Sleep and Breathing (2023) 27:265–274
https://doi.org/10.1007/s11325-022-02619-w

SLEEP BREATHING PHYSIOLOGY AND DISORDERS • ORIGINAL ARTICLE

The independent and combined association of napping and night sleep duration with stroke in Chinese rural adults

Jing Yang[1,2] · Xiaotian Liu[2] · Zhihan Zhai[2] · Wei Liao[2] · Yaling He[2] · Xueyan Wu[2] · Chongjian Wang[2] · Chunyang Sun[3] · Yuqian Li[1,2]

Received: 15 November 2021 / Revised: 14 April 2022 / Accepted: 15 April 2022 / Published online: 25 April 2022

Abstract

Background Inappropriate sleep duration is a potential cause of stroke. But the effect of napping on stroke risk remains controversial and the interaction between night sleep and napping duration remains unclear. The objective of this study was to examine the independent and combined effects of napping and nocturnal sleep duration on stroke.

Methods Subjects were derived from a rural cohort study in Henan. The Pittsburgh Sleep Quality Index (PSQI) was applied to identify nap duration and nocturnal sleep duration. Binary logistic regression was employed to indicate the dose–response relationships between naps, nocturnal sleep, total 24-h sleep duration, and stroke.

Results Among the 37,341 participants (14,485 men), 2600 suffered from a stroke. The odds ratios (ORs) and 95% confidence level (CI) for stroke in the fully adjusted model were 1.37 (1.13–1.65) for men nappers compared to non-nappers. Compared to 7–8 h of sleep per day, night sleep durations < 6 h and ≥ 9 h and 24-h sleep duration ≥ 10 h were linked to increased odds of stroke in men. The ORs (95%CI) were 1.34 (1.06–1.69) in nocturnal sleep duration < 6 h, 1.30 (1.06–1.59) in nocturnal sleep duration ≥ 9 h, and 1.40 (1.15–1.71) in 24-h sleep duration ≥ 10 h in men. In addition, long naps and prolonged nocturnal sleep duration have a joint effect on stroke in the fully adjusted model.

Conclusion The napping duration and nocturnal sleep duration have independently and jointly effects on stroke in rural populations. More research is required to explore the underlying mechanisms for this relationship.

Clinical trial registration The Henan Rural Cohort Study has been registered on the Chinese Clinical Trial Register (Registration number: ChiCTR-OOC-15006699) (http://www.chictr.org.cn/showproj.aspx?proj=11375).

Keywords Napping duration · Night sleep duration · 24-h total sleep · Stroke · Logistic regression

Introduction

Stroke is the primary source of death in China, and the burden has increased significantly between 1990 and 2010 resulting from an increasing the absolute number of people who suffered a stroke, the number of related deaths, and disability-adjusted life-years lost [1]. A recent review systematically explored the stroke prevalence and showed that the overall stroke prevalence was 5.0% in central China for those ≥ 40 years of age, with a higher incidence in men than women, and a significant increase in prevalence, especially among those aged 40–59 years [2]. Stroke, because of its suddenness and severity, places a heavy burden on individuals, families, and society. Therefore, the study of stroke risk factors and effective control may be a vital way to prevent stroke.

Jing Yang and Xiaotian Liu are contributed equally to this work.

✉ Yuqian Li
liyuqian@zzu.edu.cn

1 Department of Clinical Pharmacology, School of Pharmaceutical Science, Zhengzhou University, Zhengzhou, Henan, People's Republic of China

2 Department of Epidemiology and Biostatistics, College of Public Health, Zhengzhou University, 100 Kexue Avenue, Zhengzhou 450001, Henan, People's Republic of China

3 Department of Preventive Medicine, Henan University of Chinese Medicine, Zhengzhou, Henan, People's Republic of China

A systemic analysis of worldwide stroke burden and risk factors in 188 countries indicated that the risk factors for stroke include low physical activity, poor diet, smoking, high BMI, high SBP, high total cholesterol, and high fasting plasma glucose air pollution exposure [3]. Furthermore, previous studies indicated that getting more or less sleep than recommended and daytime napping increases stroke risk [4]. However, discussions on the risk of stroke have been inconsistent, with some research suggesting that shorter and prolonged sleep duration increases stroke risk [5], some showing that only longer or shorter sleep is associated with stroke [6], or neither was associated with stroke [7].

Insufficient sleep quantity and worse sleep quality are commonly seen in contemporary society and are related to many diseases, especially hypertension, depressive symptoms, type 2 diabetes (T2D), and stroke. A large community-based study showed that daytime napping with a high frequency (≥ 5 times/week) or long duration (> 30 min) increase the risk of stroke [8]. However, few studies have explored the effect of napping combined with night sleep duration on stroke. These studies mostly focused on the urban people and mainly investigated special groups, such as the elderly [9]. There are few studies that have paid attention to the rural areas, which make up over 40% of Chinese people [10]. Furthermore, there is no doubt that napping or night sleep duration is linked to the prevalence of stroke, but few studies have shown the relationship of 24 h of total 24-h sleep on stroke risk [11].

Exploring the connection of sleep duration and stroke may provide assistance in proposing appropriate sleep duration to reduce the incidence of stroke and provide effective sleep recommendations for individuals who aspire to a healthy lifestyle. Therefore, the objective of this study was to evaluate the relationship of napping, nocturnal sleep and 24-h sleep duration on stroke, as well as the combined effect of napping and nocturnal sleep on stroke. The study hypothesized that inappropriate sleep duration and stroke have a significant effect on a rural Chinese population.

Materials and methods

Study design and participants

Subjects were derived from a prospective cohort research study on chronic non-communicable diseases conducted in Henan Province, which included 39,259 adults (18–79 years old). Subjects were excluded if they were incapable of answering the questionnaire or reporting to the survey site because of a serious physical or mental illness. All participants fasted for at least 8 h before coming to the health screening center. Blood and urine sample collection, anthropometric measurements, clinical examination, and self-report questionnaires (general demographic characteristics, lifestyle, sleep status, personal history of illness, and family history of illness) were administered by trained physicians, nurses, and technicians. A baseline study was performed during July 2015 to September 2017 and the follow-up surveys were carried out every 3 years starting in 2018. The present study only included the data from the baseline survey. The survey details have been presented before [12]. In this survey, 37,341 participants were enrolled in the further analysis, after excluding individuals without nighttime sleep duration ($n = 36$), without daytime nap duration ($n = 6$), individuals who were shift workers ($n = 1549$), or suffered cancer ($n = 327$). This study complied with the principles which were summarized in the Helsinki Declaration. The Life Sciences Ethics Committee of Zhengzhou University endorsed this study, and every individual gave written informed consent.

