Association between Sleep duration and Incidence of type 2 Diabetes in China

Hongzhou Liu
3rd Medical Center of Chinese PLA General Hospital

Anping Wang
The First Medical Center, Chinese PLA General Hospital

Junping Wen
Fujian Provincial Hospital, Key Laboratory of Endocrinology, Fujian Medical University

Yiming Mu
The First Medical Center, Chinese PLA General Hospital

Jingtao Dou
The First Medical Center, Chinese PLA General Hospital

Weijun Gu
The First Medical Center, Chinese PLA General Hospital

Li Zang
The First Medical Center, Chinese PLA General Hospital

Saichun Zhang
The First Medical Center, Chinese PLA General Hospital

Zhaohui Lyu (metabolism301@126.com)
Chinese PLA General Hospital  https://orcid.org/0000-0002-3912-329X

Gang Chen
Fujian Provincial Hospital, Key Laboratory of Endocrinology, Fujian Medical University

Research article

Keywords: sleep duration, incidence of type 2 diabetes, prevalence

DOI: https://doi.org/10.21203/rs.3.rs-117460/v1

License: © This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License
Abstract

Objective: We assess the relationship between night sleep duration and the incidence of type 2 diabetes in China.

Methods: We used logistic regression models to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for the incidence of type 2 diabetes among 11,539 participants at baseline from the REACTION cohort.

Results: Compared to people who sleep for 7-8 h/night, people with a longer sleep duration (≥9 hours/night) had a greater risk of type 2 diabetes (hazard ratio [OR] 1.27; 95% confidence interval [CI]1.01–1.61), while shorter sleep (<6 h/night) had no significant difference. When the dataset was stratified based on selected covariates, the association between type 2 diabetes and long sleep duration became more evident among individuals < 65 years of age, male, body mass index<24 or with hypertension or hyperlipidemia, no interaction effects were observed. Furthermore, compared to people persistently sleeping 7–9 h/night, those who persistently slept ≥9 h/night had a higher risk of type 2 diabetes. The optimal sleep duration was 6.3-7.5 h/night.

Conclusion: Short or Long sleep duration were associated with a high risk of type 2 diabetes. Persistently long sleep duration increased the risk. The optimal sleep duration was 6.3-7.5 hours/night.

Introduction

Type 2 diabetes is a critical public health challenge worldwide. Patients with type 2 diabetes are at increased risk for premature mortality and hospitalization due to complications[1]. Given the global burden of type 2 diabetes, understanding the impacts of modifiable risk factors is of great importance.

Sleep is essential to the health of patients with type 2 diabetes[2]. Although humans spend about a third of their time sleeping, they may not understand the importance of it. Adequate high-quality sleep is vital to maintain the normal physiological state of the body[3]. Insufficient sleep is a health problem[4], and long sleep duration is associated with increased body mass index (BMI)[5], impaired glucose tolerance[6], and increased probability of developing type 2 diabetes[7, 8]. Although lifestyle changes, such as increasing physical activity and weight loss, are of great importance to the management of this disease, understanding the link between type 2 diabetes and sleep duration may help to reduce its incidence.

Short sleepers[9] and long sleepers[10] show increased incidence of type 2 diabetes. In addition, a study in Japan found a J-shaped relationship between sleep time and HbA1c level[11]. Therefore, this retrospective cohort study assessed the associations between both nighttime and daytime napping and risk for type 2 diabetes. We used data form the REACTION study cohort, which covered a 4-year period. To the best of our knowledge, no such study has yet explored this relationship in Chinese people with a risk for type 2 diabetes.

Methods

Study subjects

We used data from the REACTION cohort study, which investigated the association between type 2 diabetes and pre-type 2 diabetes and the risk of cancer in the Chinese population[12]. All subjects live in Laoshan, Jingding, and Gucheng communities of Beijing (China) or in Ningde and Wuyishan, Fujian Province (China). They were invited to complete baseline questionnaires and medical examinations in 2011. During the first follow-up survey in 2015, the same community were investigated, and the study had a total size of 13,311 participants.

