A Dose-Response Relationship Between Sleep Duration and Stroke According to Nonhealth Status in Central China: A Population-based Epidemiology Survey

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Purpose: The aim was to investigate the relationship between sleep duration and stroke according to nonhealth status among adults in Central China. *Methods:* A total of 18,670 participants were selected by stratified multistage random sampling method in Henan province during 2013-2015. Restricted cubic splines and logistic regression were used to calculate the association between sleep duration and stroke. *Results:* Sleep duration showing a J-shaped dose-response association with risk of stroke among the Chinese adults in the study. The respective percentages of stroke were 6.2%, 5.6%, 3.5%, 4.5%, 5.6%, and 9.2% for those whose sleep duration less than 6 h/day, 6~7 h/day, 7~8 h/day, 8~9 h/day, 9~10 h/day, and more than or equal to 10 h/day. Compared with sleep duration of 7~8 h/day, the risk of stroke increased by 37% (95% confidence interval [CI]: 8%, 73%) and 63% (95% CI: 30%, 104%) for those whose sleep duration were 9~10 h/day and more than or equal to 10 h/day. The correlations between sleep durations and stroke seemed to be stronger in men than women. Stroke was associated with shorter sleep duration in ageing 60-88 years, instead of 18-59 years. The correlation between sleep duration and stroke was statistically significant at lower education level. Furthermore, the risk of stroke was slightly higher in urban residents than rural residents. *Conclusions:* In summary, a J-shaped dose-response association between sleep duration and stroke was found among the adults in Central China. Furthermore, people who were male, older, less educated and living in urban areas had a higher risk of stroke.

Key Words: Sleep duration—stroke—dose-response association—population-based epidemiology survey

Abbreviations: PPS, probability proportional to size; TIA, transient ischemic attack; CT, computed tomography; MRI, magnetic resonance imaging; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure SE, standard error; WC, waist circumference; WHtR, waist-to-hip ratio; PBF, percentage body fat; VFI, visceral fat index; BMR, Basal metabolic rate

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Introduction

Stroke was classified as the second leading cause of death[1] and the third most common cause of disability-adjusted life-years (DALYs) worldwide in 2010.[2] In China, the annual mortality rate of stroke was approximately 160 per 100,000. In addition, China had 2.5 million new cases of stroke and 7.5 million survivors each year.[3] Given the prevalence and the severe consequences of stroke in China, controllable risk factors were urgently needed to be identified and modified. Known to all, genetic[4] and environmental factors such as smoking,[5] excessive drinking,[6] and lacking physical exercise[7] resulted in the prevalence of stroke, while some other behavioral factors may also involve in the occurrence and development of stroke.

Sleep was increasingly recognized as an important lifestyle contributor to health. Although the classification criteria for sleep duration varied, evidence-based studies had demonstrated that both shorter and longer sleep duration were significantly associated with obesity, hypertension,[8] cardiovascular disease,[9] even the total mortality.[10,11] The association between sleep duration and risk of stroke has been explored in a meta-analysis of prospective cohort studies.[12] A study reported that habitual sleep pattern was an important neurobehavioral determinant of risk in postmenopausal women of ischemic stroke.[13] A Singapore Chinese Health Study showed that both shorter and longer sleep duration were associated with the risk of increasing mortality of stroke in a Chinese population aged 45-74 years.[14]

Although the association between sleep duration and stroke were reported before, there was considerable difference in their sample size, or population. Unfortunately, few studies referred to dose-response association in Central China. Thus, the aim was to explore the association between sleep duration and stroke according to nonhealth status among Central Chinese adults in a large survey.

Methods

Study Design and Population

All participants were investigated in a community-based study from August 2013 to August 2015 in Henan province, Central China. The research was a part of national survey on cardiovascular diseases covering 31 provinces and 262 counties across China supported by the National Key R&D Program in the Twelfth Five-year Plan (No. 2011BAI11B01). The design scheme and implementer plan of this survey were published previously.[15] Five urban areas and 6 rural areas were randomly selected using the probability proportional to size method and a multistage random sampling method stratified with gender and area was used to select representative samples from the permanent residents. Participants diagnosed with myocardial infarction (216 subjects), coronary heart disease (302 subjects), and cancer (138 subjects) were excluded. Data (581 participants) incomplete were excluded either. Finally, a total of 18,670 participants aged more than or equal to18 years had been analyzed in which 1014 participants were stroke.

The protocol was approved by the Ethical Committee of the Chinese Ministry of Science and Technology. All participants were given written informed consent prior to the questionnaire.

Data Collection

The data were collected by trained interviews face-to-face with a professional questionnaire. A structured questionnaire was used to collect information on nonhealth status (age, gender, educational levels, smoking, alcohol drinking status, and physical activities) and family history. A supervisor was responsible for the procedures of quality control and staff training aiming at the standardized techniques for interviewers and measurement. Instruments were examined regularly for accuracy and reproducibility at each site.

Definition of Stroke

Stroke was defined according to the standardization of diagnosis from the World Health Organization Stroke Community Registers.[16] Those had a history of language or physical dysfunction which had been continued for more than 24-h/day and confirmed by brain computed tomography or magnetic resonance imaging could be diagnosed as stroke. Patients with a history of stroke or minor stroke and those with a history of major stroke who were eligible for the study, regardless of the subtype of stroke. Patients with stroke were diagnosed based on the medical certificate of stroke issued by the hospital.[17] The exclusion criteria included secondary stroke caused by trauma, transient ischemic attack, brain tumor, and metastatic brain tumor.

Definition of Sleep Duration

Participants were asked to answer the question: "How many hours did you sleep in a 24-hour period on average on weekdays and weekends in the past years?" The responses to these 2 questions were averaged and used as the variable of sleep duration. The average sleep duration per day was divided into 6 categories: less than 6 h/day (<6 h/day), 6~7 h/day, 7~8 h/day, 8~9 h/day, 9~10 h/day, and equal to or more than 10 h/day (≥10 h/day). Sleep duration less than 7 h/day was considered as shorter sleep duration, while equal to or longer than 9 h/day was defined as longer sleep duration. Accordingly, healthy sleep duration was 7~8 h/day.[12]

Definition of Other Variables

Current smoking was defined as having smoked more than one branch cigarette per day in the past 1 year.

