Relationship between sleep duration and hypertension in northeast China: a cross-sectional study

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ABSTRACT

Objectives Previous studies have reported that short sleep duration might increase the risk of hypertension. However, the results have been conflicting. We investigated whether sleep duration is independently associated with hypertension. We aimed to assess the relationship between sleep duration and hypertension in a population-based cross-sectional study.

Methods In this study we used multistage stratified cluster sampling. A total of 19,407 adults aged 18–79 years were enrolled in the study. The participants were divided into three groups (<7 hours/day, 7–8 hours/day and >8 hours/day) according to self-reported sleep duration. Hypertension was defined as systolic blood pressure $\geq 140$ mm Hg or diastolic blood pressure $\geq 90$ mm Hg or the use of anti-hypertensive medications. Univariate and multivariate logistic regressions were performed to determine the association between hypertension and sleep duration adjusted for sociodemographic, body mass index, and lifestyle covariates.

Results The overall prevalence of hypertension was 32.6%. Among participants aged 18–44 years, individuals sleeping less than 7 hours per day had a higher risk of hypertension (OR=1.24, 95% CI: 1.05 to 1.46), compared with those who slept 7–8 hours per day. There were no significant associations between sleep duration and hypertension in the total sample, among middle-aged adults (45–59 years) or older adults (60–79 years).

Conclusions Our study demonstrates that short sleep duration was significantly associated with hypertension among people aged 18–44 years in northeast China.

INTRODUCTION

In many countries, the diagnosis of hypertension is based on a systolic blood pressure (SBP) of at least 140 mm Hg, a diastolic blood pressure (DBP) of at least 90 mm Hg or both.12 In 2000, the overall prevalence of hypertension was 26.4% worldwide.5 In 2010, hypertension was the leading single contributor to global mortality, being responsible for more than 9 million deaths.4 Data from the National Health and Nutrition Examination Survey (NHANES) in 2011–2012 estimated the overall prevalence of hypertension among US adults aged 18 and over was 29.1% (29.7% men and 28.5% women).5

The latest data from the Global Burden of Disease Study in 2015 showed that high SBP continues to be the largest contributor to global disability-adjusted life-years (DALYs), causing 211.8 million global DALYs each year.6 According to a previous study,7 hypertension is a major risk factor for cardiovascular disease (CVD), heart attack, heart failure, stroke and kidney disease. Studies have shown that sleep duration is associated with hypertension.8 9 Short sleep duration, usually defined as less than 7 hours, 6 hours or 5 hours per night,10 was associated with an increased risk of prevalent hypertension.11 12 The relationship between self-reported sleep duration and hypertension was first reported as a U-shaped association in the Sleep Heart Health Study (SHHS).13 In the study, Gottlieb et al found that sleep duration of less than 7 hours per night and more than 8 hours per night was associated with an increased prevalence of hypertension. The results from the NHANES also demonstrated an association between sleep duration of less than 5 hours per night and an increased risk of hypertension in the same year.14 However, there are conflicting results. A community-based 7-site study15 came to the conclusion that sleep duration was unrelated to blood pressure cross-sectionally or longitudinally in midlife.
women. Similarly, a study among non-insomniac elderly subjects\textsuperscript{16} indicated that sleep duration was not associated with the prevalence of hypertension. Therefore, the relationship between sleep duration and hypertension needs to be further investigated.

In this study, we investigated the relationship between self-reported sleep duration and hypertension among subjects who participated in a representative population-based survey from the Jilin province in northeast China. Moreover, the role of age and sex in the relationship between sleep duration and hypertension was also evaluated.

METHODS

Study design and population

This study was embedded in the Jilin Provincial Chronic Disease Survey, a population-based cross-sectional study conducted from June 2012 to August 2012. A multi-stage, stratified, cluster sampling method was used to select a representative sample of community-dwelling residents who had lived in nine regions of Jilin Province (Changchun, Jilin, Siping, Liaoyuan, Tonghua, Baishan, Songyuan, Baicheng and Yanbian) for at least 6 months. The detailed stratifying process was reported previously.\textsuperscript{17} A total of 23 050 individuals were recruited and 21 435 of them completed the survey (84.9\% response rate). In this study, 2028 subjects were excluded from the statistical analyses due to missing data on marital status, occupation, income, height, weight, SBP or DBP, yielding a final sample size of 19 407 subjects. Among the 2028 excluded subjects (1218 men and 809 women), the mean age was 47.07 years (SD 13.40, range 18–79 years).