In all, 1,556 subjects were diagnosed as type 2 diabetes in 2011 and 216 subjects lacked self-reported sleep duration or reported sleep durations of <4h/night or >12h/night. These subjects were excluded. The remaining 11,539 subjects (4,043 men, 7,496 women) were enrolled in the present study.

Standard protocol approvals, registrations, and patient consents

All participants provided written informed consent and all protocols were approved by the Ethical Committee of Chinese PLA General Hospital and Fujian Provincial Hospital.

Questionnaire

Nighttime and midday sleep time and sleep quality data were obtained through a self-administrated questionnaire[12]. Sleep duration was calculated from bedtime to waking time, and was categorized into 5 groups: <6, 6 to <7, 7 to <8, 8 to <9, or ≥9 h. Midday napping was divided into groups of no napping (0 min), 1–29, 30–59, 60–89, and ≥90 minutes. Sleep quality was divided into three groups: good, fair, and poor, with frequent use of hypnotics included in the fair group.

Assessment of covariates

Data such as age, sex, smoking status and drinking status were collected during the baseline investigation by trained doctors using a detailed questionnaire. Smoking and alcohol consumption were classified into three levels: current, occasional, and never. Subjects who smoke at least 1 cigarette per day for more than half a year were defined as current smokers[13]. Subjects who drink at least 1 time per week for more than half a year were defined as current drinkers[14]. The first level was regarded as positive responses.
**Statistical analysis**

We performed all analyses with Stata statistical software, ver. 14.2 (Stata Corp, College Station, TX, USA). Data were compared using analysis of variance (ANOVA) for continuous variables and χ² analysis for categorical variables. Continuous variables are expressed as mean ± standard deviation (SD), and categorical variables are expressed as number and proportion.

Binary logistic regression was constructed to assess the ORs and 95% confidence intervals (CIs) of sleep duration and type 2 diabetes using sleep duration of 7 to 8 h/night as the reference groups, as previous studies have suggested that sleeping for 7-8 h [15, 16] is optimal. Potential covariates included in the multivariate-adjusted model were age, gender, body mass index, smoking and drinking status, hypertension and hyperlipidemia. Considering that type 2 diabetes risk might follow nonlinear trends, we used restricted cubic spline model with 3 knots at 25th, 50th and 75th percentiles of sleep duration and 7 h/night as the reference group [8, 17]. Subjects were divided into several groups by age (<65, ≥65 years), sex (male, female), BMI (<24, ≥24 kg/m²) [18], hypertension (yes, no), and hyperlipidemia (yes, no). In addition, potential interactions were tested using interaction terms of these covariates with sleep duration.

We evaluated the association between changes in sleep duration and incidence of type 2 diabetes. This association was examined using crude and multivariate-adjusted models, with subjects persistently sleeping 7–9 h/night in both surveys as the reference group.

We further evaluated the joint effects of sleep duration and midday napping and that of sleep duration and sleep quality on the risk of developing diabetes, using moderate sleep duration (7–8 h/night) with midday napping (1–29 min), and moderate sleep duration (7–8 h/night) with good sleep quality as the reference groups.

**Results**

Among 11,539 subjects, 13.11% (1,513) reported sleeping ≥ 9 h/night and 5.18% (598) reported sleeping ≥ 9 hours/night of sleep were more likely to be male, hypertension and hyperlipidemia, current smokers, current drinkers (<60 minutes were more likely to be male, hypertension and hyperlipidemia, subjects with 1–29 minutes of midday napping, those reporting midday napping ≥ 90 minutes were more likely to be female, current smokers, and current drinkers. Meanwhile, compared to 7–8 h/night of sleep, those reporting sleep duration ≥ 9 h/night were more likely to be female, current smokers, and current drinkers. Meanwhile, compared to the reference groups, participants reporting ≥ 9 hours/night of sleep were more likely to be male, hypertension and hyperlipidemia, current smokers, current drinkers (p < 0.05). In addition, compared to the reference groups, participants reporting ≥ 9 hours/night of sleep were less likely to have hypertension and hyperlipidemia (Table 1).