Sleep duration

Sleep duration was collected using the Pittsburgh Sleep Quality Index (PSQI) [13]. The daytime nap time came from the question: "Have you napped during the middle of the day in the past 30 days?" The sleep duration at night was obtained from this question: "How many sleep hours did you actually get each night in the past 30 days?" Those who answered yes were then asked: "How many times a week do you nap (frequency) and how long (min) is the nap duration." We used the following formula to calculate the average daily nap time: frequency (times/week) × duration (minutes/ per time)/7. The length of nighttime sleep plus the length of the nap gave the total length of 24 h of sleep. According to the existing epidemiological studies [14], nocturnal sleep duration was sorted by < 6 h, 6 ≤ nocturnal sleep duration < 7 h, 7 ≤ nocturnal sleep duration < 8 h (reference), 8 ≤ nocturnal sleep duration < 9 h, and nocturnal sleep duration ≥ 9 h. The daytime napping duration was categorized as 0 min (reference), 1 ≤ nap duration < 30 min, 30 ≤ nap duration < 60 min, 60 ≤ nap duration < 90 min, and nap duration ≥ 90 min. Furthermore, 24-h total sleep duration was classified into 6 groups: < 6 h, 6 ≤ total sleep duration < 7 h, 7 ≤ total sleep duration < 8 h, 8 ≤ total sleep duration < 9 h, 9 ≤ total sleep duration < 10 h, and total sleep duration ≥ 10 h.

Definition of stroke

Each participant was enrolled in the New Rural Cooperative Medical System (NRCMS), in which every individual has a uniquely identifiable ID card and health insurance card number for disease tracking purposes. The participant was defined as having had a stroke if there was a prior physician self-reported stroke diagnosis. The village physician then confirmed the NRCMS stroke history review and was

identified by an endocrinologist, a cardiologist, an epidemiologist, and a physician according to standardization approved by the criteria of the World Health Organization [15, 16].

Covariates

In the current study, the information on demographic characteristics, lifestyles, and the history of the disease was acquired by standard questionnaires administered by well trained interviewers. The demographic characteristics included age, gender, per capita income per month (< 500, 500 ~ , and 1000 ~ RMB), marital status (married/living together, separated/widowed/unmarried), and education (elementary school or below, Junior High School, Senior High School or above). Lifestyles included a high-fat diet (≥ 75 g of meat per day), more vegetables and fruits intake (≥ 500-g vegetables and fruits per day), drinker (≥ 12 times in the past year), smoker (≥ 1 cigarettes per day for over 6 months), and physical activity (low, medium, and high levels) [17]. Body mass index (BMI) was calculated by dividing weight in kilograms by the square of height (kg/m^2) [18].

Statistical analysis

Categorical and continuous variables are shown as proportions and mean ± standard deviation, respectively. Categorical and continuous and covariates between those suffering from and not suffering from stroke were respectively compared using the chi-square test and Student's *t*-test. Restricted cubic curve uses three nodes (5th, 50th, and 95th centiles) to investigate the correlation of napping, night sleep, and total 24-h sleep duration with stroke [19]. To examine the influence of naps, night sleep, and 24-h total sleep duration on stroke, the binary logistic regression model was developed with nap duration/nighttime sleep duration/24-h total sleep duration as the independent variable. Three models were established: the first model adjusting for no variables. The second model adjusted for age and gender. The third model was further adjusted for education, per capita monthly income, marital status, fatty diet, greater vegetables and fruits intake, current smoker, current drinker, BMI, physical activity, nocturnal sleep duration, nap duration, family history of stroke, hypertension, and type 2 diabetes mellitus. Furthermore, analyses stratified by sex were conducted throughout the study to examine the effect of gender on the correlation.

All statistical analysis was performed using SPSS V21. Two-tailed $P < 0.05$ was regarded as statistically significant.

Results

Characteristics of participants

The subjects' demographic characteristics and health behaviors are displayed in Table 1. The final sample of this study was 37,341 individuals (14,485 men), including 2600 individuals who were diagnosed as having a stroke. Compared with subjects without stroke, those with stroke tended to be older and had lower per capita monthly income, education level, physical activity level, and higher BMI. Additionally, participants with stroke tended to be unmarried/widowed/divorced, with longer night sleep duration, longer nap duration, and more extreme 24-h sleep duration than participants without stroke. The average 24-h sleep duration was 9.2 h and 8.8 h in men and women, respectively. Similarly, the average napping duration was 69.9 min and 58.2 min in men and women, respectively, revealing that men had longer napping duration and longer 24-h total sleep duration than women.

Relationship of naps/night/24-h sleep duration and stroke

The ORs and 95% CI of stroke with naps moreover 90 min were 1.57 (1.39–1.76) in the unadjusted model compared with non-nappers. In model 3, the ORs (95%*CI*) for participants taking a nap longer than 90 min were 1.28 (1.14–1.45) for total, 1.37 (1.13–1.65) for men, and 1.23 (1.04–1.45) for women. Each 30 min increase in nap time was related to 6.1% (3.1–9.2%) for all participants, 7.7% (3.1–12.6%) for men, 5.0% (1.0–9.2%) for women in the model with fully adjusted (Table 2).

Participants who had a short nighttime sleep (< 6 h/day) had an increased risk of stroke compared to subjects who slept 7–8 h/day for all and for men, but not for women. The ORs (95%*CI*) for less than 6 h at night were 1.26 (1.09–1.46) for all, 1.34 (1.06–1.69) for men, and 1.18 (0.97–1.43) for women, after adjusted fully confounding factors, which showed a slightly stronger relationship for men than for women. Prolonged night sleep duration (≥ 9 h/day) also raised the prevalence of stroke in those men who slept only 7–8 h (OR = 1.30, 95%CI: 1.06–1.59). In addition, the corresponding adjusted *ORs* for stroke in men were 1.15 (1.05–1.26) and 1.12 (0.99–1.26) for each hour of increase and decrease in nighttime sleep compared with the reference values (Table 3).