We adhered to the bioethics principles of the Declaration of Helsinki.

Definition of major variables

After at least 5 min of rest, two blood pressure measurements were made with the participants in a seated position, using appropriately sized cuffs and calibrated electronic sphygmomanometers (OMRON-HM-7200, Omron, Kyoto, Japan). The mean of the two blood pressure measurements taken at 2 min intervals was used in the analyses. In our study, hypertension was defined as SBP ≥140 mm Hg or DBP ≥90 mm Hg or the current use of anti-hypertensive medication.

Self-reported sleep duration was assessed by the following question: ‘On average, how many hours of actual sleep did you get each day (24 hours) during the past month?’ The results were categorised into three groups for analysis: <7 hours/day, 7–8 hours/day and ≥8 hours/day, and we chose the category of 7–8 hours/day as the reference group in accordance with a previous study.\textsuperscript{13}

A structured questionnaire was used to collect sociodemographic information of the participants, and the measured characteristics included gender (male, female), age (18–44, 45–59, 60–79 years), education (elementary, junior, senior, university), marital status (married, unmarried, separated/divorced, widowed), occupation (manual labour, mental labour, unemployed, retired) and family monthly income per capita (<1000, 1000–3000, >3000 RMB). The BMI was measured, calculated as weight (kg)/height squared (kg/m\textsuperscript{2}). Participants were categorised as underweight (BMI <18.5 kg/m\textsuperscript{2}), normal weight (BMI=18.5 to 25 kg/m\textsuperscript{2}), overweight (BMI=25.0 to 30.0 kg/m\textsuperscript{2}) or obese (BMI >30.0 kg/m\textsuperscript{2}).\textsuperscript{18} Other variables, including smoking status (yes, no, former), drinking (yes, no), salt intake (high salt, light, moderate) and physical exercise (frequently, occasionally, never) were assessed. A smoker was defined as a person who had smoked at least one cigarette a day over the past 30 days; a former smoker was defined as a person who had smoked more than 100 cigarettes cumulatively, but had quit smoking or had not reached the current smoking level at the time of the survey; participants who reported never having smoked 100 cigarettes were defined as never-smokers. A drinker was defined as a person who consumed an average of more than one alcoholic drink per week. Based on self-reported results, we divided the salt intake into three categories: high salt, light and moderate. Participants who exercised more than three times a week were defined as ‘exercise frequently’; those who exercised one or two times a week were defined as ‘exercise occasionally’; and those who usually exercised less than once a week were defined as ‘never exercise’.

Statistical analysis

Data were analysed using SPSS software (V. 24.0, IBM). \( \chi^2 \) tests were used to test the association between hypertension and categorical, potentially confounding variables. A p value of less than 0.05 was considered statistically significant. After preliminary univariate analyses, we used logistic regression models to examine the effect of sleep duration on the risk of hypertension, and the OR and 95\% CIs were calculated. Four regression models were generated. The first model (model 1) was generated without adjusting for any covariates. Covariates in the first adjusted multivariate model (model 2) included age, gender, education, marital status, occupation and family per capita monthly income. Model 3 adjusted for factors in model 2 plus BMI. Finally, model 4 was further adjusted for smoking, drinking, salt intake and physical exercise. The dependent variable was the presence of hypertension. In addition, we performed subgroup analysis stratified by age and sex.

Patient and public involvement

No patients were involved in the design of this study, the specific aims or the research questions, nor were they involved in the recruitment and conduct of the study. No patients were involved in the interpretation of study results or write-up of the manuscript. There are no plans to disseminate the results of the research to study participants.
The baseline characteristics of the study population according to sleep duration levels are presented in table 1. Of the 19,407 participants in our study (53.0% women; mean age: 47.53 years; SD: 13.13 years; range: 18–79 years), the median reported sleep duration of the study population was 7 hours per day, and an average sleep duration of 8 or more hours per day was reported by 37.8% of the study population. Significant differences were observed between sleep duration and sex, age, education, marital status, occupation, income, smoking, drinking, salt intake, exercise and BMI. Subjects with short sleep durations were slightly older, heavier and reported a sleep duration of less than 7 hours per day, and an average sleep duration of 8 or more hours per day was reported by 37.8% of the study population. Significant differences were observed between sleep duration and sex, age, education, marital status, occupation, income, smoking, drinking, salt intake, exercise and BMI. Subjects with short sleep durations were slightly older, heavier and