Average daily alcohol consumption and frequency of drinking per month were asked. Ethanol content (by weight) differed among beverages and was assumed to be 5% for beer, 12.5% for red wine, and 45% for hard liquor. One drink was defined as an average of 15 g of ethanol. Daily alcohol consumption levels were used to classify nondrinkers (abstainers, no history of alcohol consumption), moderate drinkers (up to 1 drink/day for women and up to 2 drinks/day for men), and heavy drinkers (>1 drink/day for women and >2 drinks/day for men).[18] The time of physical activity containing work-related, traffic-related and leisure-related were combined and recategorized into 3 categories: low physical activity, moderate physical activity, and high physical activity.[19] Middle school or below was considered as lower education level. Obesity was defined as body mass index (BMI) more than or equal to28 kg/m^2.[20] Hypertension was defined as systolic blood pressure (SBP) higher than or equal to 140 mmHg and/or diastolic blood pressure (DBP) higher than or equal to 90 mmHg or use of any antihypertensive medication within 2 weeks.[21]

Statistical Analysis

The categorical variables were presented as numbers and proportions and compared by Chi-square test and Wilcoxon test. The continuous data were expressed as mean ± standard deviation and compared using analysis of variance and *t* test. Sleep duration showing a J-shaped association with increased risk of stroke with a nadir at 7∼8 h/day of sleep was discovered.[11] Odds ratios (ORs) and the corresponding 95% confidence intervals (CIs) were calculated by binary logistic regression model with reference to the risk of 7∼8 h/day of sleep duration adjusted by potential confounding factors, including age, gender, nation, marital status, areas of inhabitance, family history, educational level, occupation, smoking status, drinking status, physical activity, SBP, BMI, percentage body fat (PBF), and basal metabolic rate (BMR). A dose-response association of sleep duration and risk of stroke was analyzed by fitting restricted cubic spline logistic regression setting 3 knots placed at the 25th, 50th, and 75th percentiles of sleep duration according to the distribution. Data were recorded and checked using EpiData version 3.1. All *P* values were based on 2-sided test. All the statistical analyses were performed by running the SAS V.9.1 (SAS Institute) and SPSS 21.0 (SPSS Inc., Chicago, IL).

Results

Baseline Characteristics of the Participants

In all 18,670 participants (range: 18-88 years), men accounted for 42.0% with 52.0 ± 16.8 years as mean age. Among all participants, there were 1014 patients with stroke. The crude prevalence of stroke and age-standardized prevalence of stroke were 5.43% and 2.93%, respectively. The age-standardized prevalence of stroke was 3.51% for men and 2.50% for women, respectively. Men had a higher prevalence than women in stroke ($P < .001$).

The baseline characteristics of all participants were shown in Table 1 and Table 2. Significant correlations were found between sleep duration and age, gender, marital status, areas of inhabitance, educational level, occupation, smoking status, drinking status, physical activity, family history, BMI, hypertension, obesity, and stroke. Compared with participants who had normative sleep duration (7∼8 h/day), the other participants tended to be older, Han population, urban resident, farmer, smokers, nondrinkers, and heavy drinkers, who were also more likely to have less physical activity, lower education level, higher SBP, higher PBF, higher waist-to-hip ratio, and reduced BMR. Moreover, participants with shorter or longer sleep duration tended to be higher BMI, higher DBP, higher waist circumference, and increased visceral fat index for women but not have a similar significant trend for men.

Table 3 showed characteristics of all participants with stroke according to sleep duration. The respective crude percentages of stroke were 6.2%, 5.6%, 3.5%, 4.5%, 5.6% and 9.2% for those with less than 6 h/day, 6∼7 h/day, 7∼8 h/day, 8∼9 h/day, 9∼10 h/day, and more than or equal to 10 h/day of sleep. The age-standardized prevalence of stroke for the rural population and the urban population was 3.30% and 2.00%, respectively. Furthermore, it was discovered that stroke patients were more likely to be male, elderly, Han Chinese, urban dwellers, farmer, smokers, non-drinkers and heavy drinkers, stroke patients have family history, less physical activity, lower education level, higher SBP, higher DBP, higher BMI, higher waist circumference, higher waist-to-hip ratio, higher PBF, higher visceral fat index, and reduced BMR.

Association of Sleep Duration and Stroke

A dose-response association between sleep duration and risk of stroke was found in the study and was further demonstrated through the restricted cubic spline curves in Figure 1, suggesting that the risk of stroke may be higher in people with longer sleep duration. As shown in Table 4, the odds ratio was 1.37 (1.08-1.73) for 9∼10 h/day of sleeper, 1.63 (1.30-2.04) for more than or equal to 10 h/day of sleeper compared with the healthy sleep duration (7∼8 h/day) in a fully adjusted model. The subgroup analysis classified by gender found a similar association between women and men. The ORs were 1.69 (1.21-2.35) for men and 1.54 (1.13-2.10) for women among more than or equal to 10 h/day of sleeper after adjustment, and the correlations seemed to be stronger in male than in female. Although shorter sleep duration slightly increased the risk of stroke, the relationships had

Table 1. *Baseline characteristics of study population according to sleep duration among men in Henan, China*

Characteristics	Total	<6 h (n = 373)	6∼7 h (n = 817)	7∼8 h (n = 1632)	8∼9 h (n = 2453)	9∼10 h (n = 1391)	≥10 h (n = 1170)	*P* value
Stroke (%)	504	24(6.4)***	48(5.9)***	60(3.7)	143(5.8)**	96(6.9)*	133(11.4)*	<.001
Age (year)	7836	56.73 (14.36)*	51.22 (14.95)*	47.33(16.49)	47.85(16.69)	51.52(17.71)*	59.44(17.44)*	<.001
18∼59 (%)	4959	199(53.4)	562(68.8)	1177(72.1)	1719(70.1)	825(59.3)	477(40.8)	
60∼88 (%)	2877	174(46.6)	255(31.2)	455(27.9)	734(29.9)	566(40.7)	693(59.2)	
Nation (%)	7836	373(4.8)	817(10.4)	1632(20.8)	2453(31.3)	1391(17.8)	1170(14.9)	.031
Han	7616	358(96.0)	787(96.3)	1594(97.7)	2373(96.7)	1357(97.6)	1147(98.0)	
Others	220	15(4.0)	30(3.7)	38(2.3)	80(3.3)	34(2.4)	23(2.0)	
Married (%)	6343	312(83.6)	704(86.2)*	1315(80.6)	1990(81.1)	1096(78.8)	926(79.1)	<.001
Areas (%)	7836	373(4.8)*	817(10.4)*	1632(20.8)	2453(31.3)	1391(17.8)*	1170(14.9)*	<.001
Rural resident (%)	5695	95(25.5)	234(28.6)	545(33.4%)	761(31.0%)	340(24.4)	166 (14.2)	
Urban resident (%)	2141	278(74.5)	583(71.4)	1087(66.6)	1692(69.0)	1051(75.6)	1004(85.8)	
Family history of stroke (%)	771	47(12.6)	100(12.2)	176(10.8)	222(9.1)	123(8.8)	103(8.8)	.011
Educational level (%)	7836	373(4.8)*	817(10.4)**	1632(20.8)	2453(31.3)**	1391(17.8)**	1170(14.9)*	<.001
Middle school or below	5203	281(75.3)	547(67.0)	929(56.9)	1487(60.6)	978(70.3)	981(83.8)	
High school and above	2633	92(24.7)	270(33.0)	703(43.1)	966(39.4)	413(29.7)	189(16.2)	
Occupation (%)	7836	373(4.8)*	817(10.4)**	1632(20.8)	2453(31.3)*	1391(17.8)**	1170(14.9)*	<.001
Farmer	2582	150(40.2)	262(32.1)	401(24.6)	681(27.8)	484(34.8)	604(51.6)	
Non-farmer	5254	223(59.8)	555 (67.9)	1231(75.4)	1772(72.2)	907(65.2)	566(48.4)	
Smoking (%)	7836	373(4.8)***	817(10.4)***	1632(20.8)	2453(31.3)	1391(17.8)	1170(14.9)***	<.001
Never smoker	2726	111(29.8)	248(30.4)	566(34.6)	923(37.6)	498(35.8)	380(32.5)	
Former smoker	1501	80(21.4)	145(17.7)	303(18.6)	405(16.5)	265(19.1)	303(25.9)	
Current smoker	3609	182(48.8)	424(51.9)	763(46.8)	1125(45.9)	628(45.1)	487(41.6)	
Drinking (%)	7836	373(4.8)***	817(10.4)	1632(20.8)	2453(31.3)***	1391(17.8)***	1170(14.9)***	<.001
Nondrinkers	3191	169(45.3)	302(37.0)	571(35.0)	959(39.1)	593(42.6)	597(51.0)	
Moderate drinkers	3017	117(31.4)	316(38.7)	721(44.2)	1018(41.5)	505(36.3)	340(29.1)	
Heavy drinkers	1628	87(23.3)	199(24.4)	340(20.8)	476(19.4)	293(21.1)	233(19.9)	
Physical activity (%)	7836	373(4.8)	817(10.4)	1632(20.8)	2453(31.3)	1391(17.8)	1170(14.9)	<.001
High	4440	222(59.5)	483(59.1)	950(58.2)	1412(57.6)	780(56.1)	593(50.7)	
Moderate	2268	105(28.2)	213(26.1)	474(29.1)	702(28.6)	421(30.3)	353(30.2)	
Low	1128	46(12.3)	121(14.8)	208(12.7)	339(13.8)	190(13.6)	224(19.1)	
Hypertension (%)	4504	224(60.1)***	476(58.3)***	893(54.7)	1378(56.2)	803(57.7)	730(62.4)***	.001
SBP (mmHg)	7836	133.59(20.25)**	131.52(17.41)	130.41(17.82)	130.40(17.57)	132.34(19.23)**	134.76(21.32)*	<.001
DBP (mmHg)	7836	78.61(12.13)	78.99(11.35)	78.30(11.55)	78.16(11.34)	78.55(15.75)	77.80(12.19)	.355
BMI (%) (kg/m^2)	7836	24.65(3.39)	25.10(3.40)	24.90(3.58)	24.80(3.62)	24.64(3.67)	24.39(3.61)*	<.001
Obesity (%)	4480	211(56.6)*	513(62.8)	965(59.1)	1405(57.3)	758(54.5)	628(53.7)*	<.001
Waist circumference(cm)	7836	87.56(9.63)	88.64(9.58)***	87.59(9.89)	87.28(10.20)	87.07(10.47)	87.60(10.15)	.014
Waist-to-Hip Ratio	7836	.53(0.06)	.53(0.06)**	.52(0.06)	.52(0.06)	.52(0.07)	.53(0.06)*	<.001