Subjects with a long 24-h total sleep duration (≥ 10 h/day) increased their stroke risk (OR = 2.12, 95%CI: 1.76–2.55) compared to those with 7–8 h of sleep among total participants in the unadjusted model. After layering

Table 1 The characteristics of participants according to stroke by gender

	Total ($N=37,341$)			Men ($N=14,485$)			Women ($N=22,856$)		
	Stroke	Non-stroke	*P*	Stroke	Non-stroke	*P*	Stroke	Non-stroke	*P*
Age(years), mean (SD)	64.0 (7.7)	55.4 (12.1)	< 0.001	64.4 (8.0)	56.5 (1.2)	< 0.001	63.6 (7.5)	54.7 (12.0)	< 0.001
Marital status, *n* (%)			< 0.001			< 0.001			< 0.001
Married/cohabitation	2201 (84.7)	31,229 (89.9)		1034 (86.1)	11,958 (90.0)		1167 (83.4)	19,271 (89.8)	
Unmarried/divorced/ widowed	399 (15.4)	3512 (10.1)		167 (13.9)	1326 (10.0)		232 (16.6)	2186 (10.2)	
Educational levels, *n* (%)			< 0.001			< 0.001			< 0.001
Primary school or below	1557 (59.9)	15,608 (44.9)		555 (46.2)	4485 (33.8)		1002 (71.6)	11,123 (51.8)	
Junior high school	807 (31.0)	13,882 (40.0)		479 (39.9)	6200 (46.7)		328 (23.5)	7682 (35.8)	
Senior high school or above	236 (9.1)	5251 (15.1)		167 (13.9)	2599 (19.6)		69 (4.9)	2652 (12.4)	
Average income per month, *n* (%)			< 0.001			< 0.001			< 0.001
< 500 RMB	1207 (46.4)	12,377 (35.6)		549 (45.7)	4849 (36.5)		658 (47.0)	7528 (35.1)	
500- RMB	770 (29.6)	11,545 (33.2)		364 (30.3)	4247 (32.)		406 (29.0)	7298 (34.0)	
≥ 1000 RMB	623 (24.0)	10,819 (31.1)		288 (24.0)	4188 (31.5)		335 (24.0)	6631 (30.9)	
More vegetables and fruits intake, *n* (%)	1063 (40.9)	14,594 (42.)	0.262	490 (40.8)	5756 (43.3)	0.089	573 (41.2)	8838 (41.0)	0.865
High-fat diet, *n* (%)	313 (12.0)	6748 (19.4)	< 0.001	174 (14.5)	3431 (25.8)	< 0.001	139 (9.9)	3317 (15.5)	< 0.001
Current smoker, *n* (%)	399 (15.4)	6541 (18.8)	< 0.001	395 (32.9)	6484 (48.8)	< 0.001	4 (0.3)	57 (0.3)	0.93
Current drinker, *n* (%)	286 (11.0)	6273 (18.1)	< 0.001	265 (22.1)	5701 (42.9)	< 0.001	21 (1.5)	572 (2.7)	0.027
Physical activity levels, *n* (%)			< 0.001			< 0.001			< 0.001
Light	1145 (44.0)	10,843 (31.1)		610 (50.8)	4548 (34.2)		535 (38.2)	6295 (29.3)	
Moderate	885 (34.0)	13,218 (38.1)		306 (25.5)	3675 (27.7)		579 (41.4)	9543 (44.5)	
Vigorous	570 (21.9)	10,680 (30.7)		285 (23.7)	5061 (38.1)		285 (20.4)	5619 (26.2)	
Body mass index (kg/m^2), mean (SD)	25 (3.5)	24.8 (3.6)	0.001	24.69 (3.4)	24.49 (3.5)	0.054	25.34 (3.5)	25 (3.6)	< 0.001
Night sleep duration(h), mean (SD)	7.9 (1.5)	7.8 (1.3)	< 0.001	8.0 (1.4)	7.7 (1.3)	< 0.001	7.8 (1.5)	7.8 (1.3)	0.655
Napping duration (min), mean (SD)	63.6 (51.0)	57.0 (50.3)	< 0.001	70.0 (51.1)	62.4 (49.7)	< 0.001	58.2 (50.3)	53.6 (50.4)	0.001
Total sleep duration (h), mean (SD)	8.9 (1.8)	8.7 (1.5)	< 0.001	9.2 (1.7)	8.8 (1.5)	< 0.001	8.8 (1.8)	8.7 (1.6)	0.051

by gender, the long total sleep time was significantly correlated with stroke (OR = 1.40, 95%CI: 1.15–1.71) in men in model 3. Furthermore, subjects with short total sleep duration (< 6 h/day) showed a similar association with stroke. The ORs of 24-h total sleep duration per 1-h increase and decrease were 1.06 (1.02–1.10) and 1.09 (0.92–1.30) for stroke in men (Table 4).

Additionally, restrictive cubic splines demonstrated that there was a significantly increased risk of stroke with increased daytime napping time. Additionally, a U-shaped trend was found for stroke risk and the duration of nighttime sleep. A similar association was also found in the 24-h total sleep duration and stroke (Fig. 1).

Joint effects of naps and nocturnal sleep duration for stroke

To examine the combined effects of daytime nap and nighttime sleep duration, a heat map was used to visualize how the relationship of nighttime sleep duration with stroke risk changed as nap duration increased. In the graph, there is a higher risk of stroke the darker the color of the pattern. Figure 2 shows that with a prolonged nap duration and longer or shorter night sleep duration, the darker the squares, that is, the higher the risk of stroke. In addition, in participants' nighttime sleep < 6 h, the adjusted OR tended to decrease as napping increased and the OR for stroke

Table 2 Odds ratios of stroke according to napping duration

	Napping duration (min)					Each 30-min increase
	0	1 ~	30 ~	60 ~	≥ 90	
Total						
Case/N	629/10893	267/4185	775/10431	246/3360	683/8472	
Model 1	1 (Ref.)	1.07 (0.94, 1.22)	1.33 (1.19, 1.49)	1.31 (1.12, 1.54)	1.57 (1.39, 1.76)	1.12 (1.09, 1.15)
Model 2	1 (Ref.)	1.11 (0.98, 1.26)	1.22 (1.09, 1.36)	1.17 (0.99, 1.38)	1.37 (1.22, 1.55)	1.08 (1.07, 1.08)
Model 3	1 (Ref.)	1.04 (0.92, 1.19)	1.14 (1.02, 1.28)	1.09 (0.92, 1.29)	1.28 (1.14, 1.45)	1.06 (1.03, 1.09)
Men						
Case/N	233/3493	103/1431	380/4372	132/1521	353/3668	
Model 1	1 (Ref.)	1.1 (0.89, 1.34)	1.33 (1.12, 1.58)	1.35 (1.07, 1.7)	1.63 (1.36, 1.94)	1.13 (1.08, 1.18)
Model 2	1 (Ref.)	1.15 (0.93, 1.41)	1.26 (1.06, 1.50)	1.21 (0.96, 1.53)	1.45 (1.21, 1.74)	1.09 (1.05, 1.14)
Model 3	1 (Ref.)	1.06 (0.85, 1.31)	1.16 (0.97, 1.39)	1.12 (0.88, 1.43)	1.37 (1.13, 1.65)	1.08 (1.03, 1.13)
Women						
Case/N	396/7400	164/2754	395/6059	114/1839	330/4804	
Model 1	1 (Ref.)	1.05 (0.90, 1.23)	1.27 (1.09, 1.47)	1.18 (0.94, 1.48)	1.42 (1.21, 1.66)	1.09 (1.05, 1.13)
Model 2	1 (Ref.)	1.09 (0.93, 1.28)	1.19 (1.02, 1.38)	1.14 (0.91, 1.44)	1.31 (1.12, 1.54)	1.07 (1.03, 1.11)
Model 3	1 (Ref.)	1.05 (0.89, 1.24)	1.13 (0.97, 1.32)	1.09 (0.86, 1.38)	1.23 (1.04, 1.45)	1.05 (1.01, 1.09)