| Sleep duration, h/night | Midday napping, min |
|-------------------------|---------------------|
| Variables               | F/χ² | Ρ* |
| < 6 (n = 549)           | 0    | 1  |
| 6 to < 7 (n = 1649)     | 0    | 1  |
| 7 to < 8 (n = 4162)     | 0    | 1  |
| 8 to < 9 (n = 3666)     | 0    | 1  |
| ≥ 9 (n = 1513)          | 0    | 1  |
| Age, y                  |       |    |
| 62.03 ± 9.14            | 0.01  | 1  |
| 61.10 ± 9.37            | 0.01  | 1  |
| 61.14 ± 9.17            | 0.01  | 1  |
| 61.07 ± 9.58            | 0.01  | 1  |
| 60.25 ± 10.22           | 0.01  | 1  |
| 4.31                    |       |    |
| ≤ 0.01                  |       |    |
| Midday napping, min     |       |    |
| 516/997/1225/2441       | 0.04  | 1  |
| 10.12                   |       |    |
| Male/female             |       |    |
| 203/346/615/1034        | 0.01  | 1  |
| 1484/2678/1225/2441     | 0.01  | 1  |
| 516/997/1225/2441       | 0.01  | 1  |
| 10.12                   |       |    |
| BMI, kg/m²              |       |    |
| 25.39 ± 3.35            | 0.08  | 1  |
| 25.40 ± 3.29            | 0.08  | 1  |
| 25.24 ± 3.34            | 0.08  | 1  |
| 25.23 ± 3.31            | 0.08  | 1  |
| 25.08 ± 3.41            | 0.08  | 1  |
| 2.11                    |       |    |
| ≤ 0.01                  |       |    |
| Smoking                 |       |    |
| 109                     | 0.01  | 1  |
| 284                     | 0.01  | 1  |
| 673                     | 0.01  | 1  |
| 536                     | 0.01  | 1  |
| 255                     | 0.01  | 1  |
| 13.86                   |       |    |
| ≤ 0.01                  |       |    |
| Drinking                |       |    |
| 79                      | 0.01  | 1  |
| 246                     | 0.01  | 1  |
| 494                     | 0.01  | 1  |
| 397                     | 0.01  | 1  |
| 187                     | 0.01  | 1  |
| 20.77                   |       |    |
| ≤ 0.01                  |       |    |
| Good Sleep quality      |       |    |
| 197                     | 0.01  | 1  |
| 312                     | 0.01  | 1  |
| 512                     | 0.01  | 1  |
| 403                     | 0.01  | 1  |
| 209                     | 0.01  | 1  |
| 286.25                  |       |    |
| ≤ 0.01                  |       |    |
| Comorbidities           |       |    |
| Hypertension            | 142   | 1  |
| Hyperlipidemia          | 86    | 1  |
| Abbreviation: BMI = body mass index. Data mean (SD) are presented for continuous variables. *p Values were derived from ANOVA for continuous variables and χ² tests for categorical variables.

