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Original Article

Gender-specific independent and combined dose–response association of napping and night sleep duration with type 2 diabetes mellitus in rural Chinese adults: the RuralDiab study

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A R T I C L E I N F O

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A B S T R A C T

Objective: The aim of this study was to explore the independent and combined dose–response association of napping and night sleep duration with type 2 diabetes mellitus (T2DM) among different genders in the rural Chinese population.
Methods: For this research, a total of 19,257 participants were enrolled in the Rural Diabetes, Obesity and Lifestyle (*RuralDiab*) study. Napping and night sleep duration were assessed using the Pittsburgh Sleep Quality Index (PSQI). Restricted cubic splines and logistic regression were used to estimate the relationship between napping and night sleep duration with T2DM.
Results: A linear dose–response relationship between napping duration and T2DM as well as a U-shaped relationship between night sleep duration and T2DM were found. Compared with those who reported no napping, participants who had a napping duration of ≥91 min were associated with a 19% increase in prevalence of T2DM. Adjusted odds ratios (ORs) (95% confidence intervals (CIs)) for T2DM were 1.48 (1.03, 2.14) and 1.50 (1.22, 1.85) for shorter (≤5 h) and longer (>9 h) night sleep duration compared with the referential group. Additionally, the combination of longer napping duration (≥91 min) and night sleep duration (>9 h) increased 104% (95% CI: 45%, 128%) prevalence for T2DM. These associations were not found in males but were evident in females.
Conclusions: Longer napping duration and extreme night sleep duration increased the prevalence of T2DM. Meanwhile, longer napping and night sleep duration might be jointly associated with a higher prevalence of T2DM.

1. Introduction

Type 2 diabetes mellitus (T2DM), which is characterized by increased blood glucose concentration, imposes a high level of global, individual and social costs. In 2015, it was estimated that the prevalence of diabetes in adults was 8.8% worldwide; meaning that 415 million people lived with diabetes and 5.0 million deaths were attributed to the disease [1]. It is estimated that diabetes will lead to a global health expenditure of 490 billion United States dollars (USD) due to diabetes in 2030 [2]. In particular, 75% of the patients are from low- and middle-income countries, including China [1]. According to the International Diabetes Federation, the number of diabetes patients is expected to go from 98.4 million to 142.7 million in China from 2013 to 2035 [3]. Moreover, it has been reported that

Abbreviations: ADA, American Diabetes Association; BMI, body mass index; BP, blood pressure; CIs, confidence intervals; FPG, fasting plasma glucose; h, hours; IPAQ, international physical activity questionnaire; min, minutes; ORs, odds ratio; PSQI, Pittsburgh Sleep Quality Index; RERI, relative excess risk of interaction; RMB, renminbi; RuralDiab, Rural Diabetes, Obesity and Lifestyle; SD, standard deviation; T2DM, type 2 diabetes mellitus; USD, United States dollars.

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diabetes in rural areas of China has become a significant public health problem and the age-standardized prevalence of diabetes has reached 6.98% [4]. It is generally acknowledged that, except for genetic factors, there are many other modifiable risk factors contributing to diabetes, particularly lifestyle factors which have changed dramatically, especially in developing countries.

Daytime napping, a common and traditional ritual in China, was reported to lead to deleterious health consequences including diabetes [5]. Physiological data suggests that improper night sleep duration leads to striking alterations in metabolic and endocrine function such as decreased glucose tolerance, increased sympathetic tone and cortisol concentration [6]. Additionally, a growing number of epidemiological studies have reported that self-reported non-optimal night sleep duration is associated with adverse health effects, such as diabetes, hypertension, heart disease and mortality [7,8]. Two studies showed that napping and night sleep duration may independently and jointly affect diabetes in older Americans and middle-aged Chinese [9,10], yet inconsistent conclusions were found in the two prospective researches. Furthermore, some studies indicated that this association was ethnic- and gender-specific [11,12], However, most previous studies focused on Western populations. Evidence of the independent and combined relationship between napping and night sleep duration with T2DM in rural adults remains limited.

Therefore, the aim of the current study was to investigate the gender-specific independent and combined dose–response relationship between napping and night sleep duration with T2DM in rural Chinese adults.