### Table 1: Characteristics of the three groups stratified according to sleep duration

| Characteristic          | Group                          | <7 hours/day | 7–8 hours/day | >8 hours/day | χ²  | P value |
|-------------------------|-------------------------------|--------------|---------------|--------------|-----|---------|
| Numbers of subjects     |                               | 7106 (36.6)  | 4964 (25.6)   | 7337 (37.8)  |     |         |
| Sex                     | Male                          | 3364 (36.9)  | 2406 (26.4)   | 3348 (36.7)  | 10.143 | 0.006  |
|                         | Female                        | 3742 (36.4)  | 2558 (24.9)   | 3989 (38.7)  |     |         |
| Age                     | 18–44                         | 2100 (26.5)  | 2148 (27.1)   | 3683 (46.4)  | 660.611 | <0.001 |
|                         | 45–59                         | 3295 (42.9)  | 1940 (25.3)   | 2440 (31.8)  |     |         |
|                         | 60–79                         | 1711 (45.0)  | 876 (23.1)    | 1214 (31.9)  |     |         |
| Education               | Elementary                    | 2316 (40.0)  | 1362 (23.5)   | 2111 (36.5)  | 109.944 | <0.001 |
|                         | Junior                        | 1999 (35.7)  | 1447 (25.8)   | 2154 (38.5)  |     |         |
|                         | Senior                        | 1887 (38.1)  | 1232 (24.9)   | 1833 (37.0)  |     |         |
|                         | University                    | 904 (29.5)   | 923 (30.1)    | 1239 (40.4)  |     |         |
| Marital status          | Married                       | 6101 (36.4)  | 4321 (25.7)   | 6360 (37.9)  | 184.756 | <0.001 |
|                         | Unmarried                     | 343 (25.9)   | 366 (27.7)    | 613 (46.4)   |     |         |
|                         | Separated/divorced            | 180 (49.8)   | 75 (20.8)     | 106 (29.4)   |     |         |
|                         | Widowed                       | 482 (51.2)   | 202 (21.4)    | 258 (27.4)   |     |         |
| Occupation              | Manual labour                 | 3241 (35.4)  | 2294 (25.1)   | 3622 (39.5)  | 172.040 | <0.001 |
|                         | Mental labour                 | 2071 (33.5)  | 1653 (26.7)   | 2461 (39.8)  |     |         |
|                         | Unemployed                    | 741 (40.9)   | 450 (24.9)    | 618 (34.2)   |     |         |
|                         | Retired                       | 1053 (46.7)  | 567 (25.1)    | 636 (28.2)   |     |         |
| Income (RMB)            | <1000                         | 3032 (38.2)  | 1927 (24.2)   | 2990 (37.6)  | 29.632 | <0.001 |
|                         | 1000–3000                     | 3452 (36.2)  | 2503 (26.3)   | 3570 (37.5)  |     |         |
|                         | >3000                         | 622 (32.2)   | 534 (27.6)    | 777 (40.2)   |     |         |
| Smoking                 | Never                         | 4094 (34.5)  | 3061 (25.8)   | 4717 (39.7)  | 69.354 | <0.001 |
|                         | Yes                           | 2375 (39.8)  | 1503 (25.2)   | 2092 (35.0)  |     |         |
|                         | Ever                          | 637 (40.7)   | 400 (25.6)    | 528 (33.7)   |     |         |
| Drinking                | No                            | 4786 (35.9)  | 3391 (25.4)   | 5163 (38.7)  | 15.863 | <0.001 |
|                         | Yes                           | 2320 (38.3)  | 1573 (25.9)   | 2174 (35.8)  |     |         |
| Salt intake             | Moderate                      | 2283 (34.0)  | 1767 (26.3)   | 2670 (39.7)  | 31.938 | <0.001 |
|                         | High salt                     | 2777 (37.9)  | 1856 (25.3)   | 2699 (36.8)  |     |         |
|                         | Light                         | 2046 (38.2)  | 1341 (25.0)   | 1968 (36.8)  |     |         |
| Physical exercise       | Never                         | 3326 (36.7)  | 2249 (24.9)   | 3477 (38.4)  | 112.339 | <0.001 |
|                         | Frequently                    | 2342 (40.4)  | 1522 (26.2)   | 1936 (33.4)  |     |         |
|                         | Occasionally                  | 1438 (31.6)  | 1193 (26.2)   | 1924 (42.2)  |     |         |
| Body mass index (BMI)   | Normal weight                 | 3915 (35.8)  | 2797 (25.6)   | 4223 (38.6)  | 39.105 | <0.001 |
|                         | Underweight                   | 260 (30.7)   | 205 (24.2)    | 381 (45.1)   |     |         |
|                         | Overweight                    | 2462 (38.5)  | 1648 (25.8)   | 2286 (35.7)  |     |         |
|                         | Obese                         | 469 (38.2)   | 314 (25.5)    | 447 (36.3)   |     |         |
had a lower level of education than subjects sleeping 7 to 8 hours per day (table 1). They were also more likely to be men, smokers, drinkers and have a high salt diet. Individuals with more hours of sleep per night were younger and more likely to be non-smokers and non-drinkers.