During the follow-up investigation, we documented 694 type 2 diabetes. Compared to people who slept for 7–8 h/night, the ORs (95% CIs) of type 2 diabetes were 1.21 (0.85–1.72) for < 6 hours/night, 0.91 (0.70–1.17) for 6–7 hours/night, 1.03 (0.85–1.24) for 8–9 hours/night, and 1.27 (1.01–1.61) for ≥ 9 hours/night.
hours/night ($p = 0.04$), respectively. After adjusting for age (continuous), sex, body mass index (continuous), smoking status (yes or no), drinking status (yes or no), hypertension (yes or no), hyperlipidemia (yes or no), similar associations were observed for those obtaining $\geq 9$ h/night of sleep ($p = 0.02$) (Table 2). Compared to participants napping for 1–29 minutes, the ORs (95% CIs) of type 2 diabetes were 1.30 (0.53–3.20) for those reporting no midday napping, 1.04 (0.38–2.83) for 30–59 minutes, 1.02 (0.39–2.65) for 60–89 minutes, and 1.27 (0.48–3.31) for midday napping $\geq 90$ minutes. In addition, no significant association was observed between these groups after adjusting for age, sex, body mass index, smoking status, drinking status, type 2 diabetes mellitus, hyperlipidemia. Restricted cubic spline regression analysis showed a J-shaped curve and confirmed that people who slept $\geq 9$ h/night had a high risk of type 2 diabetes (Fig. 1). The optimal nighttime sleep duration was 7.2–7.5 h, and it was 6.3–7.5 h after adjusting for all variables. When stratified by selected covariates, the association between type 2 diabetes and long sleep duration became more evident in individuals who were < 65 years of age, male, body mass index < 24 or with hypertension or hyperlipidemia, no interaction effects was observed (Fig. 2).

| Variable                  | Model 1: crude | Model 2: adjusted OR (95% CI)* | P  | OR (95% CI) | P  |
|---------------------------|----------------|--------------------------------|----|-------------|----|
| Sleep duration, hours/night |                |                                |    |             |    |
| < 6                       | 38/549         | 1.21 (0.85–1.72)               | 0.29 | 1.15 (0.80–1.64) | 0.45 |
| 6 to < 7                  | 87/1649        | 0.91 (0.70–1.17)               | 0.44 | 0.90 (0.70–1.64) | 0.43 |
| 7 to < 8                  | 241/4162       | 1                              | 1   | 1           | 1   |
| 8 to < 9                  | 218/3666       | 1.03 (0.85–1.24)               | 0.77 | 1.04 (0.86–1.26) | 0.68 |
| $\geq$ 9                  | 110/1513       | 1.27 (1.01–1.61)               | 0.04 | 1.32 (1.05–1.68) | 0.02 |
| Midday napping, minutes   |                |                                |    |             |    |
| 0                         | 596/9678       | 1.30 (0.53–3.20)               | 0.57 | 1.10 (0.44–2.74) | 0.84 |
| 1–29                      | 5/104          | 1                              | 1   | 1           | 1   |
| 30–59                     | 20/402         | 1.04 (0.38–2.83)               | 0.94 | 1.39 (0.50–3.82) | 0.53 |
| 60–89                     | 37/757         | 1.02 (0.39–2.65)               | 0.97 | 1.30 (0.49–3.42) | 0.60 |
| $\geq$ 90                 | 36/598         | 1.27 (0.48–3.31)               | 0.63 | 1.53 (0.58–4.02) | 0.39 |

Abbreviations: CI = confidence interval; OR = odds ratio.

*Adjusted for age (continuous), sex, body mass index (continuous), smoking status (current, former, or never), drinking status (current, former, or never), hypertension (yes or no), and hyperlipidemia (yes or no).

Table 3 shows the relationship between change in sleep time with type 2 diabetes. Compared to participants who reported between 7–9 h of sleep in both surveys, those who reported sleeping $\geq 9$ hours in both surveys showed ORs of 1.51 (95% CI 1.05–2.17) and 1.54 (95% CI 1.07–2.24), indicating higher risk of diabetes. In addition, after adjusting for all variables, the OR was 1.54 (95% CI 1.07–2.24).
### Table 3