Table 1 (*Continued*)

Characteristics	Total	<6 h (n = 373)	6~7 h (n = 817)	7~8 h (n = 1632)	8~9 h (n = 2453)	9~10 h (n = 1391)	≥10 h (n = 1170)	*P* value
Percentage body fat	7836	24.58(6.44)***	24.44(5.98)**	23.71(6.60)	23.53(6.70)	23.91(6.85)	24.92(6.30)*	<.001
Visceral fat index	7836	11.58(4.98)	11.57(4.73)***	11.07(4.89)	10.94(5.09)	11.11(5.26)	11.37(5.01)	.009
Basal metabolic rate (kcal)	7836	1546.56 (158.60)*	1586.83 (172.37)	1594.74 (172.85)	1586.00 (169.07)	1561.13 (179.92)*	1518.24 (178.61)*	<.001

BMI, body mass index; SE, standard error; WC, waist circumference; WHtR, waist-to-hip ratio; PBF, percentage body fat; VFI, visceral fat index; BMR, Basal metabolic rate; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Frequencies (percentages), mean with standard deviation of each variable are presented.

P value were calculated using the analysis of variance for continuous variables and the chi-square test for qualitative variables.

Symbols denote significant differences from reference group (7~8 hours/day) (*$P < .001$; **$P < .01$; ***$P < .05$) with *t* test, Wilcoxon test, or chi-square test.

attenuated to no statistical significance for both men and women after adjustment. Participants with more than or equal to 10 h/day sleep duration had approximately 1.6-fold and 2-fold risk of stroke for aged 18-59 years and aged 60~88 years (OR: 1.63, 95% CI: 1.08-2.46; OR: 2.00, 1.51-2.64, respectively). Moreover, the study revealed that sleep duration of 6~7 h/day was associated with 73% (95% CI: 24%-143%) increased risk of stroke among aged 60-88 years. However, the interaction between shorter sleep duration and the risk of stroke was not found in aged 18-59 years.

Sleeping 6~7 h/day or more than 9~10 h/day were associated with higher incidence of stroke than sleeping 7~8 h/day in subjects with lower education level. The OR was 1.39 (1.06-1.83) for those with 6~7 h/day sleep and 1.67 (1.33-2.09) for those with more than or equal to 10 h/day sleep among participants at lower educational level after adjustment. However, the association was not statistically significant between sleep duration and stroke in a higher educational level. The association between sleep duration and stroke was evident among urban and rural residents. Urban residents had a 2-fold higher *OR* (*OR*: 2.08, 95% *CI*: 1.12-3.87) for participants with 6~7 h/day of sleep and a 2 times higher *OR* (*OR*: 1.90, 95% *CI*: 1.01-3.65) for the more than or equal to 10 h/day of sleep group after adjusted. No interaction was found between stroke and sleep duration for the rural resident after adjusted, except for that more than or equal to 10 h/day of sleep duration increased risk of stroke by 56% (*OR*: 1.56, 95% *CI*: 1.22-1.99).

Discussion

In the study, a J-shaped dose-response association between sleep duration and risk of stroke was found, which suggested that the risk of stroke may be higher with longer sleep duration. However, the correlations seemed to be stronger for men than women. In addition, longer sleep duration was positively associated with stroke among aged 60-88 years. Interestingly, shorter sleep duration was associated with stroke in aged 60-88 years, but not in aged 18-59 years. The research also indicated that people who received lower education level had a higher risk of stroke than those with higher education level. Furthermore, urban residents slightly increased the risk of stroke than rural residents. Our research revealed that the higher incidence of stroke in those with longer sleep duration was not entirely due to non-health status, because longer sleep duration itself was an independent predictor of stroke. In addition, shorter sleep duration was only associated with greater incidence of stroke in those with lower education level and the elderly (aged 60-88).