Model 1 was unadjusted

Model 2 was adjusted for age and gender (only for total participants)

Model 3 was adjusted for age, gender, education levels, average income per month, marital status, more vegetables and fruits intake, high-fat diet, current smoker, current drinker, physical activity, body mass index, night sleep duration, family history of stroke, hypertension, and type 2 diabetes mellitus

Table 3 Odds ratios of stroke according to night sleep duration

	Night sleep duration (h)					Each 1-h increase	Each 1-h decrease
	< 6	6 ~	7 ~	8 ~	≥ 9		
Total							
Case/N	277/3622	487/7735	790/13023	659/8933	387/4028		
Model 1	1.28 (1.11, 1.48)	1.04 (0.93, 1.17)	1 (Ref.)	1.23 (1.11, 1.37)	1.65 (1.45, 1.87)	1.25 (1.18, 1.33)	1.09 (1.01, 1.18)
Model 2	1.20 (1.04, 1.39)	1.06 (0.94, 1.19)	1 (Ref.)	1.10 (0.99, 1.23)	1.20 (1.05, 1.37)	1.08 (1.02, 1.15)	1.08 (1.07, 1.09)
Model 3	1.26 (1.09, 1.46)	1.09 (0.96, 1.23)	1 (Ref.)	1.08 (0.96, 1.21)	1.11 (0.97, 1.27)	1.06 (0.99, 1.13)	1.09 (1.01, 1.18)
Men							
Case/N	113/1391	217/3122	355/5087	317/3298	199/1587		
Model 1	1.18 (0.95, 1.47)	1.00 (0.84, 1.19)	1 (Ref.)	1.42 (1.21, 1.66)	1.91 (1.59, 2.30)	1.38 (1.26, 1.50)	1.04 (0.93, 1.17)
Model 2	1.20 (0.96, 1.51)	1.05 (0.88, 1.25)	1 (Ref.)	1.24 (1.06, 1.46)	1.43 (1.18, 1.72)	1.20 (1.09, 1.31)	1.08 (0.96, 1.21)
Model 3	1.34 (1.06, 1.69)	1.10 (0.91, 1.33)	1 (Ref.)	1.17 (0.99, 1.39)	1.30 (1.06, 1.59)	1.15 (1.05, 1.26)	1.12 (0.99, 1.26)
Women							
Case/N	164/2231	270/4613	435/7936	342/5635	188/2441		
Model 1	1.37 (1.14, 1.65)	1.07 (0.92, 1.25)	1 (Ref.)	1.11 (0.96, 1.29)	1.44 (1.21, 1.72)	1.15 (1.06, 1.25)	1.12 (1.01, 1.24)
Model 2	1.18 (0.98, 1.43)	1.06 (0.90, 1.24)	1 (Ref.)	1.00 (0.86, 0.16)	1.02 (0.85, 1.23)	1.00 (0.92, 1.08)	1.07 (0.97, 1.19)
Model 3	1.18 (0.97, 1.43)	1.07 (0.91, 1.25)	1 (Ref.)	1.00 (0.86, 1.17)	0.97 (0.80, 1.17)	0.98 (0.90, 1.07)	1.06 (0.96, 1.18)

Model 1 was unadjusted

Model 2 was adjusted for age and gender (only for total participants)

Model 3 was adjusted for age, gender, education levels, average income per month, marital status, more vegetables and fruits intake, high-fat diet, current smoker, current drinker, physical activity, body mass index, napping duration, family history of stroke, hypertension, and type 2 diabetes mellitus

Table 4 Odds ratios of stroke according to 24-h total sleep duration

	Total sleep duration (h)						Each 1-h increase	Each 1-h decrease
	< 6	6 ~	7 ~	8 ~	9 ~	≥ 10		
Total								
Case/N	140/1843	238/3939	495/8531	652/10434	530/7442	545/5152		
Model 1	1.34 (1.10, 1.62)	1.04 (0.89, 1.22)	1 (Ref.)	1.08 (0.96, 1.22)	1.25 (1.10, 1.41)	1.92 (1.69, 2.18)	1.11 (1.08, 1.14)	1.16 (1.05, 1.28)
Model 2	1.14 (0.93, 1.39)	1.04 (0.89, 1.23)	1 (Ref.)	1.00 (0.88, 1.13)	1.04 (0.91, 1.18)	1.38 (1.21, 1.57)	1.05 (1.02, 1.07)	1.09 (0.98, 1.20)
Model 3	1.17 (0.96, 1.43)	1.07 (0.91, 1.26)	1 (Ref.)	0.99 (0.88, 1.12)	1.01 (0.88, 1.15)	1.29 (1.13, 1.47)	1.03 (1.01, 1.06)	1.11 (1.00, 1.23)
Men								
Case/N	46/601	92/1395	219/3271	282/4060	273/2970	289/2188		
Model 1	1.16 (0.83, 1.61)	0.98 (0.77, 1.27)	1 (Ref.)	1.04 (0.87, 1.25)	1.41 (1.17, 1.70)	2.12 (1.76, 2.55)	1.05 (1.11, 1.19)	1.09 (0.93, 1.29)
Model 2	1.02 (0.73, 1.43)	0.99 (0.76, 1.28)	1 (Ref.)	0.93 (0.77, 1.12)	1.15 (0.95, 1.39)	1.51 (1.25, 1.82)	1.08 (1.04, 1.12)	1.05 (0.89, 1.24)
Model 3	1.11 (0.79, 1.57)	1.05 (0.81, 1.37)	1 (Ref.)	0.93 (0.77, 1.13)	1.11 (0.91, 1.35)	1.40 (1.15, 1.71)	1.06 (1.02, 1.10)	1.09 (0.92, 1.30)
Women								
Case/N	94/1242	146/2544	276/5260	370/6374	257/4472	256/2964		
Model 1	1.48 (1.16, 1.89)	1.10 (0.89, 1.35)	1 (Ref.)	1.11 (0.95, 1.31)	1.10 (0.92, 1.31)	1.71 (1.43, 2.04)	1.07 (1.04, 1.11)	1.20 (1.06, 1.37)
Model 2	1.20 (0.93, 1.53)	1.08 (0.88, 1.33)	1 (Ref.)	1.06 (0.90, 1.25)	0.94 (0.79, 1.12)	1.27 (1.06, 1.52)	1.02 (0.99, 1.06)	1.11 (0.98, 1.27)
Model 3	1.19 (0.93, 1.52)	1.07 (0.87, 1.32)	1 (Ref.)	1.04 (0.89, 1.23)	0.93 (0.77, 1.11)	1.20 (1.00, 1.44)	1.01 (0.98, 1.05)	1.11 (0.98, 1.27)