2. Materials and methods

2.1. Study population

The study population was derived from the Rural Diabetes, Obesity and Lifestyle (*RuralDiab*) study, which was performed in the rural areas in Henan province and registered before the onset of patient enrollment in Chinese Clinical Trial Register (Registration number: ChiCTR-OOC-15006699). In total, 23,278 people aged between 18 and 79 years old were recruited. The data was collected by questionnaires, medical examinations and fasting blood samples. We excluded participants: who were younger than 35 years ($N = 882$) or older than 74 years ($N = 1139$); had type 1 diabetes mellitus ($N = 2$); had incomplete information on diagnoses of T2DM ($N = 21$), were without information about napping duration ($N = 23$) or night sleep duration ($N = 13$); had a napping duration > 99.5% (180 min) ($N = 61$) or night sleep duration ≤ 0.25% (3 h) or > 99.75% (12 h) ($N = 97$); were night shift workers ($N = 134$); were diagnosed with cancer ($N = 166$) or stroke ($N = 1483$). Finally a total of 19,257 participants were remained in this analysis.

The protocol of this study was in accordance with the guidelines of the Helsinki Declaration, and was approved by the ethic committee of the Zhengzhou University Life Science Ethics Committee. All study participants signed the informed consents.

2.2. Data collection and laboratory measurements

Well trained interviewers administered the face-to-face interview questionnaires to collect general demographic characteristics (age, gender, educational level, socioeconomic status and marital status, etc.), lifestyles (smoking, alcohol drinking, physical activity and sleeping, etc.), individual history of disease and medication and family history of disease. Education level was grouped into elementary school or below, junior high school and high school or above. Socioeconomic status was evaluated based on average monthly individual income (<500, 500~, and ≥1000 renminbi (RMB)). Marital status was defined as married/cohabitating and unmarried/divorced/widowed. Smoking was considered as at least one cigarette per day for more than half a year. Alcohol drinking was defined as drinking alcohol at least 12 times per year. Physical activity was grouped into low, moderate and high levels based on the International Physical Activity Questionnaire (IPAQ) [13]. Mental stress during the last month was evaluated using the negative events, and defined as none, a little, general and severe. Family history of disease was defined as parents or siblings of the respondents had a history of disease. Anthropometric measurements including height, weight, waist circumference. Hip circumference were measured twice with the subjects in light clothing and shoes off. Blood pressure (BP) was measured three times at 30-s intervals in the sitting position after 5 min breaks according to American Heart Association's standardized protocol [14], with an electronic sphygmomanometer (HEM-770A Fuzzy, Omron, Japan). The average values of the measurements were calculated for analysis.

After at least 8 h of overnight fasting, venous blood samples were drawn from the participants for laboratory measurements. Fasting blood glucose (FBG) was measured by ROCHE Cobas C501 automatic biochemical analyzer with glucose oxidative method (GOD-PAP).

2.3. Assessment of napping and night sleep duration

Sleep quality and sleep duration were assessed using the Pittsburgh Sleep Quality Index (PSQI), which is a self-rated questionnaire assessing sleep quality and disturbances [15]. The reliability and validity of PSQI in Chinese was assessed by Liu et al. [16]. Night sleep duration was taken from the following question of the PSQI: "How many hours of actual sleep duration did you get at night during the past month?" Napping duration was obtained by the question: "Did you nap during the midday time over the past months?" If they answered in the affirmative, they were asked the duration they usually nap for. Disturbance in respiration during night sleep were evaluated through the question: "Have you had disturbance in respiration in night sleep during the past month (none, less than one time per week, one to two times per week, three or more times per week)?" Based on the observation of the restricted cubic splines and existing epidemiological studies [7,17,18], participants were divided into groups according to napping and night sleep duration and assigned the references: (1) napping duration: 0 min (reference), 1–30 min, 31–60 min, 61–90 min and ≥91 min; (2) night sleep duration: ≤5 h, 5–6 h, 6–7 h, 7–8 h (reference), 8–9 h and >9 h.

2.4. Definition of T2DM

The determination of T2DM was based on the American Diabetes Association (ADA) diagnostic criteria (2009) [19]. Participants were defined as having T2DM if the fasting blood glucose ≥7.0 mmol/L or having a self-reported previous diagnosis of diabetes by a physician after excluding type 1 diabetes mellitus, gestational diabetes mellitus, and diabetes due to other causes.

2.5. Statistical analysis

Continuous and categorical characteristic variables between subjects with diabetes and subjects without diabetes were presented as mean (plus and minus standard deviations) and number (percentage), and were compared by Student's *t*-tests and chi-squared tests. Restricted cubic spline in logistic regression recommended by Loic Desquilbet and François Mariotti [20] was used to explore the dose–response relationship between