The J-shaped dose-response association between sleep duration and stroke was found in present study, which was similar to other studies.[12,22-25] Furthermore, our

Table 2. *Baseline characteristics of study population according to sleep duration among women in Henan, China*

Characteristics	Total	<6 h (n = 564)	6∼7 h (n = 927)	7∼8 h (n = 2009)	8∼9 h (n = 3296)	9∼10 h (n = 2262)	≥10 h (n = 1776)	*P* value
Stroke (%)	510	34(6.0)**	50(5.4)**	66(3.3)	113(3.4)	109(4.8)***	138(7.8)*	<.001
Age (year)	10834	59.37(12.87)*	54.83(14.10)*	49.86(16.32)	50.03(16.29)	51.80(17.13)*	57.49(16.80)*	<.001
18∼59 (%)	6583	265(47.0)	546(58.9)	1371(68.2)	2206(66.9)	1355(59.9)	840(47.3)	
60∼88 (%)	4251	299(53.0)	381(41.1)	638(31.8)	1090(33.1)	907(40.1)	936(52.7)	
Nation (%)	10834	564(5.2)	927(8.6)	2009(18.5)	3296(30.4)	2262(20.9)	1776(16.4)	.006
Han	10481	535(94.9)	888(95.8)	1939(96.5)	3187(96.7)	2199(97.2)	1733(97.6)	
Others	353	29(5.1)	39(4.2)	70(3.5)	109(3.3)	63(2.8)	43(2.4)	
Married (%)	8221	430(76.2)	754(81.3)*	1515(75.4)	2515(76.3)	1678(7.2)	1329(74.8)	<.001
Areas (%)	10834	564(5.2)*	927(8.6)	2009(18.5)	3296(30.4)*	2262(20.9)*	1776(16.4)*	<.001
Rural resident (%)	8249	435(77.1)	669(72.2)	1409(70.1)	2421(73.5)	1763(77.9)	1552(87.4)	
Urban resident (%)	2585	129(22.9)	258(27.8)	600(29.9%)	875(26.5%)	499(22.1)	224(12.6)	
Family history of stroke (%)	9636	474(84.0)*	124(13.4)	232(11.5)	352(10.7)	230(10.2)	170(9.6)*	<.001
Educational level (%)	10834	564(5.2)*	927(8.6)**	2009(18.5)	3296(30.4)	2262(20.9)**	1776(16.4)*	<.001
Middle school or below	8294	488(86.5)	725(78.2)	1410(70.2)	2384(72.3)	1721(76.1)	1566(88.2)	
High school and above	2540	76(13.5)	202(21.8)	599(29.8)	912(27.7)	541(23.9)	210(11.8)	
Occupation (%)	10834	564(5.2)*	927(8.6)**	2009(18.5)	3296(30.4)	2262(20.9)**	1776(16.4)*	<.001
Farmer	5177	319(56.6)	438(47.2)	847(42.2)	1420(43.1)	1074(47.5)	1079(60.8)	
Non-farmer	5657	245(43.4)	489(52.8)	1162(57.8)	1876(56.9)	1188(52.5)	697(39.2)	
Smoking (%)	10834	564(5.2)*	927(8.6)	2009(18.5)	3296(30.4)	2262(20.9)	1776(16.4)*	<.001
Never smoker	10657	543(96.3)	902(87.3)	1985(98.8)	3255(98.8)	2224(98.3)	1748(98.4)	
Former smoker	43	2(0.4)	5(0.5)	7(0.3)	8(0.2)	10(0.4)	11(0.6)	
Current smoker	134	19(3.4)	20(2.2)	17(0.8)	33(1.0)	28(1.2)	17(1.0)	
Drinking (%)	10834	564(5.2)*	927(8.6)**	2009(18.5)	3296(30.4)	2262(20.9)**	1776(16.4)**	<.001
Non-drinkers	9725	523(92.7)	840(90.6)	1783(88.8)	2914(88.4)	2011(88.9)	1654(93.1)	
Moderate drinkers	977	32(5.7)	67(7.2)	207(10.3)	344(10.4)	229(10.1)	98(5.5)	
Heavy drinkers	132	9(1.6)	20(2.2)	19(0.9)	38(1.2)	22(1.0)	24(1.4)	
Physical activity (%)	10834	564(5.2)	927(8.6)	2009(18.5)	3296(30.4)	2262(20.9)	1776(16.4)	.028
High	6741	369(65.4)	605(65.3)	1264(62.9)	2083(63.2)	1359(60.1)	1061(59.7)	
Moderate	3174	156(27.7)	244(26.3)	578(28.8)	949(28.8)	706(31.2)	541(30.5)	
Low	919	39(6.9)	78(8.4)	167(8.3)	264(8.0)	197(8.7)	174(9.8)	
Hypertension (%)	5255	335(59.4)	474(51.1)	870(43.3)	1488(45.1)	1090(48.2)	998(56.2)	<.001
SBP (mmHg)	10834	134.64(21.95)*	130.22(21.27)**	127.31(21.19)	127.40(21.76)	129.68(23.04)*	133.53(23.55)*	<.001
DBP (mmHg)	10834	75.17(11.87)**	74.48(10.92)***	73.63(10.98)	73.79(10.98)	73.99(11.72)	74.79(11.56)**	.002
BMI (%) (kg/m^2)	10834	25.82(3.61)*	25.34(3.88)***	24.99(4.06)	24.99(3.94)	24.94(3.94)	25.46(4.02)*	<.001
Obesity (%)	6427	407(72.2)	579(62.5)	1135(56.5)	1915(58.1)	1280(56.6)	1111(62.6)	<.001
Waist circumference (cm)	10834	86.85(9.77)*	85.42(10.51)*	83.62(11.46)	83.61(10.99)	84.05(11.25)	86.36(11.01)*	<.001
Waist-to-Hip Ratio	10834	.57(0.07)*	.55(0.07)*	.54(0.08)	.54(0.08)	.54(0.08)***	.56(0.08)*	<.001

Table 2 (*Continued*)

Characteristics	Total	<6 h (n = 564)	6~7 h (n = 927)	7~8 h (n = 2009)	8~9 h (n = 3296)	9~10 h (n = 2262)	≥10 h (n = 1776)	*P* value
Percentage body fat	10834	35.67(4.79)*	34.09(5.21)*	32.99(5.98)	32.99(6.06)	33.37(6.03)***	34.64(5.81)*	<.001
Visceral fat index	10834	9.49(4.02)*	8.69(4.25)**	8.23(4.35)	8.19(4.39)	8.22(4.47)	8.99(4.47)*	<.001
Basal metabolic rate (kcal)	10834	1258.78 (143.04)	1269.29 (144.82)	1271.00 (140.09)	1269.93 (142.50)	1256.40 (142.83)**	1250.31 (155.37)*	<.001

BMI, body mass index; SE, standard error; WC, waist circumference; WHtR, waist-to-hip ratio; PBF, percentage body fat; VFI, visceral fat index; BMR, Basal metabolic rate; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Frequencies (percentages), mean with standard deviation of each variable are presented.

P value were calculated using the analysis of variance for continuous variables and the chi-square test for qualitative variables.