Model 1 was unadjusted

Model 2 was adjusted for age and gender (only for total participants)

Model 3 was adjusted for age, gender, education levels, average income per month, marital status, more vegetables and fruits intake, high fat diet, current smoker, current drinker, physical activity, body mass index, family history of stroke, hypertension, and type 2 diabetes mellitus

was the lowest in the napping duration > 90 min. To be specific, compared with non-nappers with 7–8 h of nighttime sleep duration, participants who had nocturnal sleep duration < 6 h and napping duration ≥ 30 min had a higher prevalence of stroke in men (OR: 1.85, 95%CI: 1.20–2.86 for men). Subjects with over 90-min napping duration and over 8-h nighttime sleep duration also appeared to have greater odds of stroke, especially in men (OR: 1.59, 95%CI: 1.13–2.25 for those with 8 ~ 9-h nocturnal sleep duration and OR: 1.69, 95%CI: 1.16–2.47 for those with over 9-h nocturnal sleep duration). Among women, similar trends were also observed, but were not statistically significant. However, participants with over 90-min napping duration and less than 6-h night sleep duration had a lower risk of stroke, the ORs (95%CI) was 1.21 (0.86–1.71) for all, 1.30 (0.78–2.17) for men, and 1.13 (0.70–1.80) for women, compared with participants who took 31–90 min of naps, although not statistically significant.

Discussion

In this study, it was shown that long naps (≥ 90 min) and longer (≥ 9 h) or shorter (< 6 h) nocturnal sleep duration, as well as extreme 24-h total sleep duration (≥ 10 h/day) increased the risk of stroke in people living in rural China. After stratification by gender, both men and women increased the risk of stroke when prolonging the napping duration, but long or short nocturnal sleep duration and 24-h total sleep duration were linked to higher odds of stroke only in men. Furthermore, there exists a combined effect between nap duration and nighttime sleep duration on stroke. The longer the nap time in people with adequate or excessive nighttime sleep (≥ 6 h), the greater the risk of stroke, the longer the nap time in people with short nighttime sleep (< 6 h), the lower the risk of stroke. The current study may help to better identify significant risk variables regarding sleep.

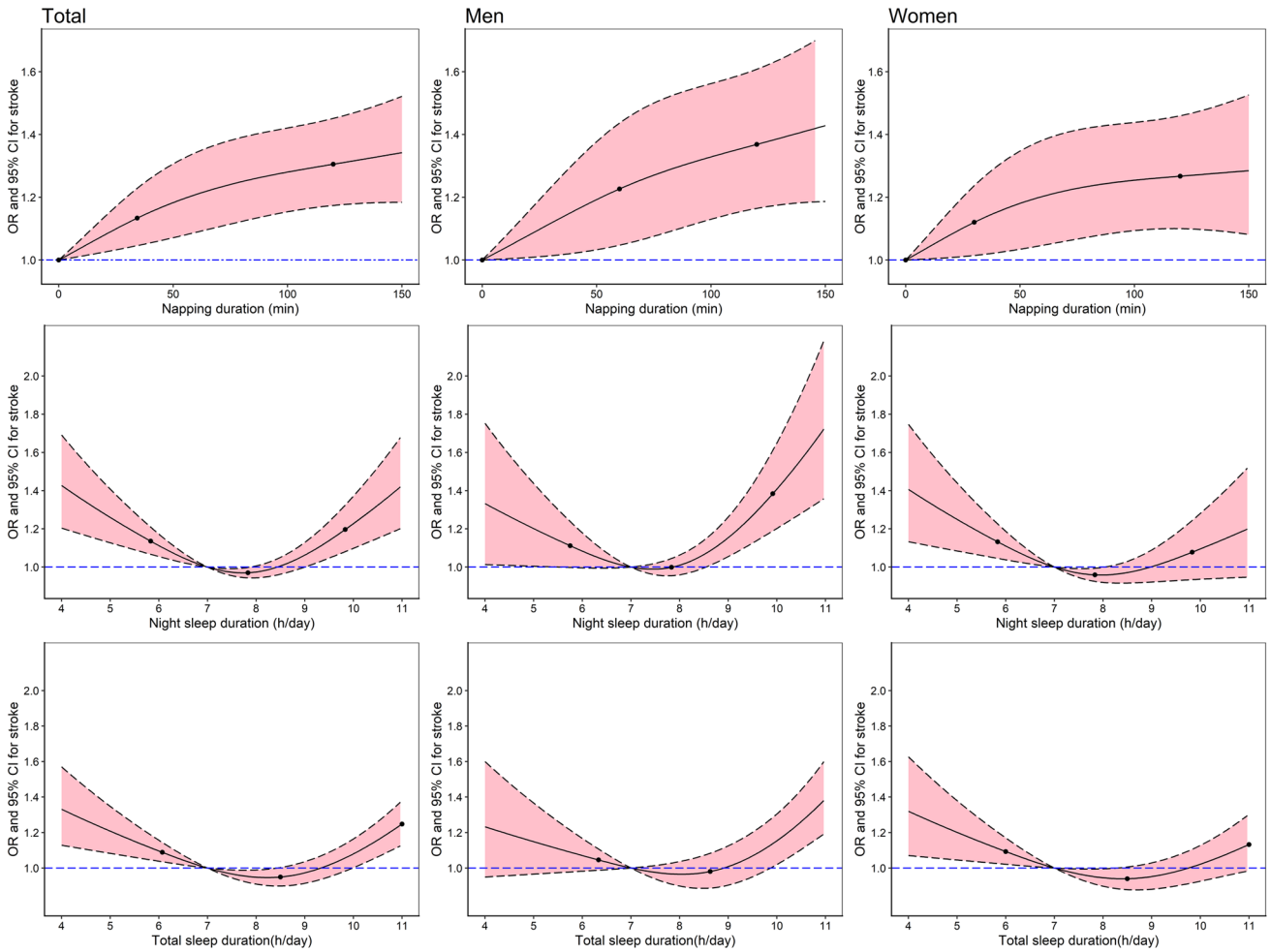

Fig. 1 Associations between napping duration, night sleep duration, total sleep duration and stroke among total, men and women, when adjusted for age, gender (only for total participants), education levels, average income per month, marital status, more vegetables and fruits intake, high-fat diet, current smoker, current drinker, physical activity, body mass index, family history of stroke, hypertension and type 2 diabetes mellitus, napping duration, and night sleep duration

