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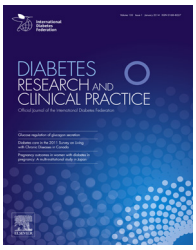

Effects of sleep duration and sleep quality on prevalence of type 2 diabetes mellitus: A 5-year follow-up study in China

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ABSTRACT

Objective: To explore the interactions of sleep quality and sleep duration on the development of type 2 diabetes mellitus (DM2) in Chinese adults.

Research design and methods: We randomly selected 11,842 Chinese subjects from the Xuzhou community of China and obtained self-reported quality and duration of sleep by questionnaire. DM2 was assessed by fasting blood glucose. Sleep quality was categorized as good, common, or poor. Sleep duration was measured by average hours of sleep per night. We evaluated interaction, relative excess risk of interaction (RERI), the attributable proportion (AP), and the synergy index (S) using a logistic regression model.

Results: The relative risk for the development of DM2 was higher in subjects with short sleep duration (1.67 [1.34–2.16]) or poor sleep quality (1.91 [1.31–2.74]) or long sleep duration (1.45 [1.02–1.77]). DM2 occurred more frequently with poor sleep quality combined with short sleep duration (odds ratio: 6.21; 95% confidence interval (CI): 2.78–11.81). RERI, AP, and S values (and their 95% CI) were 3.99 (1.41–7.76), 0.64 (0.45–0.76), and 5.15 (3.74–7.89) for the interaction between poor sleep quality and short sleep duration. In subjects with poor sleep quality combined with long sleep duration, the RERI, AP, and S values (and 95% CI) were 0.13 (−0.19 to 0.66), 0.07 (−0.35 to 0.18), and 1.19 (0.85–2.11).

Conclusions: Interactions between poor sleep quality and short sleep duration were additive. Preventive measures should focus on short sleep duration and poor sleep quality.

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1. Introduction

Chronic sleep loss and poor sleep quality are very common in today's society [1,2]. The long-term effect of poor sleep quality or sleep loss not only has a significantly negative impact on morbidity and mortality [3,4], but also increases the risk of developing type 2 diabetes mellitus (DM2) [5–11]. Many experimental studies [12–14] have shown that sleep duration and sleep quality are attributable to a decrease in glucose tolerance and reduced insulin sensitivity. These data have provided evidence for epidemiological surveys that have shown that the risk of DM2 is increased by chronic sleep loss and poor sleep quality. However, most of these studies were in Western countries, whereas little is known in Eastern countries [15]. Our previous results also suggest that poor quality of sleep and sleep duration (<6 h per night) are independent risk factors for DM2, even after adjusting for a large number of possible confounders [16,17]. However, these were cross-sectional surveys, not prospective studies, so it is not clear whether the results are applicable to the Chinese population. Evidence increasingly suggests that the epidemiology of DM2 depends on ethnicity [11].

Although inappropriate sleep or poor sleep quality play a role in the development of DM2, there is no understanding of the combined effect of sleep duration and poor sleep quality on prevalence of the DM2 in relatively healthy persons. The primary aim of this cohort study was to examine the combined effects of sleep quality and sleep duration on the risk of developing diabetes in relatively healthy individuals. A secondary aim was to assess the associations of sleep quality and DM2, and of sleep duration and DM2 in China.

2. Research design and methods

2.1. Study population

We prospectively followed a representative sample of the Xuzhou population, with the aim of determining the prevalence and risk factors for DM2. The baseline survey was performed from March to November 2008 with a sample of 23,742 residents (11,676 men and 12,066 women) of district 10 of Xuzhou aged 15–75 years, who were selected by multi-stage stratified random sampling. After this cross-sectional prevalence study of DM2 risk factors, subjects entered into a cohort for a prospective observational study. The cohort constituted 15,939 subjects over 18 years of age. After exclusion of subjects with prevalent diabetes at baseline ($n = 954$), subjects who were aged <18 years and those with missing data for fasting and 2-h glucose levels ($n = 6849$), there were 12,592 non-diabetic subjects in the cohort, who were re-examined from May to November 2013. Those who developed diabetes in the follow-up and those who completed the final examination were included in the current study. The main reason for lack of attendance at follow-up examinations, despite repeated calls, was either migration or other personal reasons.

The study protocol was approved by the Xuzhou Center for Disease Control and Prevention. All participants provided written informed consent.

2.2. Clinical, anthropometric, and laboratory measurements

Subjects were interviewed privately and face-to-face by trained interviewers using pretested questionnaires. Initially, information on age, sex, marital status, current employment status, level of education, cigarette smoking, alcohol intake, physical activity, family history of diseases including diabetes, hypertension, heart disease, and cancer were measured using a standard questionnaire. Employment status was categorized as manual, non-manual, unemployed, and retired. Education was categorized into below high school, high school, and above high school level. Marital status was defined as married or not married (i.e., single, divorced, widowed, or separated). Living conditions were defined as living alone or with someone else. Lifestyle variables included cigarette smoking, alcohol drinking, and physical activity level. Cigarette smoking was defined as having smoked at least 100 cigarettes in their lifetime. Information was obtained on the amount and type of alcohol that was consumed during the previous year, and alcohol drinking was defined as the consumption of at least 30 g alcohol per week for 1 year or more. Regular leisure-time physical activity was defined as participating in moderate or vigorous activity for no less than 30 min per day at least 3 days a week. A positive family history of diabetes was defined as having at least one parent or sibling with diabetes. A history of cardiovascular disease was defined as previous ischemic heart disease and/or a cerebrovascular accident. Body mass index (BMI) was calculated by dividing the weight in kilograms by height in meters squared. BMI was categorized as underweight ($\leq$18.5 kg/m^2), normal weight (18.5–24.0 kg/m^2), and overweight/obese ($\geq$24.0 kg/m^2), abdominal obesity was a waist circumference >85 or >90 cm in female and male individuals, respectively [18].

Systolic and diastolic blood pressures were measured twice in a seated position in the right arm and the mean value was considered the subject's blood pressure. A blood sample was taken after 12–14 h of overnight fasting and was centrifuged within 30–45 min of collection. All blood analyses were performed at the laboratory on the day of blood collection. Fasting plasma glucose was measured by the hexokinase method. The glucose measurements were done by the same method at baseline and at the final examinations. A subject was defined as having diabetes if the diagnosis had been made by a doctor or if the subject was receiving antidiabetes therapy (insulin and/or tablets) or if two fasting blood samples showed glucose concentrations according to the recommendations of the Chinese Diabetes Society [19] at the final follow-up.

Self-reported sleep quality during the previous year was recorded in three categories (good, common, or poor). Subjects were asked to rate difficulties with initiating and maintaining sleep on a five-point scale (1), no problems, average <1 day per month; (2), minor problems, average 1–3 days per month; (3), moderate problems, average 4–7 days per month; (4), severe problems, average 8–15 days per month; (5), very severe problems, average $\leq$16 days per month). Good sleep was defined as no or minor problems, a few days of lost sleep as moderate problems (common), and poor sleep as frequent severe or very severe problems. Before the formal investigation, we conducted a pilot study. 675 subjects were sampled by