Symbols denote significant differences from reference group (7~8 hours/day) (*$P < .001$; **$P < .01$; ***$P < .05$) with *t* test, Wilcoxon test, or chi-square test.

findings revealed the importance of a comprehensive scrutiny of potentially confounding mediators and factors when examining the association between sleep duration and stroke. The association was consistent with the results of the Singapore Chinese Health Study.[14] Similarly, recent evidence suggested that longer sleep duration (≥9 h/day/day) was associated with greater likelihoods of obesity, coronary heart disease, and stroke.[26] In addition, both shorter and longer sleep duration was associated with higher risks of stroke, which has been surveyed in a considerable amount of published cohort studies.[22,23,27]

Sleep Duration and Stroke by Age and Gender

The age-adjusted prevalence of stroke was significantly higher in men than in women. The findings that age-specific stroke prevalence of men aged more than or equal to 40 years was significantly greater than the women which were similarly be described in a nationwide population based survey performed among the Chinese adults.[28] Shorter sleep duration was associated with stroke in people aged 60-88 years, but not in age 18-59 years. Consistent with the results from a 10-year follow-up large research on the relationship between shorter sleep duration and mortality in elderly (60-86 years old), but not in middle-aged (32-59 years old).[29] The relationship between sleep duration and stroke was largely influenced by ageing and age-related sleep changes in elderly subjects. A serious question was whether there were an adequate sample sizes in the analysis to measure the relationship between sleep duration and stroke in nonelderly subjects. The nonelderly group (n = 11,542) had a higher sample size than the elderly group (n = 7128). As expected, the majority of stroke occurred in the elder (n = 767), while the incidence of stroke was relatively low in the nonelderly subjects (n = 247). Therefore, the lack of association between sleep duration and stroke in the nonelderly may be due to a lack of statistical capacity in regression models.[29]

Sleep Duration and Stroke by Educational Level and Residential Area

The strength of the link at the lower educational level was similar to that found in previous studies in the current research, with 39% greater risk of stroke for sleeping 9 h/day and 67% greater for sleeping more than or equal to 10 h/day than for sleeping 7 h/day. An epidemiological prospective study found that both low socioeconomic status in childhood and adulthood socioeconomic status could predict the risk of stroke and their criteria for low socioeconomic status were less than high school (<9 years). Previous studies have shown a significant increase in the risk of stroke among people with lower levels of education and current studies confirm this positive association.[30] Besides, a meta-analysis found that individuals with low education status (<11 years) had a higher

Table 3. *Characteristics of participants with stroke according to sleep duration in Henan, China*

Characteristics	Total	<6 h (n = 937)	6∼7 h (n = 1744)	7∼8 h (n = 3641)	8∼9 h (n = 5749)	9∼10 h (n = 3653)	≥10 h (n = 2946)	*P* value
Stroke (%)	1014	58(6.2)	98(5.6)	126(3.5)	256(4.5)	205(5.6)	271(9.2)	<.001
Gender								<.001
Men	504	24(6.4)	48(5.9)	60(3.7)	143(5.8)	96(6.9)	133(11.4)	
Women	510	34(6.0)	50(5.4)	66(3.3)	113(3.4)	109(4.8)	138(7.8)	
Age (year)	1014	58(6.2)	98(5.6)	126(3.5)	256(4.5)	205(5.6)	271(9.2)	<.001
18∼59 (%)	247	9(1.9)	24(2.2%)	50(2.0%)	71(1.8%)	43(2.0%)	50(3.8%)	
60∼88 (%)	767	49(10.4)	74(11.6%)	76(7.0%)	185(10.1%)	162(11.0%)	221(13.6%)	
Nation (%)								.271
Han	977	56(6.3)	94(5.6)	123(3.5)	247(4.4)	196(5.5)	261(9.1)	
Others	37	2(4.5)	4(5.8)	3(2.8)	9(4.8)	9(9.3)	10(15.2)	
Marital status (%)								<.001
Married	842	43(5.8)	85(5.8)	111(3.9)	213(4.7)	167(6.0)	223(9.9)	
Single	172	15(7.7)	13(4.5)	15(1.8)	43(3.5)	38(4.3)	48(6.9)	
Areas (%)	1014	58(6.2)	98(5.6)	126(3.5)	256(4.5)	205(5.6)	271(9.2)	<.001
Rural	859	46(6.5)	74(5.9)	106(4.2)	207(5.0)	177(6.3)	249(9.7)	
Urban	155	12(5.4)	24(4.9)	20(1.7)	49(3.0)	28(3.3)	22(5.6)	
Family history (%)								<.001
Negative	817	46(5.8)	78(5.1)	100(3.1)	197(3.8)	172(5.2)	224(8.4)	
Positive	197	12(8.8)	20(8.9)	26(6.4)	59(10.3)	33(9.3)	47(17.2)	
Educational level (%)	1014	58(6.2)	98(5.6)	126(3.5)	256(4.5)	205(5.6)	271(9.2)	<.001
Middle school or below	908	51(6.6)	84(6.6)	106(4.5)	220(5.7)	189(7.0)	258(10.1)	
High school and above	106	7(4.2)	14(3.0)	20(1.5)	36(1.9)	16(1.7)	13(3.3)	
Occupation (%)								<.001
Farmer	618	45(9.6)	58(8.3)	75(6.0)	146(6.9)	120(7.7)	174(10.3)	
Non-farmer	396	13(2.8)	40(3.8)	51(2.1)	110(3.0)	85(4.1)	97(7.7)	
Smoking (%)								<.001
Never smoker	630	41(6.3)	55(4.8)	70(2.7)	154(3.7)	136(5.0)	174(8.2)	
Former smoker	214	6(7.3)	23(15.3)	33(10.6)	51(12.3)	37(13.5)	64(20.4)	
Current smoker	170	11(5.5)	20(4.5)	23(2.9)	51(4.4)	32(4.9)	33(6.5)	
Drinking (%)								<.001
Nondrinkers	748	44(6.4)	66(5.8)	86(3.7)	184(4.8)	157(6.0)	211(9.4)	
Moderate drinkers	152	7(4.7)	19(5.0)	17(1.8)	48(3.5)	30(4.1)	31(7.1)	
Heavy drinkers	114	7(7.3)	13(5.9)	23(6.4)	24(4.7)	18(5.7)	29(11.3)	
Physical activity (%)		58(6.2)	98(5.6)	126(3.5)	256(4.5)	205(5.6)	271(9.2)	<.001
Low	151	6(7.1)	13(6.5)	9(2.4)	33(5.5)	28(7.2)	62(15.6)	
Moderate	364	23(8.8)	37(8.1)	41(3.9)	89(5.4)	82(7.3)	92(10.3)	
High	499	29(4.9)	48(4.4)	76(3.4)	134(3.8)	95(4.4)	117(7.1)	
Hypertension (%)	763	45(8.1)	74(7.8)	91(5.2)	199(6.9)	144(7.6)	210(12.2)	<.001

Table 3 (*Continued*)