Association of change in sleep duration between surveys with type 2 diabetes

| Variable                      | Model 1: crude | *Model 2: adjusted OR (95% CI) | P | OR (95% CI) | P |
|-------------------------------|----------------|-------------------------------|---|-------------|---|
| **Sleep duration, hours/night in 2011** | **Sleep duration, hours/night in 2015** | cases/total | OR(95% CI) | P | OR(95% CI) | P |
| 7–9                           | 7–9            | 164/2713                      | 1 | 1           | 1 |
| ≤ 7                           | 7–9            | 74/1184                       | 1.04(0.78–1.38) | 0.81 | 0.98(0.74–1.31) | 0.91 |
| ≥ 9                           | 7–9            | 47/702                        | 1.12(0.80–1.56) | 0.52 | 1.13(0.80–1.58) | 0.50 |
| ≤ 7                           | ≤ 7            | 183/3282                      | 0.92(0.74–1.14) | 0.44 | 0.86(0.69–1.07) | 0.19 |
| 7–9                           | ≤ 7            | 125/2239                      | 0.92(0.72–1.67) | 0.49 | 0.88(0.69–1.12) | 0.29 |
| ≥ 9                           | ≤ 7            | 24/370                        | 1.08(0.69–1.68) | 0.74 | 1.03(0.66–1.61) | 0.90 |
| ≤ 7                           | ≥ 9            | 8/158                         | 0.83(0.40–1.72) | 0.61 | 0.83(0.40–1.72) | 0.61 |
| 7–9                           | ≥ 9            | 30/450                        | 1.11(0.74–1.66) | 0.61 | 1.11(0.74–1.67) | 0.62 |
| ≥ 9                           | ≥ 9            | 39/441                        | 1.51(1.05–2.17) | 0.03 | 1.54(1.07–2.24) | 0.02 |

Abbreviations: CI = confidence interval; OR = odds ratio.

*adjusted for age (continuous), sex, body mass index (continuous), smoking status (current, former, or never), drinking status (current, former, or never), hypertension (yes or no) and hyperlipidemia (yes or no).

We further explored the combined effect of sleep duration and midday napping and that of sleep duration and sleep quality on the risks of type 2 diabetes. Compared to those who reported moderate lengths of nighttime (7–8 h/night) and midday sleep (1–29 minutes), participants with long sleep duration at night (≥ 9 hours/night) and midday (> 90 minutes) had a higher risk of diabetes (OR 2.28, 95% CI 0.83–6.26) (Table 4). Subjects with ≥ 9 hours/night of sleep and good sleep quality (OR 1.31, 95% CI 1.02–1.69) had a high risk of diabetes than those who reported moderate nighttime sleep duration (7–8 h/night) and good sleep quality. After adjustments, the OR was 1.37 (95% CI 1.06–1.77) (Table 5).
### Table 4