### Table 2  Baseline characteristics of the participants stratified by hypertension

| Characteristic          | Group          | Hypertension Number of subjects (%) | χ²   | P value | OR    | 95% CI |
|------------------------|----------------|-------------------------------------|------|---------|-------|--------|
|                       |                | No (67.4)                           | Yes (32.6) |       |       |       |
| Number of subjects     |                | 13087                               | 6320 | 155.787 | <0.001| 1.000  |
| Sex                    | Male           | 5742 (63.0)                         | 3376 (37.0) | 0.682 | 0.642 to 0.724 |
|                        | Female         | 7345 (71.4)                         | 2944 (28.6) | 0.682 | 0.642 to 0.724 |
| Age                    | 18–44          | 6608 (83.3)                         | 1323 (16.7) | 1181.906 | <0.001| 1.000  |
|                        | 45–59          | 4722 (61.5)                         | 2953 (38.5) | 3.124 | 2.898 to 3.366 |
|                        | 60–79          | 1757 (46.2)                         | 2044 (53.8) | 5.811 | 5.327 to 6.338 |
| Education              | Elementary     | 3509 (60.6)                         | 2280 (39.4) | 282.324 | <0.001| 1.000  |
|                        | Junior         | 3779 (67.5)                         | 1821 (32.5) | 0.742 | 0.687 to 0.801 |
|                        | Senior         | 3408 (68.8)                         | 1544 (31.2) | 0.697 | 0.644 to 0.755 |
|                        | University     | 2391 (78.0)                         | 675 (22.0) | 0.434 | 0.393 to 0.480 |
| Marital status         | Married        | 11201 (66.7)                        | 5581 (33.3) | 366.705 | <0.001| 1.000  |
|                        | Unmarried      | 1157 (66.7)                         | 165 (33.3) | 0.286 | 0.242 to 0.338 |
|                        | Separated/divorced | 251 (69.5) | 110 (30.5) | 0.880 | 0.701 to 1.103 |
|                        | Widowed        | 478 (50.7)                          | 464 (49.3) | 1.948 | 1.708 to 2.222 |
| Occupation             | Manual labour  | 6159 (67.3)                         | 2988 (32.7) | 417.761 | <0.001| 1.000  |
|                        | Mental labour  | 4634 (74.9)                         | 1551 (25.1) | 0.688 | 0.640 to 0.739 |
|                        | Unemployed     | 1107 (61.2)                         | 702 (38.8) | 1.303 | 1.174 to 1.446 |
|                        | Retired        | 1187 (52.6)                         | 1069 (47.4) | 1.850 | 1.685 to 2.031 |
| Income (RMB)           | <1000          | 5026 (63.2)                         | 2923 (36.8) | 118.706 | <0.001| 1.000  |
|                        | 1000–3000      | 6641 (69.7)                         | 2884 (30.3) | 0.747 | 0.701 to 0.795 |
|                        | >3000          | 1420 (73.5)                         | 513 (26.5) | 0.621 | 0.556 to 0.694 |
| Smoking                | Never          | 8293 (69.9)                         | 3579 (30.1) | 145.176 | <0.001| 1.000  |
|                        | Yes            | 3930 (65.8)                         | 2040 (34.2) | 1.203 | 1.126 to 1.285 |
|                        | Ever           | 864 (55.2)                          | 701 (44.8) | 1.880 | 1.689 to 2.092 |
| Drinking               | No             | 9306 (69.8)                         | 4034 (30.2) | 105.100 | <0.001| 1.000  |
|                        | Yes            | 3781 (62.7)                         | 2286 (37.3) | 1.395 | 1.309 to 1.487 |
| Salt intake            | Moderate       | 4748 (70.7)                         | 1972 (29.3) | 50.369 | <0.001| 1.000  |
|                        | High salt      | 4784 (65.2)                         | 2548 (34.8) | 1.282 | 1.194 to 1.377 |
|                        | Light          | 3555 (66.4)                         | 1800 (33.6) | 1.219 | 1.128 to 1.317 |
| Physical exercise      | Never          | 6298 (69.6)                         | 2754 (30.4) | 283.246 | <0.001| 1.000  |
|                        | Frequently     | 3430 (59.1)                         | 2370 (40.9) | 1.580 | 1.475 to 1.693 |
|                        | Occasionally   | 3359 (73.7)                         | 1196 (26.3) | 0.814 | 0.752 to 0.882 |
| BMI                    | Normal weight  | 6727 (76.2)                         | 2105 (23.8) | 1063.588 | <0.001| 1.000  |
|                        | Underweight    | 752 (88.9)                          | 94 (11.1) | 0.359 | 0.288 to 0.446 |
|                        | Overweight     | 4211 (61.5)                         | 2639 (38.5) | 2.172 | 2.034 to 2.318 |
|                        | Obese          | 1397 (48.5)                         | 1482 (51.5) | 3.142 | 2.787 to 3.542 |
| Sleep duration         | <7 hours/day   | 4480 (63.0)                         | 2626 (37.0) | 103.575 | <0.001| 1.000  |
|                        | 7–8 hours/day  | 3415 (68.8)                         | 1549 (31.2) | 1.292 | 1.197 to 1.396 |
|                        | >8 hours/day   | 5192 (70.8)                         | 2145 (29.2) | 0.911 | 0.842 to 0.985 |
The characteristics of the study population stratified by hypertension are shown in table 2. In our study, the overall prevalence of hypertension was 32.6% (37.0% men, 28.6% women). Hypertension was found to be associated with sex, age, education, marital status, occupation and family monthly income per capita. Additionally, hypertension was associated with smoking, drinking, salt intake, exercise and BMI. As shown in table 2, there was significant difference between sleep duration and the prevalence of hypertension. Hypertensive subjects were more likely to sleep for shorter durations.