Our results indicated a U-shaped effect of nocturnal sleep duration and stroke. A follow-up study discovered that the duration of sleep (< 6 h or > 8 h) independently raised the risk of stroke and that sleep quality and sleep duration had an interactive influence on stroke [20]. This study has shown similar results to our study. Furthermore, another study found that shorter and longer duration of nighttime sleep were both associated with stroke in older individuals among participants who reported poor physical health [21]. Other studies have come to similar conclusions as this study that both shorter nighttime sleep and longer nighttime sleep are linked to stroke risk [22, 23]. The present study also found that long naps were correlated with stroke. A study based on a large community reported that daytime napping duration with a high frequency (≥ 5 times/week) or long duration (> 30 min) increases stroke risk [8]. Similarly, a prospective cohort study concluded that napping habits were related to cardiovascular disorders risk [24]. In addition, the present study provided important evidence of the coeffect of prolonged napping and prolonged nocturnal sleep on stroke. Yang et al. also reported that prolonged nighttime sleep and prolonged napping were separately and jointly linked to the prevalence of the cardiovascular disease [25]. A prospective cohort study similarly concluded that sleep duration ≥ 9 h at night and naps > 90 min were jointly correlated with a higher risk of stroke [14]. This study found that nap may moderate the risk of stroke from short nighttime sleep. A previous study from 21 countries that included 116,632 study subjects found similar findings to ours, which found that daytime naps were related to cardiovascular events risk and death, except for those who slept less at night, suggesting that napping may be a compensatory mechanism when sleep deprivation occurs at night [26].

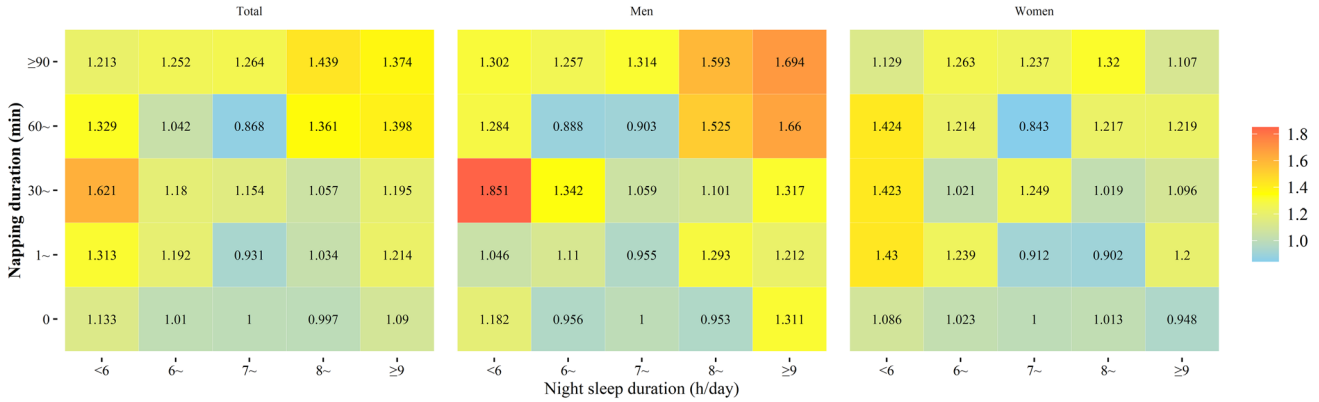

Fig. 2 Combined effect between night sleep duration and napping duration on stroke among total, men, and women. The night sleep duration was divided into < 6, 6 ~ , 7 ~ , 8 ~ , and ≥ 9, and napping duration was separated into 0, 1 ~ , 30 ~ , 60 ~ , and ≥ 90. Take non-nappers with 7–8 h of night sleep duration as the reference. The data in each square represent the effect size of each outcome (odds ratios (95% CI) for stroke). Covariates: age, gender (only for total participants), education levels, average income per month, marital status, more vegetables and fruits intake, high-fat diet, current smoker, current drinker, physical activity, body mass index, family history of stroke, hypertension and type 2 diabetes mellitus, napping duration, and night sleep duration

Although emerging research has established the link of sleep duration and the prevalence of stroke, a lot of conclusions remain controversial. Research from the China health and retirement longitudinal study of 4785 Chinese over the age of 65 found that short sleep duration per 24 h significantly increased the risk of stroke, which is in line with the current study. But, the research also reported that napping was not associated with stroke [27]. This could be because the study's participants were older, so the connection between naps and stroke was not significant. A Mendelian randomization study found sleep duration is not significantly associated with stroke [28]. This may be due to residual confounding factors (obstructive sleep apnea or obesity) that may bias the results of the observational studies [29]. There is evidence that long night sleep rather than a short night sleep is linked to the risk of stroke [30, 31]. The source of this discrepancy may be due to differences in the study sample.

Several biological mechanisms related to sleep may explain the relationship between shorter or longer sleep duration with stroke. Potential risk factors for stroke are hypertension, diabetes, smoking, hyperlipidemia, and physical inactivity [32]. A study conducted in 1999 first showed that participants had a 24% decrease in insulin sensitivity after restricting sleep to 4 h per night for five nights [33]. Additional mechanisms of decreased insulin sensitivity after sleep interruption include increased sympathetic activity in the autonomic nervous system. A rapid increase in blood pressure and heart rate has been observed in the morning as well as after napping [34]. Similarly, plasma catecholamine concentration also increases rapidly after waking up [35]. The sympathetic nervous system has an important influence on the pathogenesis of hypertension [36]. Long sleep duration and daytime napping may lead to altered activity of the hypothalamic–pituitary–adrenal system, which increases the risk of adverse vascular events [37].

A novel finding of this study is that there is a joint effect of daytime nap time and nighttime sleep time on stroke. In addition, the relationship of 24-h total sleep duration on the stroke risk was also explored in this study, rarely reported in prior studies. A strength of the study is that it included participants who were recruited from rural areas which tended to suffer from inadequate medical resources. Furthermore, various potential confounding factors were adjusted for.

Several limitations exist in the current study. First, sleep conditions were self-reported by participants, with no objective measurement and a potential lack of accuracy. However, participants received adequate training on their sleep habits, and the study also included comprehensive information on sleep status, which may have led to more accurate results. Second, this was a cross-sectional study, and because stroke was self-reported by the study subjects, some of the study subjects may have changed their sleep duration due to stroke, that is, stroke may have increased or decreased the need for sleep or the opportunity to nap, so this study design could not establish causality. However, some cross-sectional surveys and prospective studies have obtained similar results [14, 29, 38]. Third, since we only counted the period after lunch as nap time, our study may have underestimated nap duration and total sleep duration. Fourth, although our study considered numerous possible confounding factors, it was not possible to exclude potential confounding factors completely such as depression and sleep apnea, which might modify or

mediate the relationship. However, one large prospective cohort study adjusted for depression and obtained similar results to the current study [26].

