5.1±0.46</td>
</tr>
<tr>
<td>History of hypercholesterolemia (%)</td>
<td>7.5</td>
<td>7.8</td>
<td>8.4</td>
</tr>
<tr>
<td>History of hypertension (%)</td>
<td>11.8</td>
<td>13.1</td>
<td>13.6</td>
</tr>
<tr>
<td>Smoking (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>44.4</td>
<td>37.1</td>
<td>30.0</td>
</tr>
<tr>
<td>Past</td>
<td>15.9</td>
<td>12.6</td>
<td>14.1</td>
</tr>
<tr>
<td>Current</td>
<td>39.7</td>
<td>50.3</td>
<td>55.9</td>
</tr>
<tr>
<td>Family history of diabetes (%)</td>
<td>18.2</td>
<td>19.1</td>
<td>17.8</td>
</tr>
<tr>
<td>Sleeping time (hours) (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;6</td>
<td>14.3</td>
<td>16.9</td>
<td>30.3</td>
</tr>
<tr>
<td>6-7</td>
<td>41.9</td>
<td>44.6</td>
<td>42.4</td>
</tr>
<tr>
<td>7-8</td>
<td>34.3</td>
<td>31.6</td>
<td>21.9</td>
</tr>
<tr>
<td>8&lt;</td>
<td>9.5</td>
<td>6.9</td>
<td>5.4</td>
</tr>
<tr>
<td>Alcohol intake quartiles (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1Q (0mg/week)</td>
<td>48.3</td>
<td>51.8</td>
<td>51.0</td>
</tr>
<tr>
<td>2Q (0.1-2.5mg/week)</td>
<td>1.6</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>3Q (2.6-25.0mg/week)</td>
<td>25.9</td>
<td>23.6</td>
<td>20.9</td>
</tr>
<tr>
<td>4Q (25.1- mg/week)</td>
<td>24.2</td>
<td>23.4</td>
<td>27.1</td>
</tr>
</tbody>
</table>

* Plus-minus values are means ± SD
† Plus-minus values are means ± SE
‡ BMI denotes body mass index
§ MET-h denotes metabolic equivalent hours
Table 2. Self-reported sleep duration, difficulty in sleeping, difficulty maintaining sleeping and risk of type 2 diabetes.

<table>
<thead>
<tr>
<th>Self-reported sleep duration</th>
<th>Age-adjusted Model*</th>
<th>Model 1 †</th>
<th>Model 2 ‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6 hours</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>6-7 hours</td>
<td>0.84 (0.57-1.24)</td>
<td>0.92 (0.61-1.39)</td>
<td>0.92 (0.61-1.9)</td>
</tr>
<tr>
<td>7-8 hours</td>
<td>1.05 (0.71-1.55)</td>
<td>1.07 (0.70-1.62)</td>
<td>1.07 (0.70-1.62)</td>
</tr>
<tr>
<td>&gt; 8 hours</td>
<td>0.98 (0.57-1.67)</td>
<td>0.92 (0.52-1.64)</td>
<td>0.92 (0.52-1.64)</td>
</tr>
<tr>
<td>P for trend</td>
<td>0.549</td>
<td>0.933</td>
<td>0.723</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Self-reported difficulty in sleeping</th>
<th>Age-adjusted Model*</th>
<th>Model 1 §</th>
<th>Model 2 ¶</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Sometimes</td>
<td>1.33 (1.00-1.76)</td>
<td>1.39 (1.04-1.88)</td>
<td>1.42 (1.05-1.91)</td>
</tr>
<tr>
<td>Often</td>
<td>1.65 (1.07-2.54)</td>
<td>1.63 (1.04-2.59)</td>
<td>1.61 (1.00-2.58)</td>
</tr>
<tr>
<td>P for trend</td>
<td>0.007</td>
<td>0.011</td>
<td>0.005</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Self-reported difficulty maintaining sleeping</th>
<th>Age-adjusted Model*</th>
<th>Model 1 §</th>
<th>Model 2 ¶</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Sometimes</td>
<td>1.31 (0.99-1.73)</td>
<td>1.31 (0.97-1.77)</td>
<td>1.31 (0.97-1.76)</td>
</tr>
<tr>
<td>Often</td>
<td>1.38 (0.91-2.11)</td>
<td>1.34 (0.86-2.01)</td>
<td>1.37 (0.87-2.16)</td>
</tr>
<tr>
<td>P for trend</td>
<td>0.043</td>
<td>0.074</td>
<td>0.063</td>
</tr>
</tbody>
</table>

* Adjusted for age at baseline (5 year increments)

† Adjusted for age, gender, history of smoking, history of hypertension, history of high cholesterol, potential history of diabetes, exercise (MET-h/week) quartiles, and assigned intervention (health promotion)

‡ Adjusted for all variables in model 2 and BMI (kg/m², quartiles)

§ Adjusted for age, gender, BMI (kg/m², quartiles), history of smoking, history of hypertension, history of high cholesterol, potential history of diabetes, exercise (MET-h/week) quartiles, and assigned intervention (health promotion)

¶ Adjusted for all variables in model 2 and sleep duration categories
FIGURE LEGENDS

Figure 1. The relationship between difficulty initiating and maintaining sleep and SF36 domain scores

Mean scores for the sub-domains of the SF-36 at baseline for different categories of difficulty initiating sleep and difficulty maintaining sleep (none, sometimes, often). SF-36 sub-domains included general health, vitality, role-physical, role-emotional, and mental health.
Figure 1.