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Original Article

Association of sleep duration and incidence of diabetes modified by tea consumption: a report from the Shanghai men's health study

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ABSTRACT

Objectives: To evaluate the association between sleep duration and the incidence of diabetes stratified by sleep-related factors among Chinese men.
Methods: This study included 34,825 men who provided information on sleep-related questions in the Shanghai Men's Health Study, a population-based cohort study conducted in Shanghai, China from 2002 to 2011. Participants were excluded who had a history of diabetes or who were diagnosed with diabetes within 2 years of recruitment. Cox regression was employed to evaluate the influence of sleep duration and its interaction with sleep-related factors on diabetes risk.
Results: A total of 1521 incident cases were documented during a median of 5.6 follow-up years. Adjusted hazard ratios and 95% confidence intervals were 1.0 (0.9–1.1) and 1.2 (1.0–1.3) for men who slept <7 and ≥8 h per day, respectively, compared with those who slept 7 h per day ($p_{trend} = 0.01$). Stratified analyses revealed that the association between sleep duration and risk of diabetes was only statistically significant among current smokers and regular drinkers, never tea drinkers, men with a high body mass index, hypertension or comorbidity, and men who did not work nightshift or who snored. A statistically significant interaction between tea drinking and sleep duration was observed ($p_{interaction} = 0.01$). The above association patterns remained when daytime nappers were excluded from the analyses.
Conclusions: The data suggested that longer sleep duration, particularly among individuals already exhibiting factors linked to poor quality of sleep, was associated with diabetes. The association between sleep duration and diabetes may be modified by tea drinking, especially in older men or men with more sleep-related factors.

1. Introduction

Both sleeping quantity and quality play important roles in human health. The American Sleep Foundation has reported that a large majority (75%) of American adults complain of having had at least one symptom of a sleep problem [1] such as difficulty falling asleep, waking up too early, and not being able to get back to sleep, or snoring. Both short and long sleep duration have been reported to be long-term risk factors for poor health, including obesity, diabetes, cardiovascular disease, and cancer [2–5].

However, data are inconsistent on the association between the duration and quality of sleep and the prevalence/incidence of diabetes. Results from cross-sectional studies and prospective studies have shown both short and long sleep duration, following a U-shaped pattern, to be associated with an increased risk of diabetes [6–8]. A Finish study reported this U-shaped association in women only [9]. Several other studies, however, found that either short sleep duration or long sleep duration, but not both, were associated with an incidence of diabetes [10,11]. Other studies have reported no association between sleep duration and diabetes [12,13].

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Sleep duration may affect glucose metabolism by reducing glucose intolerance, insulin resistance, and acute insulin response to glucose [3]. The relationship between sleep duration and diabetes incidence may be influenced by many factors that influence the quality of sleep, such as body mass index (BMI), snoring, and night shift work, and physical and economic conditions [2]. Furthermore, evidence suggests that the risk factors for diabetes may vary by ethnicity [14,15]. However, the vast majority of previous research studies on the association of sleep duration and diabetes risk have been conducted in developed countries, and few studies have focused on the effects of sleep-quality-related factors on this association.

Using data from the Shanghai Men's Health Study, a population-based cohort study of middle-aged Chinese men, a systematic evaluation was conducted of the association between sleep duration and diabetes risk, and its modification by sleep-quality-related factors.

2. Methods

2.1. Study population

The Shanghai Men's Health Study (SMHS) is a population-based cohort study of 61,480 Chinese men aged 40–74 years and living in urban Shanghai, China. Participants were recruited to the study from April 2002 to June 2006. A total of 83,033 eligible men from eight communities in urban Shanghai were invited to participate by trained interviewers through in-person contact, and 61,480 men who had no prior history of cancer were ultimately enrolled in the study (response rate 74.0%). Reasons for non-participation were refusal ($n = 17{,}823$, 21.5%), out of area during enrollment ($n = 2370$, 2.9%), and other miscellaneous reasons including poor health or hearing problems ($n = 1360$, 1.6%). Sleep-related questions were added to the study after initiation of study enrollment. Thus, sleep information was unavailable for 16,776 SMHS participants, who were excluded from the current study.

Approximately 91% of SMHS participants provided a spot urine sample for the study, on which a urine glucose test was conducted. Participants who had positive results to the urine glucose test or who did not complete a urine test ($n = 7367$) were excluded from the current study. Additionally, the study excluded SMHS participants who reported a history of diabetes at the baseline survey or were possible diabetes cases ($n = 1881$), who were diagnosed with diabetes within the first 2 years of study enrollment ($n = 256$), or who had <2 years of follow-up ($n = 375$) from the study. The final analytic data set comprised 34,825 men.