Table 3 shows the results of multiple logistic regressions performed to test the association between hypertension and categorical sleep duration adjusted for different potential confounders. For the total sample, participants who slept less than 7 hours per day were significantly more likely to be hypertensive (OR=1.30, 95% CI: 1.20–1.40, model 1). After adjusting for sociodemographic variables (OR=1.09, 95% CI: 1.00 to 1.18, model 2), sociodemographic variables and BMI (OR=1.09, 95% CI: 1.00 to 1.18, model 3), a sleep duration of less than 7 hours per day continued to be associated with a higher risk of hypertension. However, the observed association between sleep duration and hypertension was attenuated after adjusting for sociodemographic variables and BMI. Then, after adjusting for sociodemographic variables, BMI, and lifestyle factors, a short sleep duration (<7 hours/day) was no longer associated with hypertension (OR=1.08, 95% CI: 0.99–1.17, model 4). Among longer sleepers who slept 8 or more hours per day, after adjusting for relevant confounders, we did not find an association between a longer sleep duration and hypertension (OR=1.01, 95% CI: 0.92–1.10, model 4).

The logistic regression analyses were repeated after stratifying by age (18–44, 45–59, 60–79 years). Subjects between the ages of 18 and 44 years who slept less than 7 hours per day were associated with a higher probability of hypertension after considering different covariates (OR=1.38, 95% CI: 1.18 to 1.61, model 1; OR=1.35,
95% CI: 1.15 to 1.59, model 2; OR=1.27, 95% CI: 1.08 to 1.50, model 3; OR=1.24, 95% CI: 1.05 to 1.46, model 4). However, all four models failed to show any significant associations between sleep duration and hypertension either among subjects between the ages of 45–59 years or among subjects between the ages of 60–79 years.