**Joint effects of sleep duration and midday napping on incidence of diabetes**

| Variable | Model 1: crude |  | Model 2: adjusted OR (95% CI) |  |
|----------|----------------|-----------------|-------------------------------|---|
| Sleep duration, hours/night in 2011 | Midday napping min/day | cases/total | OR(95% CI) | P | OR(95% CI) | P |
| 7<8 | 0 | 216/3553 | 1.16(0.58–2.30) | 0.68 | 0.81(0.40–1.61) | 0.54 |
| 7<8 | 1–29 | 9/170 | 1 | 1 |
| 7<8 | 30–89 | 13/341 | 0.71(0.30–1.69) | 0.44 | 0.75(0.31–1.79) | 0.51 |
| 7<8 | ≥ 90 | 3/98 | 0.57(0.15–2.14) | 0.40 | 0.57(0.15–2.16) | 0.37 |
| < 7 | 0 | 96/1760 | 1.03(0.51–2.08) | 0.93 | 0.70(0.34–1.42) | 0.32 |
| < 7 | 1–29 | 7/112 | 1.19(0.43–3.30) | 0.73 | 1.21(0.43–3.37) | 0.72 |
| < 7 | 30–89 | 15/244 | 1.17(0.50–2.74) | 0.72 | 1.12(0.48–2.65) | 0.79 |
| < 7 | ≥ 90 | 7/82 | 1.67(0.60–4.65) | 0.33 | 1.54(0.55–4.36) | 0.41 |
| 8–<9 | 0 | 191/3164 | 1.15(0.58–2.28) | 0.69 | 0.81(0.40–1.63) | 0.55 |
| 8–<9 | 1–29 | 2/126 | 0.29(0.06–1.36) | 0.12 | 0.33(0.07–1.55) | 0.16 |
| 8–<9 | 30–89 | 19/300 | 1.21(0.54–2.741) | 0.65 | 1.26(0.55–2.86) | 0.59 |
| 8–<9 | ≥ 90 | 6/76 | 1.53(0.53–4.47) | 0.43 | 1.53(0.52–4.51) | 0.44 |
| ≥ 9 | 0 | 93/1201 | 1.50(0.74–3.04) | 0.26 | 1.06(0.52–2.17) | 0.87 |
| ≥ 9 | 1–29 | 4/64 | 1.19(0.35–4.02) | 0.78 | 1.15(0.34–3.92) | 0.83 |
| ≥ 9 | 30–89 | 5/179 | 0.51(0.17–1.57) | 0.24 | 0.56(0.18–1.71) | 0.31 |
| ≥ 9 | ≥ 90 | 8/69 | 2.35(0.87–6.36) | 0.09 | 2.28(0.83–6.26) | 0.11 |

**Abbreviations:** CI = confidence interval; OR = odds ratio.

*adjusted for age (continuous), sex, body mass index (continuous), smoking status (current, former, or never), drinking status (current, former, or never), hypertension (yes or no) and hyperlipidemia (yes or no).

### Table 5

**Joint effects of sleep duration and sleep quality on the incidence of type 2 diabetes**

| Variable | Model 1: crude |  | Model 2: adjusted OR (95% CI)* |
|----------|----------------|-----------------|-------------------------------|
| Sleep duration, hours/night in 2011 | Sleep quality | cases/total | OR(95% CI) | P | OR(95% CI) | P |
| 7<8 | 1 | 204/3650 | 1.32(0.92–1.89) | 0.14 | 1.39(0.96–2.01) | 0.08 |
| 7<8 | 2 | 37/512 | 0.99(0.77–1.28) | 0.97 | 0.98(0.76–1.26) | 0.86 |
| ≤ 7 | 1 | 94/1689 | 1.10(0.74–1.66) | 0.65 | 1.12(0.75–1.66) | 0.58 |
| 8–<9 | 1 | 197/3263 | 1.09(0.89–1.33) | 0.43 | 1.10(0.90–1.35) | 0.35 |
| 8–<9 | 2 | 21/403 | 0.93(0.59–1.47) | 0.75 | 0.97(0.61–1.54) | 0.89 |
| ≥ 9 | 1 | 94/1304 | 1.31(1.02–1.69) | 0.04 | 1.37(1.06–1.77) | 0.02 |
| ≥ 9 | 2 | 16/209 | 1.40(0.83–2.38) | 0.21 | 1.46(0.85–2.50) | 0.17 |

### Discussion

In this large retrospective cohort study, we found that subjects who slept more than 9 h per night had a high risk of type 2 diabetes. Moreover, optimal sleep duration at night was 6.3–7.5 h after adjusting for age, sex, body mass index, smoking status, drinking status, hypertension and hyperlipidemia. To avoid an influence of region on our results, we selected people in both the northern and southern regions of China. To the best of our knowledge, this is the first
This work was supported by National Key R&D Program of China (2018YFC1314100). We thank the Department of Endocrinology, The First Medical Center, Chinese PLA General Hospital and the Department of Endocrinology, Fujian Provincial Hospital.

Funding

This work was supported by National Key R&D Program of China (2018YFC1314100)
Duality of Interest

No potential conflicts of interest relevant to this article were reported.