A structured questionnaire was used to collect information on demographic characteristics, disease history, and lifestyle factors, including physical activity level, smoking and drinking history, dietary intake, tea consumption, and shiftwork. Anthropometric measurements (taken at the baseline survey by trained interviewers) included height, weight, and circumference of waist, and hips. The BMI was calculated as weight (in kg) divided by the square of height (in m), and the waist hip ratio (WHR) was calculated as waist circumference divided by hip circumference.

Sleep-related information was collected by the following questions: “In the past year, how many hours on average did you sleep per day? (Including sleeping at night time and napping during the day time, but not including waking time during the sleep period)” and “In the past year, did you nap during the day at least once a week? (Not including time slept during the daytime if you worked nightshift).”

2.2. Ascertainment of type 2 diabetes

Information on type 2 diabetes (T2D) was self-reported and collected during the in-person follow-up surveys, which took place every 2–3 years after baseline enrollment. The current study considered individuals who reported having a diagnosis of T2D and who met at least one of the following criteria, recommended by the American Diabetes Association, as having the study outcome: 1) fasting glucose concentration ≥7 mmol/L on at least two separate occasions; 2) an oral-glucose-tolerance test (OGTT) performed at the doctor's office with a value ≥11.1 mmol/L; and/or 3) use of hypoglycemic medication (i.e., insulin or oral hypoglycemic drugs). Twelve self-reported diabetes cases that did not meet the above criteria, and 30 men who died of diabetes but had no information on diabetes diagnosis were excluded from the current study.

2.3. Statistical analysis

Sleep duration was categorized into three groups in the analysis: <7 h, 7 h, and ≥8 h. ANOVA was used for comparing continuous variables and Chi-squared test was used for dichotomous variables between T2D cases and healthy men. Cox regression was applied to calculate hazard ratios (HRs) and 95% CIs for each sleep duration group, adjusted for potential confounders at the baseline survey. The study used 7 h of sleep duration as reference in the analysis because this group has been previously suggested to be associated with the lowest incidence of diabetes [8]. Covariates, including age at interview (continuous), smoking (pack-years), alcohol consumption (drinks per day), current tea drinking (yes/no), energy intake (continuous), and physical activity (met-hours/year), snoring (yes/no), self-reported nightshift work history (yes/no), BMI (continuous), family history of diabetes (yes/no), hypertension (yes/no), and comorbidity (yes/no) were included in the COX model.

Tests for linear trend were performed by using an ordinal value for each sleep category (1 for <7 h, 2 for 7 h, and 3 for ≥8 h) as the continuous variable in the model. Sleep-quality-related factors, such as physical inactivity, smoking, drinking, high BMI (≥25), comorbidity (≥1), hypertension (yes), and snoring (yes), were treated as the risk factors, and the total number of risk factors for each participant was tallied to calculate a ‘risk score’. The score was categorized to three categories: low risk (score = 0–2), moderate risk (score = 3–4), and high risk (score > 4). All p-values were two-tailed and differences at $p < 0.05$ were accepted as statistically significant. All analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC).

3. Results

The average age of cohort participants was 55.0 years (standard deviation (SD) = 9.6 years). Average sleep duration was 7.1 h (SD = 1.3 h). About 26.3% of participants in the study reported sleep duration of 7 h per day, and 18,651 participants reported no daytime napping (nocturnal sleep only).

Table 1 shows selected demographic characteristics, lifestyle factors, and anthropometric measurements, as well as daytime napping and snoring by diabetes status. All data presented in Table 1 are age-adjusted. Over an average of 5.6 years of follow-up, a total of 1521 diabetes cases were documented from 2 years after study enrollment. Participants who developed diabetes were older, had higher BMI and WHR, and were more likely to have higher energy intake, higher prevalence of coronary heart disease and hypertension, and a family history of diabetes and snoring, compared with diabetes-free participants. There were no significant differences in education, income, or lifestyle factors between diabetes cases and healthy men.

Sleep duration was positively associated with diabetes risk, with HRs (95% CIs) of 1.00 (0.87–1.14) and 1.16 (1.02–1.32) for men who slept <7 and ≥8 h per day, respectively, compared with those who slept 7 h per day ($p_{\text{for trend}} = 0.01$) (Table 2). Analyses stratified by