Repeating the analysis for men and women separately, we found that the unadjusted results were similar between men and women. Subjects who reported sleeping less than 7 hours per day were significantly more likely to be hypertensive than subjects who reported getting 7 to less than 8 hours of sleep per day (men: OR=1.24, 95% CI: 1.12 to 1.39, model 1; women: OR=1.36, 95% CI: 1.22 to 1.51, model 1). When sociodemographic variables, BMI and lifestyle factors were included in the models, sleep duration was not associated with the risk of hypertension in either male or female subjects.

**DISCUSSION**

This present study described an analysis of data, collected from the Jilin Provincial Chronic Disease Survey, that investigates the relationship between sleep duration and hypertension. In this cross-sectional study, we observed an association between short sleep durations (<7 hours/day) and an increased risk of hypertension in young adults (18–44 years). This association was attenuated by the inclusion of the multivariate models of sociodemographic covariates—BMI and lifestyle factors. Compared with the young adults, an association between short sleep duration and hypertension was not found for middle-aged participants (45–59 years), old participants (60–79 years) or the total sample. Furthermore, no association between sleep duration and hypertension was found when male or female participants were analysed separately.

There have been several studies focusing on the relationship between sleep duration and blood pressure. However, this relationship is still controversial. Recent reviews and meta-analyses have further clarified the association between short sleep durations and hypertension risk. Two adult meta-analyses showed similar results, indicating that short sleep durations were associated with an increased risk of hypertension (OR=1.20, 95% CI: 1.09 to 1.32, p<0.001; OR=1.21, 95% CI: 1.09 to 1.34, p<0.001). A meta-analysis based on 17 cohort studies demonstrated that short sleep durations increased the risk of hypertension incidence (OR=1.21, 95% CI: 1.05 to 1.40). In fact, the relationship between hypertension and sleep duration may vary by age. In 2008, a Korean study found that short sleep durations were associated with hypertension prevalence only in those aged less than 60 years. This was consistent with a Spanish study, which demonstrated that self-reported sleep duration was not associated with hypertension in older adults. In our study, short sleep duration was associated with a higher risk of hypertension in younger adults but not in middle-aged or elderly individuals. Changes in sleep quality and quantity in later life may be related to this age-dependent association. Furthermore, participants experiencing hypertension are probably less likely to survive into their later years. In the cross-sectional and prospective analyses of the Whitehall II Study, short duration of sleep (<5 hours/night) was associated with increased risk of hypertension among women when compared with the median sleep duration of 7 hours. The result of the Whitehall II Study showed a gender-specific association between short sleep duration and prevalent and incident hypertension. However, in our findings, no association between sleep duration and hypertension was observed in men or women after taking into account potential confounders. Two factors may explain the differential association of short sleep duration and hypertension in the male and female groups. First, hormonal influences may play an important role, especially during the premenopausal period. Second, the SHHS indicated that male and female participants answer questions on sleep differently. Therefore, the differential self-reporting of sleep habits of male and female participants may have an impact on these gender-specific associations.

In addition to short sleep duration, sleep disorders such as sleep insomnia and obstructive sleep apnoea and other sleep quality problems have also been shown to be risk factors for hypertension. Sherwood et al reported that poor sleep quality was associated with non-dipping blood pressure and the potential mechanism might be heightened sympathetic activity. Thomas et al proposed other potential mechanisms including activation of the hypothalamic–pituitary–adrenal axis and the stress-diathesis model. Unfortunately, sleep quality or related issues were not recorded in our study, and we will try to take sleep quality into account in our future investigations.

The biological mechanisms underlying the association of short sleep duration with hypertension are complex and not fully understood. Early data indicated a lower level of sympathetic-nerve activity and blood pressure during deep non-rapid-eye-movement (REM) sleep. During REM sleep, there is an increase of sympathetic-nerve activity resulting in surges in blood pressure. Some other studies have also demonstrated that increased sympathetic activity due to short sleep durations may be associated with hypertension. An increased, 24-hour, haemodynamic load due to a prolonged exposure to short sleep durations may lead to structural adaptation such as arterial or left ventricular hypertrophy remodelling, which gradually leads to the functioning of the entire cardiovascular system under high-pressure balance. One recent study found that sleep loss might affect blood pressure reactions to stress, contributing to an increased risk of some CVD. In addition, disrupted circadian rhythmicity and autonomic balance caused by short sleep durations may contribute to hypertension.