Authors' contributions

ZH L and GC designed the experiment. HZ L, AP W and JP W performed the experiment, analyzed data and wrote the manuscript. YM M, JT D, WJ G, SC Z and LZ edited the manuscript.

References

1. Group IDF. Update of mortality attributable to diabetes for the IDF Diabetes Atlas: Estimates for the year 2013. Diabetes Res Clin Pract 2015, 109(3):461-465.
2. Alnaji A, Law GR, Scott EM: The role of sleep duration in diabetes and glucose control. Proc Nutr Soc 2016, 75(4):512-520.
3. Gallicchio L, Kalesan B: Sleep duration and mortality: a systematic review and meta-analysis. J Sleep Res 2009, 18(2):148-158.
4. Prevention. CDC: Epidemic ISLPh: 2014. Available at: http://www.cdc.gov/sleep/pubs/2014/CDC-report.pdf.
5. Patel SR, Malhotra A, White DP, Gottlieb DJ, Hu FB: Association between reduced sleep and weight gain in women. Am J Epidemiol 2006, 164(10):947-954.
6. Spiegel K, Leprotte R, Van Cauter E: Impact of sleep debt on metabolic and endocrine function. Lancet 1999, 354(9188):1435-1439.
7. Cespedes EM, Dudley KA, Sotres-Alvarez D, Zee PC, Daviglus ML, Shah NA, Talavera GA, Gallo LC, Mattei J, Qi Q et al.: Joint associations of insomnia and sleep duration with prevalent diabetes: The Hispanic Community Health Study/Study of Latinos (HCHS/SOL). J Diabetes 2016, 8(3):387-397.
8. Yaggi HK, Araujo AB, Mckinlay JB: Sleep duration as a risk factor for the development of type 2 diabetes. Diabetes Care 2006, 29(3):657-661.
9. Kim CR, Song Y-M, Shin J-Y, Gim W: Association between Sleep Duration and Impaired Fasting Glucose in Korean Adults: Results from the Korean National Health and Nutrition Examination Survey 2011-2012. Korean J Fam Med 2016, 37(1):51-56.
10. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA: Quantity and quality of sleep and incidence of type 2 diabetes: a systematic review and meta-analysis. Diabetes care 2010, 33(2):414-420.
11. Ohkuma T, Fuji H, Iwase M, Kikuchi Y, Ogata S, Idewaki Y, Ide H, Doi Y, Hirakawa Y, Nakamura U et al.: Impact of sleep duration on obesity and the glycemic level in patients with type 2 diabetes: the Fukuoka Diabetes Registry. Diabetes Care 2013, 36(3):611-617.
12. Ning G: Risk Evaluation of cAnCers in Chinese diabeTic Individuals: a IONgitudinal (REACTION) study. J Diabetes 2012, 4(2):172-173.
13. Yang G, Fan L, Tan J, Qi G, Zhang Y, Samet JM, Taylor CE, Becker K, Xu J: Smoking in China: findings of the 1996 National Prevalence Survey. JAMA 1999, 282(13):1247-1253.
14. Yuan JM, Ross RK, Gao YT, Henderson BE, Yu MC: Follow up study of moderate alcohol intake and mortality among middle aged men in Shanghai, China. Brmj 1997, 314(7073):18-23.
15. Kwok CS, Kontopantelis E, Kuligowski G, Gray M, Muhyaldeen A, Gale CP, Peat GM, Cleator J, Chew-Graham C, Loke YK et al.: Self-Reported Sleep Duration and Quality and Cardiovascular Disease and Mortality: A Dose-Response Meta-Analysis. J Am Heart Assoc 2018, 7(15):e008552.
16. Yamada T, Hara K, Shojima N, Yamauchi T, Kadowaki T: Daytime Napping and the Risk of Cardiovascular Disease and All-Cause Mortality: A Prospective Study and Dose-Response Meta-Analysis. Sleep 2015, 38(12):1945-1953.
17. Desquilbet L, Mariotti F: Dose-response analyses using restricted cubic spline functions in public health research. Stat Med 2010, 29(9):1037-1057.
18. Ren Q, Su C, Wang H, Wang Z, Du W, Zhang B: Change in Body Mass Index and Its Impact on Incidence of Hypertension in 18-65-Year-Old Chinese Adults. Int J Environ Res Public Health 2016, 13(3).
19. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA: Quantity and quality of sleep and incidence of type 2 diabetes: a systematic review and meta-analysis. Diabetes Care 2010, 33(2):414-420.
20. Fang W, Li Z, Wu L, Cao Z, Liang Y, Yang H, Wang Y, Wu T: Longer habitual afternoon napping is associated with a higher risk for impaired fasting plasma glucose and diabetes mellitus in older adults: results from the Dongfeng-Tongji cohort of retired workers. Sleep Med 2013, 14(10):950-954.
21. Lam KB, Jiang CQ, Thomas GN, Arora T, Zhang WS, Taheri S, Adab P, Lam TH, Cheng KK: Napping is associated with increased risk of type 2 diabetes: the Guangzhou Biobank Cohort Study. Sleep 2010, 33(3):402-407.
22. Zhou J, Kessler AS, Su D: Association between Daytime Napping and Chronic Diseases in China. Am J Health Behav 2016, 40(2):182-193.
23. Hublin C, Lehtovirta M, Partinen M, Koskenvuo M, Kaprio J: Napping and the risk of type 2 diabetes: a population-based prospective study. Sleep Med 2016, 17:144-148.
24. Xu Q, Song Y, Hollenbeck A, Blair A, Schatzkin A, Chen H: Day napping and short night sleeping are associated with higher risk of diabetes in older adults. Diabetes Care 2010, 33(1):78-83.
25. Yoon IY, Kripke DF, Elliott JA, Youngstedt SD, Rex KM, Hauger RL: Age-related changes of circadian rhythms and sleep-wake cycles. J Am Geriatr Soc 2003, 51(8):1085-1091.
26. Singh R, Kluding PM: Fatigue and related factors in people with type 2 diabetes. Diabetes Educ 2013, 39(3):320-326.
27. Jemere T, Mossie A, Berhanu H, Yeshaw Y: Poor sleep quality and its predictors among type 2 diabetes mellitus patients attending Jimma University Medical Center, Jimma, Ethiopia. *BMC Res Notes* 2019, 12(1):488.