Characteristics	Total	<6 h (n = 937)	6~7 h (n = 1744)	7~8 h (n = 3641)	8~9 h (n = 5749)	9~10 h (n = 3653)	≥10 h (n = 2946)	*P* value
SBP (mmHg)	1014	142.61(23.16)	142.99(20.84)	140.70(23.12)	141.44(21.85)	142.35(24.64)	145.19(24.52)	<.001
DBP (mmHg)	1014	76.65(12.08)	78.56(10.55)	80.85(12.85)	79.66(11.60)	78.40(11.51)	79.79(12.40)	<.001
BMI (%) (kg/m^2)	1014	25.40(3.53)	25.61(4.20)	26.24(4.15)	26.33(3.81)	25.75(3.76)	26.09(3.85)	<.001
Obesity (%)	707	37(63.8)	61(62.2)	91(72.2)	189(73.8)	134(65.4)	195(72.0)	<.001
Waist circumference (cm)	1014	87.64(8.65)	89.73(9.45)	90.72(10.65)	91.02(9.54)	89.54(10.09)	90.87(9.92)	<.001
Waist-to-Hip Ratio	1014	.56(.06)	.57(.06)	.57(.07)	.57(.06)	.57(.07)	.58(.07)	<.001
Percentage body fat	1014	31.88(7.87)	31.50(6.58)	32.32(6.53)	31.55(6.65)	32.13(6.75)	32.02(6.84)	<.001
Visceral fat index	1014	10.68(4.94)	11.40(5.44)	11.65(4.90)	12.58(5.13)	11.58(5.35)	11.93(4.98)	<.001
Basal metabolic rate (kcal)	1014	1347.08 (192.60)	1387.05 (221.15)	1413.12 (218.04)	1437.52 (200.51)	1372.69 (197.91)	1387.38 (215.23)	.418

BMI, body mass index; SE, standard error; WC, waist circumference; WHtR, waist-to-hip ratio; PBF, percentage body fat; VFI, visceral fat index; BMR, Basal metabolic rate; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Frequencies (percentages), mean with standard deviation of each variable are presented.

P value were calculated using the *t* test for continuous variables and the chi-square test for qualitative variables.

risk of stroke of about a third than those with higher education status,[31] which is consistent with our findings. Subjects with higher education status may pursue a healthier and better lifestyle and consciously self-regulate sleep duration and habits, thus reducing their risk of stroke.

The age-standardized prevalence of stroke among rural population was significantly higher than urban population. Similar to the Global Burden of Diseases (GBD 2010), the age-standardized incidence of stroke in low-income and middle-income countries far exceeded those in high-income countries.[32] In China, rural population had poor medical conditions, low income and low educational levels. Meanwhile, the investigation revealed that stroke burden in China has increased over the past 30 years and remained particularly high in rural areas.[28] However, we also found that urban residents slightly increased the risk of stroke compared with rural residents. The reason could be that Chinese people have experienced rapid urbanization, accelerated population aging, changed eating habits, and lifestyle in the past 10 years, including increased energy intake, fat intake, the amount of smoking, alcohol consumption, and decreased physical activities. Consistent with our findings, the incidence of stroke was significantly higher from 1984 to 2004 in urban population aged 25-74 years in Beijing.[33]

The biological mechanisms for the association between sleep duration and increased risk of stroke have not been entirely clarified. Many studies have shown that sleep duration influenced the occurrence of stroke by direct effect or indirect effect. Sleep played an important role in the circadian rhythm, hormone secretion, metabolic, and lifestyle changes. Longer sleep duration might lead to the changes of circadian rhythm, which further influenced the activity of both the sympathetic and parasympathetic systems, thereby increased the risk of stroke.[34] Circadian rhythms contributed to changes in blood pressure and prevalence of some cardiovascular diseases.[35] Previous studies have reported that rotating night shift work disrupted circadian rhythms and was an independent risk factor for ischemic stroke.[36] Several researches suggested that excessive sleep duration led to the increase the occurrence of stroke and mortality, which might be attributed to sleep disorders, such as sleep disordered breathing. In summary, the results of this study supported the role of shorter and longer sleep durations acted as fundamental determinant of the elevated risk of stroke in China.

Strengths and Limitations

There were several key strengths in this study. Primarily, large sample size, detailed epidemiologic information and overall analyses in relation to the different subgroups of gender, age, educational level, and areas of inhabitance researching the correlation between sleep duration and stroke, which improve the evidence of the current discovery. In addition, multiple classification of sleep duration

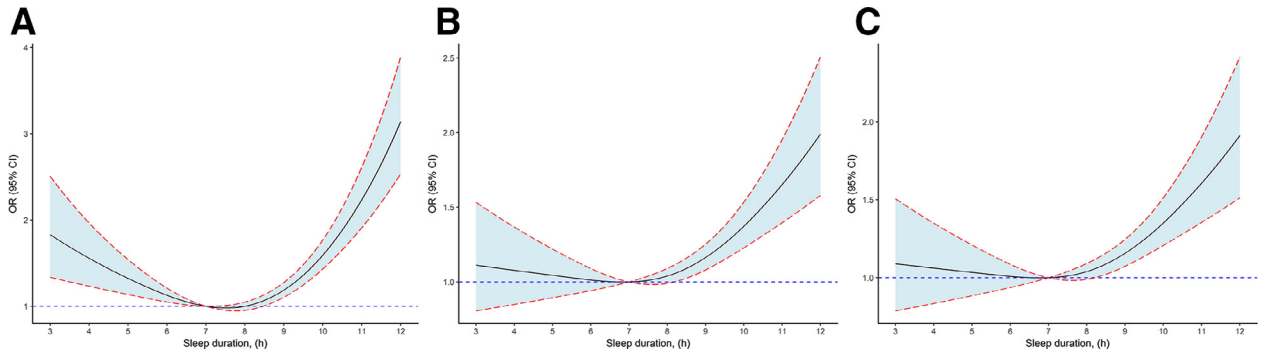

Figure 1. *Odds ratios (ORs; solid lines) and 95% confidence intervals (CIs, dashed lines) of stroke for sleep duration from restricted cubic splines. (A) Model 1, unadjusted. (B) Model 2, adjusted for age and employment. (C) Model 3, adjusted for age, gender, nation, marital status, areas of inhabitance, family history, educational level, occupation, smoking status, drinking status, physical activity, SBP, BMI, PBF and BMR. Abbreviations: BMI, body mass index; BMR, Basal metabolic rate; PBF, percentage body fat; SBP, systolic blood pressure.*

Table 4. *Odds Ratios (95% confidence intervals) for stroke according to sleep duration by gender, age and nonhealth factors*