This analysis has several strengths. This study is based on data from a large representative sample of the Jilin population, and this prospective study minimised selection and recall biases. There were excellent response rates to sleep-duration questions, hypertension questions,
and measurements. Finally, a broad range of covariates were controlled in the analysis, including age, sex, education, marital status, income, occupation, BMI, drinking, smoking, salt intake and exercise. A limitation of this study lies in the properties of the cross-sectional study and the recall bias of self-reported sleep duration.

CONCLUSION
The results of our study revealed a significant association between short sleep duration (<7 hours/day) and hypertension in the sample of young adults, indicating that short sleep duration is an important risk factor for hypertension in young adults. We suggest that younger adults in the Jilin Province should maintain a sufficient sleep duration. Furthermore, the Center for Disease Control and Prevention of the Jilin Province should pay close attention and publicise health damage caused by short sleep durations.

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Patient consent Obtained.

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Data sharing statement The survey was implemented by School of Public Health, Jilin University and Jilin Center for Disease Control and Prevention in Jilin Province in 2012. According to relevant regulations, the data can not be shared.

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REFERENCES
1. Aronov WS. Hypertension guidelines. Hypertension 2011;58:347–8.
2. Poulter NR, Prabhakaran D, Caulfield M. Hypertension. Lancet 2015;386:801–12.
3. Kearney PM, Whelton M, Reynolds K, et al. Global burden of hypertension: analysis of worldwide data. Lancet 2005;365:217–23.
4. Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380:2296–307.
5. Nwankwo T, Yoon SS, Burt V, et al. Hypertension among adults in the United States: National Health and Nutrition Examination Survey, 2011–2012. NCHS Data Brief 2013;133:1–8.
6. GBD 2015 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet 2016;388:1659–724.
7. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. Hypertension 2003;42:1206–52.
8. St-Onge MP, Grandner MA, Brown D, et al. Sleep duration and quality: Impact on lifestyle behaviors and cardiometabolic health: A scientific statement from the american heart association. Circulation 2016;134:e367–e86.
9. Faraut B, Touchette E, Gamble H, et al. Short sleep duration and increased risk of hypertension: a primary care medicine investigation. J Hypertens 2012;30:1354–63.
10. Pepin JL, Borel AL, Tamisier R, et al. Hypertension and sleep: overview of a tight relationship. Sleep Med Rev 2014;18:509–19.
11. Wang Q, Xi B, Liu M, et al. Short sleep duration is associated with hypertension risk among adults: a systematic review and meta-analysis. Hypertens Res 2012;35:1012–8.
12. Guo X, Zheng L, Wang J, et al. Epidemiological evidence for the link between sleep duration and high blood pressure: a systematic review and meta-analysis. Sleep Med 2013;14:324–32.
13. Gottlieb DJ, Redline S, Nieto FJ, et al. Association of usual sleep duration with hypertension: the sleep Heart Health Study. Sleep 2006;29:1009–14.
14. Gangwisch JE, Heymsfield SB, Boden-Albala B, et al. Short sleep duration as a risk factor for hypertension: analyses of the first National Health and Nutrition Examination Survey. Hypertension 2006;47:833–9.
15. Matthews KA, Chang Y, Kravitz HM, et al. Sleep and risk for high blood pressure and hypertension in midlife women: the SWAN (Study of Women’s Health Across the Nation) Sleep Study. Sleep Med 2014;15:203–8.
16. Sforza E, Saint Martin M, Barthelemy JC, et al. Association of self-reported sleep and hypertension in non-insomniac elderly subjects. J Clin Sleep Med 2014;10:965–71.
17. Wang S, Kou C, Liu Y, et al. Rural-urban differences in the prevalence of chronic disease in northeast China. Asia Pac J Public Health 2015;27:394–406.