In summary, the present findings suggest that night sleep, daytime napping, and total 24-h sleep duration are independently correlated with an elevated risk of stroke in individuals living in rural China. In addition, in the presence of adequate or excessive nighttime sleep, the risk of stroke increased with increasing nap time. However, when nighttime sleep is insufficient, proper napping may mitigate the risk of stroke. Our study highlights the importance of appropriate sleep duration as an important factor in adopting a healthier lifestyle, and people who want to maintain a healthy life should aim for an appropriate sleep duration.

Acknowledgements The authors thank all of the participants, coordinators, and administrators for their support and help during the research. In addition, the authors would like to thank Dr. Tanko Abdulai for his critical reading of the manuscript.

Author contribution Chongjian Wang and Yuqian Li conceived and designed the experiments. Jing Yang, Xiaotian Liu, Zhihan Zhai, Wei Liao, Yaling He, and Xueyan Wu gathered data. Jing Yang and Xiaotian Liu analyzed the data. Jing Yang drafted the manuscript. Xiaotian Liu, Zhihan Zhai, Wei Liao, Yaling He, and Xueyan Wu modified the manuscript. All of the authors contributed to the revision of the manuscript and approved the final manuscript.

Funding This research was supported by the Foundation of National Key Program of Research and Development of China (Grant NO: 2016YFC0900803), Science and Technology Innovation Team Support Plan of Colleges and Universities in Henan Province (Grant NO:21IRTSTHN029), National Natural Science Foundation of China (Grant NO: 81573243, 81930092), Foundation of Medical Science and Technology of Henan province (NO: 201702367, 2017T02098), and Discipline Key Research and Development Program of Zhengzhou University (Grant NO: XKZDQY202008, XKZDQY202002). The funders had no role in the study design, data collection, and analysis, decision to publish, or preparation of the manuscript.

Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval Ethics approval was obtained from the "Zhengzhou University Life Science Ethics Committee", and written informed consent was obtained for all participants. Ethics approval code: [2015] MEC (S128).

Consent to participate All subjects signed the informed consent.

Consent for publication All authors agree with the publication.

Conflict of interest The authors declare no competing interests.

References

1. Wu S, Wu B, Liu M, Chen Z, Wang W, Anderson CS, Sandercock P, Wang Y, Huang Y, Cui L et al (2019) Stroke in China: advances and challenges in epidemiology, prevention, and management. Lancet Neurol 18(4):394–405. https://doi.org/10.1016/S1474-4422(18)30500-3
2. Liu J, Shi Z, Bai R, Zheng J, Ma S, Wei J, Liu G, Wang Y (2020) Temporal, geographical and demographic trends of stroke prevalence in China: a systematic review and meta-analysis. Ann Transl Med 8(21):1432. https://doi.org/10.21037/atm-19-4342
3. Feigin VL, Roth GA, Naghavi M, Parmar P, Krishnamurthi R, Chugh S, Mensah GA, Norrving B, Shiue I, Ng M et al (2016) Global burden of stroke and risk factors in 188 countries, during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet Neurol 15(9):913–924. https://doi.org/10.1016/S1474-4422(16)30073-4
4. Jin X, Chen H, Li Y, Xu W, Chen X, Tian L, Teng W (2021) Association between daytime napping and stroke: A dose-response meta-analysis. J Sleep Res 30:e13366. https://doi.org/10.1111/jsr.13366
5. Fang J, Wheaton AG, Ayala C (2014) Sleep duration and history of stroke among adults from the USA. J Sleep Res 23(5):531–537. https://doi.org/10.1111/jsr.12160
6. Kakizaki M, Kuriyama S, Nakaya N, Sone T, Nagai M, Sugawara Y, Hozawa A, Fukudo S, Tsuji I (2013) Long sleep duration and cause-specific mortality according to physical function and self-rated health: the Ohsaki Cohort Study. J Sleep Res 22(2):209–216. https://doi.org/10.1111/j.1365-2869.2012.01053.x
7. Westerlund A, Bellocco R, Sundstrom J, Adami HO, Akerstedt T, TrolleLagerros Y (2013) Sleep characteristics and cardiovascular events in a large Swedish cohort. Eur J Epidemiol 28(6):463–473. https://doi.org/10.1007/s10654-013-9802-2
8. Yan B, Jin X, Li R, Gao Y, Zhang J, Li J, Wang G (2020) Association of daytime napping with incident stroke in middle-aged and older adults: a large community-based study. Eur J Neurol 27(6):1028–1034. https://doi.org/10.1111/ene.14197
9. Li W, Taskin T, Gautam P, Gamber M, Sun W (2021) Is there an association among sleep duration, nap, and stroke? Findings from the China Health and Retirement Longitudinal Study. Sleep Breath 25(1):315–323. https://doi.org/10.1007/s11325-020-02118-w
10. Dong X, Li Y, Yang K, Zhang L, Xue Y, Yu S, Liu X, Tu R, Qiao D, Luo Z et al (2021) Associations of spicy food flavor and intake frequency with blood lipid levels and risk of abnormal serum lipid levels in Chinese rural population: A cross-sectional study. Public Health Nutr 24:1–36. https://doi.org/10.1017/S1368980021001853
11. Li X, Pang X, Liu Z, Zhang Q, Sun C, Yang J, Li Y (2018) Joint effect of less than 1 h of daytime napping and seven to 8 h of night sleep on the risk of stroke. Sleep Med 52:180–187. https://doi.org/10.1016/j.sleep.2018.05.011
12. Liu X, Mao Z, Li Y, Wu W, Zhang X, Huo W, Yu S, Shen L, Li L, Tu R et al (2019) Cohort Profile: The Henan Rural Cohort: a prospective study of chronic non-communicable diseases. Int J Epidemiol 48(6):1756–1756j. https://doi.org/10.1093/ije/dyz039
13. Zheng B, Li M, Wang KL, Lv J (2016) Analysis of the reliability and validity of the Chinese version of Pittsburgh sleep quality index among medical college students. J Peking Univ (Health Sci) 48(3):424–428
14. Zhou L, Yu K, Yang L, Wang H, Xiao Y, Qiu G, Liu X, Yuan Y, Bai Y, Li X et al (2020) Sleep duration, midday napping, and sleep quality and incident stroke: The Dongfeng-Tongji cohort. Neurology 94(4):e345–e356. https://doi.org/10.1212/WNL.0000000000008739