Characteristics	Sample models	Number of stroke, Odds Ratio (95% Confidence Interval)					
		<6 h	6∼7 h	7∼8 h	8∼9 h	9∼10 h	≥10 h
Total							
	Model 1	1.84(1.34-2.53)*	1.66(1.27-2.18)*	1	1.30(1.05-1.62)*	1.66(1.32-2.08)*	2.83(2.27-3.51)*
	Model 2	1.22(.88-1.69)	1.43(1.08-1.88)*	1	1.26(1.01-1.57)*	1.37(1.09-1.72)*	1.68(1.34-2.11)*
	Model 3	1.19(.86-1.66)	1.39(1.05-1.83)*	1	1.25(1.01-1.56)*	1.37(1.08-1.73)*	1.63(1.30-2.04)*
Gender							
Male	Model 1	1.80(1.11-2.93)*	1.64(1.11-2.41)*	1	1.62(1.19-2.21)*	1.94(1.40-2.70)*	3.36(2.45-4.60)*
	Model 2	1.16(.70-1.91)	1.44(.97-2.14)	1	1.56(1.14-2.13)*	1.46(1.04-2.05)*	1.71(1.23-2.38)*
	Model 3	1.17(.71-1.93)	1.41(.94-2.09)	1	1.53(1.12-2.10)*	1.47(1.05-2.07)*	1.69(1.21-2.35)*
Female	Model 1	1.89(1.24-2.89)*	1.68(1.15-2.45)*	1	1.05(.77-1.42)	1.49(1.09-2.04)*	2.48(1.84-3.35)*
	Model 2	1.28(.83-1.98)	1.41(.96-2.07)	1	1.02(.74-1.39)	1.32(.96-1.80)	1.64(1.20-2.48)*
	Model 3	1.20(.78-1.86)	1.42(.96-2.08)	1	1.02(.74-1.39)	1.27(.93-1.75)	1.54(1.13-2.10)*
Age							
Aged18∼59	Model 1	0.99(.48-2.02)	1.11(.68-1.81)	1	0.92(.64-1.33)	1.01(.67-1.52)	1.97(1.33-2.94)*
	Model 2	0.65(.31-1.33)	0.86(.53-1.42)	1	1.98(.68-1.42)	1.00(.66-1.530	1.77(1.17-2.66)*
	Model 3	0.62(.30-1.28)	0.82(.50-1.36)	1	0.98(.67-1.42)	0.98(.64-1.50)	1.63(1.08-2.46)*
Aged 60∼88	Model 1	1.55(1.06-2.25)*	1.76(2.16-2.47)*	1	1.51(1.14-2.00)*	1.65(1.24-2.20)*	2.10(1.60-2.76)*
	Model 2	1.52(1.04-2.21)*	1.75(1.25-2.45)*	1	1.51(1.14-1.99)*	1.64(1.24-2.18)*	2.07(1.57-2.72)*
	Model 3	1.51(1.04-2.21)*	1.73(1.24-2.43)*	1	1.51(1.14-2.00)*	1.66(1.25-2.21)*	2.00(1.51-2.64)*
Educational level							
Middle school or below	Model 1	1.84(1.34-2.53)*	1.66(1.27-2.18)*	1	1.30(1.05-1.62)*	1.66(1.32-2.08)*	2.83(2.27-3.51)*
	Model 2	1.22(.88-1.69)	1.43(1.09-1.88)*	1	1.26(1.01-1.57)*	1.37(1.09-1.72)*	1.68(1.34-2.11)*
	Model 3	1.21(.87-1.67)	1.39(1.06-1.83)*	1	1.26(1.01-1.57)*	1.39(1.10-1.76)*	1.67(1.33-2.09)*
High school and above	Model 1	2.79(1.16-6.69)*	1.96(.98-3.91)	1	1.25(.72-2.17)	1.09(.56-2.12)	2.16(1.06-4.38)*
	Model 2	1.24(.50-3.09)	1.21(.59-2.48)	1	1.27(.72-2.24)	1.08(.54-2.13)	1.32(.63-2.79)
	Model 3	1.29(.52-3.22)	1.23(.60-2.53)	1	1.28(.73-2.27)	1.16(.59-2.31)	1.46(.69-3.10)
Residential area							
Rural resident	Model 1	1.56(1.09-2.22)*	1.42(1.04-1.92)*	1	1.20(.94-1.52)	1.51(1.18-1.94)*	2.43(1.93-3.08)*
	Model 2	1.12(.78-1.61)	1.27(0.93-1.73)	1	1.16(.91-1.48)	1.28(1.00-1.65)	1.62(1.27-2.06)*
	Model 3	1.10(.76-1.58)	1.23(.90-1.67)	1	1.16(.91-1.48)	1.28(.99-1.65)	1.56(1.22-1.99)*
Urban resident	Model 1	3.18(1.53-6.61)*	2.89(1.58-5.27)*	1	1.74(1.03-2.94)*	1.94(1.09-3.47)*	3.36(1.82-6.23)*
	Model 2	1.69(.80-3.59)	2.13(1.15-3.96)*	1	1.76(1.03-3.01)*	1.74(.96-3.16)	1.84(0.96-3.51)
	Model 3	1.72(.81-3.66)	2.08(1.12-3.87)*	1	1.78(1.04-3.04)*	1.85(1.02-3.38)*	1.90(1.01-3.65)*

Model 1: unadjusted.

Model 2: adjusted for age and gender.

Model 3: adjusted for age, gender, nation, marital status, areas of inhabitance, family history, educational level, occupation, smoking status, drinking status, physical activity, SBP, BMI, PBF and BMR

*$P < .05$.

in data analysis and adjusted for important confounders would reduce bias in association estimates. However, several limitations should be considered. First, this was a cross-sectional design and causal associations cannot be inferred. Second, the ascertainment of stroke patients according to the medical certificate of stroke issued by the hospital may underestimate the incidence of stroke. The detailed information of sleep duration was self-reported in subjective measures, which was hard to account and quantify, and may inevitably lead to bias. Future studies should determine the independent contribution of sleep duration and other risk factors of stroke. Moreover, the effects of subjective or objective sleep quality on the occurrence and development of health outcomes were also not investigated. Even though we did not include diabetes mellitus and dyslipidemia in the analysis of risk factors for stroke in the research. However, a prospective cohort study in Europe has revealed that sleep duration more than 8 hours significantly increased the risk of stroke after adjusted for sex, social class, education, marital status, smoking, alcohol intake, hypnotic drug use, family history of stroke, body mass index, physical activity, depression, hypnotic drug use, systolic blood pressure, diastolic blood pressure, pre-existing diabetes, and myocardial infarction, cholesterol level, and hypertension drug use.[37] Moreover, a 10-year follow-up study in the United States has shown that more than 8 hours of long sleep duration increased the risk of stroke after adjusted for other confounding factors, serum cholesterol level, and diabetes,[38] which is consistent with the results of a cohort study in the Chinese population[23,39] and European population.[40] So we should believe the results of our study are true and reliable. Therefore, future prospective cohort studies and polycentric studies are needed to confirm this relationship.

Conclusions

A dose-response association of sleep duration and stroke was found among the Chinese adults, and found longer sleep duration might contribute to the increased risk of stroke. Specifically male, older persons, less educated people, and people living in urban areas had a higher risk of stroke. It was suggested that people should develop a good sleeping habit to prevent disease.

Authors' Contributions

All authors conceived of or participated in the study. Qiaoyun Guo and Weihong Xie analyzed the data and wrote the first draft of the manuscript. Rui Peng, Yan Ma, Feifei Chong, Yanli Wang, and Mengmeng Song collected the data and revised the manuscript. Hua Ye and Peng Wang reviewed and revised the manuscript. Kaijuan Wang and Chunhua Song performed and designed study. All authors read and approved the final manuscript.

Compliance with Ethical Standards

Conflict of interests All authors declared that they have no potential conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jstrokecerebrovasdis.2019.04.016.