18. Clinical guidelines on the identification, evaluation, and treatment of high blood pressure. Lancet 2011;378:1942–53.
19. Fung MM, Peters K, Ancoli-Israel S, et al. Self-reported sleep duration and blood pressure values in Japanese male subjects. Environ Health Prev Med 2013;18:215–20.
20. Poulter N, Dorn JM, Cappuccio FP, et al. Sleep and sleep disorders in older adults. Sleep Med Rev 2013;17:595–91.
21. Kuciene R, Dulskiene V. Associations of short sleep duration with prehypertension and hypertension among Lithuanian children and adolescents: a cross-sectional study. BMC Public Health 2014;14:255.
22. Peach H, Gaultney JF, Reeve CL. Sleep characteristics, body mass index, and risk for hypertension in young adolescents. J Youth Adolesc 2015;44:271–84.
23. Hoevenaar-Blom MP, Spijkerman AM, Kromhout D, et al. Sleep duration and sleep quality in relation to 12-year cardiovascular disease incidence: the MORGENT study. Sleep 2011;34:1487–92.
24. Knutson KL. Sleep duration and cardiometabolic risk: a review of the epidemiologic evidence. Best Pract Res Clin Endocrinol Metab 2010;24:731–43.
25. Gangwisch JE. Epidemiological evidence for the links between sleep, circadian rhythms and metabolism. Obes Rev 2009;10 Suppl 2(Suppl 2):37–45.
26. Meng L, Zheng Y, Hui R. The relationship of sleep duration and insomnia to risk of hypertension incidence: a meta-analysis of prospective cohort studies. Hypertens Res 2013;36:985–95.
27. Wang Y, Mei H, Jiang YR, et al. Relationship between duration of sleep and hypertension in adults: A meta-analysis. J Clin Sleep Med 2015;11:1047–56.
28. Choi KM, Lee JS, Park HS, et al. Short sleep duration and sleep quality in relation to 12-year cardiovascular disease incidence: the MORGENT study. Sleep 2011;34:1487–92.
29. Knutson KL. Sleep duration and cardiometabolic risk: a review of the epidemiologic evidence. Best Pract Res Clin Endocrinol Metab 2010;24:731–43.
33. Baldwin CM, Kapur VK, Holberg CJ, et al. Associations between gender and measures of daytime somnolence in the Sleep Heart Health Study. Sleep 2004;27:305–11.
34. Fernandez-Mendoza J, Vgontzas AN, Liao D, et al. Insomnia with objective short sleep duration and incident hypertension: The penna state cohort. Hypertension 2012;60:929–35.
35. Budhiraja R, Roth T, Hudgel DW, et al. Prevalence and polysomnographic correlates of insomnia comorbid with medical disorders. Sleep 2011;34:859–67.
36. Floras JS. Hypertension and Sleep Apnea. Can J Cardiol 2015;31:889–97.
37. Kara B, Tenekeci EG. Sleep quality and associated factors in older turkish adults with hypertension: A pilot study. J Transcult Nurs 2017;28:296–305.
38. Fiorentini A, Valente R, Perciaccante A, et al. Sleep’s quality disorders in patients with hypertension and type 2 diabetes mellitus. Int J Cardiol 2007;114:E50–E52.
39. Liu RQ, Qian Z, Trevathan E, et al. Poor sleep quality associated with high risk of hypertension and elevated blood pressure in China: results from a large population-based study. Hypertens Res 2016;39:54–9.
40. Sherwood A, Routledge FS, Wohlgemuth WK, et al. Blood pressure dipping: ethnicity, sleep quality, and sympathetic nervous system activity. Am J Hypertens 2011;24:982–8.
41. Thomas SJ, Calhoun D, Sleep CD. Sleep, insomnia, and hypertension: current findings and future directions. J Am Soc Hypertens 2017;11:122–9.
42. Somers VK, Dyken ME, Mark AL, et al. Sympathetic-nerve activity during sleep in normal subjects. N Engl J Med 1993;328:303–7.
43. Spiegelhalder K, Fucha L, Ladwig J, et al. Heart rate and heart rate variability in subjectively reported insomnia. J Sleep Res 2011;20(1 Pt 2):137–45.
44. Kario K, Schwartz JE, Pickering TG. Changes of nocturnal blood pressure dipping status in hypertensives by nighttime dosing of alpha-adrenergic blocker, doxazosin : results from the HALT study. Hypertension 2000;35:787–94.
45. Folkow B. “Structural factor” in primary and secondary hypertension. Hypertension 1990;16:89–101.
46. Franzén PL, Gianaros PJ, Marsland AL, et al. Cardiovascular reactivity to acute psychological stress following sleep deprivation. Psychosom Med 2011;73:679–82.