28. Taheri S, Lin L, Austin D, Young T, Mignot E: Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. *PLoS Med* 2004, 1(3):e62.

29. Reutrakul S, Van Cauter E: Sleep influences on obesity, insulin resistance, and risk of type 2 diabetes. *Metabolism* 2018, 84:56-66.

30. Tsao TS, Lodish HF, Fruebis J: ACRP30, a new hormone controlling fat and glucose metabolism. *Eur J Pharmacol* 2002, 440(2-3):213-221.

31. Berg AH, Combs TP, Scherer PE: ACRP30/adiponectin: an adipokine regulating glucose and lipid metabolism. *Trends Endocrinol Metab* 2002, 13(2):84-89.

32. Reutrakul S, Mokhlesi B: Obstructive Sleep Apnea and Diabetes: A State of the Art Review. *Chest* 2017, 152(5):1070-1086.

33. Johns MW: A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep* 1991, 14(6):540-545.

34. Tan X, Chapman CD, Cedernaes J, Benedict C: Association between long sleep duration and increased risk of obesity and type 2 diabetes: A review of possible mechanisms. *Sleep Med Rev* 2018, 40:127-134.

35. Knutson KL, Van Cauter E, Zee P, Liu K, Lauderdale DS: Cross-sectional associations between measures of sleep and markers of glucose metabolism among subjects with and without diabetes: the Coronary Artery Risk Development in Young Adults (CARDIA) Sleep Study. *Diabetes Care* 2011, 34(5):1171-1176.