References

1. Norrving B, Kissela B. The global burden of stroke and need for a continuum of care. Neurology 2013;80 (3 Suppl 2):S5-S12.
2. Krishnamurthi RV, Feigin VL, Forouzanfar MH, et al. Global and regional burden of first-ever ischaemic and haemorrhagic stroke during 1990-2010: findings from the Global Burden of Disease Study 2010. Lancet Glob Health 2013;1:e259-e281.
3. Liu L, Wang D, Wong KS, Wang Y. Stroke and stroke care in China: huge burden, significant workload, and a national priority. Stroke 2011;42:3651-3654.
4. Lubitz SA, Parsons OE, Anderson CD, et al. Atrial fibrillation genetic risk and ischemic stroke mechanisms. Stroke 2017;48:1451-1456.
5. Cai H, Cai B, Sun L, et al. Association between PTGS1 polymorphisms and functional outcomes in Chinese patients with stroke during aspirin therapy: interaction with smoking. J Neurol Sci 2017;376:211-215.
6. Bardach AE, Caporale JE, Rubinstein AL, Danaei G. Impact of level and patterns of alcohol drinking on coronary heart disease and stroke burden in Argentina. PLoS One 2017;12:e0173704.
7. Meschia JF, Bushnell C, Boden-Albala B, et al. Guidelines for the primary prevention of stroke: a statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2014;45: 3754-3832.
8. 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;11:1047-1056.
9. Covassin N, Singh P. Sleep duration and cardiovascular disease risk: epidemiologic and experimental evidence. Sleep Med Clin 2016;11:81-89.
10. Cai H, Shu XO, Xiang YB, et al. Sleep duration and mortality: a prospective study of 113 138 middle-aged and elderly Chinese men and women. Sleep 2015;38:529-536.
11. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Sleep duration and all-cause mortality: a systematic review and

meta-analysis of prospective studies. Sleep 2010;33:585-592.
12. He Q, Sun H, Wu X, et al. Sleep duration and risk of stroke: a dose-response meta-analysis of prospective cohort studies. Sleep Med 2017;32:66-74.
13. Chen JC, Brunner RL, Ren H, et al. Sleep duration and risk of ischemic stroke in postmenopausal women. Stroke 2008;39:3185-3192.
14. Pan A, De Silva DA, Yuan JM, Koh WP. Sleep duration and risk of stroke mortality among Chinese adults: Singapore Chinese health study. Stroke 2014;45:1620-1625.
15. Wang Z, Zhang L, Chen Z, et al. Survey on prevalence of hypertension in China: background, aim, method and design. Int J Cardiol 2014;174:721-723.
16. Tuomilehto J, Kuulasmaa K. WHO MONICA Project: assessing CHD mortality and morbidity. Int J Epidemiol 1989;18(3 Suppl 1):S38-S45.
17. He L, Tang X, Song Y, et al. Prevalence of cardiovascular disease and risk factors in a rural district of Beijing, China: a population-based survey of 58,308 residents. BMC Public Health 2012;12:34.
18. Li Z, Bai Y, Guo X, Zheng L, Sun Y, Roselle AM. Alcohol consumption and cardiovascular diseases in rural China. Int J Cardiol 2016;215:257-262.
19. Armstrong T, Bull F. Development of the World Health Organization Global Physical Activity Questionnaire (GPAQ). J Public Health 2006;14:66-70.
20. Wang Z, Wang X, Hao G, et al. A national study of the prevalence and risk factors associated with peripheral arterial disease from China: the China Hypertension Survey, 2012-2015. Int J Cardiol 2019;275:165-170.
21. Wang Z, Chen Z, Zhang L, et al. Status of hypertension in China: results from the China Hypertension survey, 2012-2015. Circulation 2018;137:2344-2356.
22. Li W, Wang D, Cao S, et al. Sleep duration and risk of stroke events and stroke mortality: a systematic review and meta-analysis of prospective cohort studies. Int J Cardiol 2016;223:870-876.
23. Song Q, Liu X, Zhou W, et al. Long sleep duration and risk of ischemic stroke and hemorrhagic stroke: the Kailuan Prospective Study. Sci Rep 2016;6:33664.
24. Ge B, Guo X. Short and long sleep durations are both associated with increased risk of stroke: a meta-analysis of observational studies. Int J Stroke 2015;10:177-184.
25. Itani O, Jike M, Watanabe N, Kaneita Y. Short sleep duration and health outcomes: a systematic review, meta-analysis, and meta-regression. Sleep Med 2017;32:246-256.
26. Liu Y, Wheaton AG, Chapman DP, Croft JB. Sleep duration and chronic diseases among U.S. adults age 45 years and older: evidence from the 2010 behavioral risk factor surveillance system. Sleep 2013;36:1421-1427.
27. He Q, Sun H, Wu X, et al. Sleep duration and risk of stroke: a dose−response meta-analysis of prospective cohort studies. Sleep Med 2017;32:66-74.
28. Wang W, Jiang B, Sun H, et al. Prevalence, Incidence, and Mortality of Stroke in China: results from a Nationwide Population-Based Survey of 480 687 Adults. Circulation 2017;135:759-771.
29. Liu L, Xue F, Ma J, et al. Social position and chronic conditions across the life span and risk of stroke: a life course epidemiological analysis of 22,847 American adults in ages over 50. Int J Stroke 2013;8(Suppl A100):50-55.
30. Centers for Disease Control and Prevention (CDC). Prevalence of stroke−United States, 2006-2010. MMWR Morb Mortal Wkly Rep 2012;61:379-382.
31. Mchutchison CA, Backhouse EV, Cvoro V, Shenkin SD, Wardlaw JM. Education, socioeconomic status and intelligence in childhood and stroke risk in later life: a meta-analysis. Epidemiology 2017;28:608-618.
32. Feigin VL, Forouzanfar MH, Krishnamurthi R, et al. Global and regional burden of stroke during 1990-2010: findings from the Global Burden of Disease Study 2010. Lancet 2014;383:245-254.
33. Zhao D, Liu J, Wang W, et al. Epidemiological transition of stroke in China: twenty-one-year observational study from the Sino-MONICA-Beijing Project. Stroke 2008;39:1668-1674.
34. Patyar S, Patyar RR. Correlation between sleep duration and risk of stroke. J Stroke Cerebrovasc Dis 2015;24:905-911.
35. McNamara P, Seo SB, Rudic RD, et al. Regulation of CLOCK and MOP4 by nuclear hormone receptors in the vasculature: a humoral mechanism to reset a peripheral clock. Cell 2001;105:877-889.
36. Brown DL, Feskanich D, Sanchez BN, et al. Rotating night shift work and the risk of ischemic stroke. Am J Epidemiol 2009;169:1370-1377.
37. Leng Y, Cappuccio FP, Wainwright NW, et al. Sleep duration and risk of fatal and nonfatal stroke: a prospective study and meta-analysis. Neurology 2015;84:1072-1079.
38. Qureshi AI, Giles WH, Croft JB, Bliwise DL. Habitual sleep patterns and risk for stroke and coronary heart disease: a 10-year follow-up from NHANES I. Neurology 1997;48:904-911.
39. Tu X, Cai H, Gao YT, et al. Sleep duration and its correlates in middle-aged and elderly Chinese women: the Shanghai Women's Health Study. Sleep Med 2012;13:1138-1145.
40. von Ruesten A, Weikert C, Fietze I, Boeing H. Association of sleep duration with chronic diseases in the European Prospective Investigation into Cancer and Nutrition (EPIC)-Potsdam study. PLoS One 2012;7:e30972.