15. Aho K, Harmsen P, Hatano S, Marquardsen J, Smirnov VE, Strasser T (1980) Cerebrovascular disease in the community: results of a WHO collaborative study. Bull World Health Organ 58(1):113–130
16. Wang Y, Li Y, Liu X, Zhang H, Abdulai T, Tu R, Tian Z, Qian X, Jiang J, Qiao D et al (2019) Prevalence and influencing factors of coronary heart disease and stroke in Chinese rural adults: the Henan Rural Cohort Study. Front Public Health 7:411. https://doi.org/10.3389/fpubh.2019.00411
17. Fan M, Lyu J, He P (2014) Chinese guidelines for data processing and analysis concerning the International Physical Activity Questionnaire. Chin J Epidemiol 35(8):961–964
18. Liao W, Luo ZC, Hou YT, Cui NN, Liu XT, Huo WQ, Wang F, Wang CJ (2020) Age and gender specific association between obesity and depressive symptoms: a large-scale cross-sectional study. Bmc Public Health 20(1):1565. https://doi.org/10.1186/s12889-020-09664-8
19. Desquilbet L, Mariotti F (2010) Dose-response analyses using restricted cubic spline functions in public health research. Stat Med 29(9):1037–1057. https://doi.org/10.1002/sim.3841
20. Ji A, Lou H, Lou P, Xu C, Zhang P, Qiao C, Yang Q (2020) Interactive effect of sleep duration and sleep quality on risk of stroke: an 8-year follow-up study in China. Sci Rep 10(1):8690. https://doi.org/10.1038/s41598-020-65611-y
21. Li W, Kondracki A, Gautam P, Rahman A, Kiplagat S, Liu H, Sun W (2021) The association between sleep duration, napping, and stroke stratified by self-health status among Chinese people over 65 years old from the China health and retirement longitudinal study. Sleep Breath 25(3):1239–1246. https://doi.org/10.1007/s11325-020-02214-x
22. Pan A, De Silva DA, Yuan J-M, Koh W-P (2014) Sleep duration and risk of stroke mortality among Chinese adults: Singapore Chinese health study. Stroke 45(6):1620–1625. https://doi.org/10.1161/STROKEAHA.114.005181
23. Cappuccio FP, Cooper D, D'Elia L, Strazzullo P, Miller MA (2011) Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies. Eur Heart J 32(12):1484–1492. https://doi.org/10.1093/eurheartj/ehr007
24. Tanabe N, Iso H, Seki N, Suzuki H, Yatsuya H, Toyoshima H, Tamakoshi A (2010) Daytime napping and mortality, with a special reference to cardiovascular disease: the JACC study. Int J Epidemiol 39(1):233–243. https://doi.org/10.1093/ije/dyp327
25. Yang L, Yang H, He M, Pan A, Li X, Min X, Zhang C, Xu C, Zhu X, Yuan J et al (2016) Longer sleep duration and midday napping are associated with a higher risk of CHD incidence in middle-aged and older Chinese: the Dongfeng-Tongji Cohort Study. Sleep 39(3):645–652. https://doi.org/10.5665/sleep.5544
26. Wang C, Bangdiwala SI, Rangarajan S, Lear SA, AlHabib KF, Mohan V, Teo K, Poirier P, Tse LA, Liu Z et al (2019) Association of estimated sleep duration and naps with mortality and cardiovascular events: a study of 116 632 people from 21 countries. Eur Heart J 40(20):1620–1629. https://doi.org/10.1093/eurheartj/ehy695
27. Chen P, Baylin A, Lee J, Dunietz GL, Cantoral A, Tellez Rojo MM, Peterson KE, Jansen EC (2021) The association between sleep duration and sleep timing and insulin resistance among adolescents in Mexico City. J Adolesc Health 69(1):57–63. https://doi.org/10.1016/j.jadohealth.2020.10.012
28. Lu H, Wu PF, Li RZ, Zhang W, Huang GX (2020) Sleep duration and stroke: a Mendelian randomization study. Front Neurol 11:976. https://doi.org/10.3389/fneur.2020.00976
29. Titova OE, Michaelsson K, Larsson SC (2020) Sleep duration and stroke: prospective cohort study and Mendelian randomization analysis. Stroke 51(11):3279–3285. https://doi.org/10.1161/STROKEAHA.120.029902
30. Cai H, Shu X-O, Xiang Y-B, Yang G, Li H, Ji B-T, Gao J, Gao Y-T, Zheng W (2015) Sleep duration and mortality: a prospective study of 113 138 middle-aged and elderly Chinese men and women. Sleep 38(4):529–536. https://doi.org/10.5665/sleep.4564
31. Chien K-L, Chen P-C, Hsu H-C, Su T-C, Sung F-C, Chen M-F, Lee Y-T (2010) Habitual sleep duration and insomnia and the risk of cardiovascular events and all-cause death: report from a community-based cohort. Sleep 33(2):177–184
32. Campbell BCV, Khatri P (2020) Stroke. Lancet 396(10244):129–142. https://doi.org/10.1016/s0140-6736(20)31179-x
33. Spiegel K, Leproult R, Van Cauter E (1999) Impact of sleep debt on metabolic and endocrine function. Lancet 354(9188):1435–1439. https://doi.org/10.1016/S0140-6736(99)01376-8
34. Zhang J, Jin X, Li R, Gao Y, Li J, Wang G (2019) Influence of rapid eye movement sleep on all-cause mortality: a community-based cohort study. Aging Albany NY 11(5):1580–1588. https://doi.org/10.18632/aging.101858
35. Rasch B, Dodt C, Mölle M, Born J (2007) Sleep-stage-specific regulation of plasma catecholamine concentration. Psychoneuroendocrinology 32(8–10):884–891. https://doi.org/10.1016/j.psyneuen.2007.06.007
36. Grassi G, Ram VS (2016) Evidence for a critical role of the sympathetic nervous system in hypertension. J Am Soc Hypertens 10(5):457–466. https://doi.org/10.1016/j.jash.2016.02.015
37. Kim YH, Ahn DS, Joeng JH, Chung S (2014) Suppression of peripheral sympathetic activity underlies protease-activated receptor 2-mediated hypotension. Korean J Physiol Pharmacol 18(6):489–495. https://doi.org/10.4196/kjpp.2014.18.6.489
38. Liu L, Yang J, Wang J, Nie M, Wang Z, Guan H, Hu J, Hong F (2022) Relationship between sleep duration and stroke history in middle-aged and elderly in Guiyang: a cross-sectional survey. Neuropsychiatr Dis Treat 18:243–252. https://doi.org/10.2147/NDT.S340834