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Association between nighttime sleep and successful aging among Chinese older people

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Abstract

Objective: This study aims to assess the association between sleep and successful aging among Chinese ≥ 60 years of age.

Methods: Data came from the baseline survey of the China Health and Retirement Longitudinal Study. Two self-reported questions about sleep quality and duration were examined. Successful aging was defined following Rowe and Kahn's multidimensional model. Multivariable logistic regression was applied to assess the adjusted association between sleep and successful aging.

Results: The average number of self-reported hours of sleep was 6.2 ± 2.0 among older Chinese. Successful aging was related to sleep duration, with the proportion of those adults considered to be aging successfully falling into the following sleep duration categories: < 6 hrs – 7.8%; 6hrs – 16.3%; 7hrs – 19.1%; 8hrs – 14.7%; and ≥ 9 hrs – 12.8%. The plots between sleep duration and successful aging were an inverse U-shape. Participants who slept less than 6hrs per day had lower odds ratio of successful aging (OR=0.52, 95% CI 0.40-0.67) relative to those who slept duration of 7hrs per day. Compared with those who reported poor sleep less than once a week, older people who reported poor sleep 5-7 days a week showed a lower odds of successful aging (OR=0.29, 95% CI 0.21-0.39).

Conclusion: Older age, shorted or longer sleep, and poor sleep were related to lower of successful aging. Most Chinese older adults are experiencing insufficient sleep and poor sleep quality, which could be an important influential factor of successful aging.

Keywords: aging; China; elderly; sleep; successful

1. Introduction

China's population is aging rapidly; the 212 million of people aged 60 years and over accounted for 15.5% of the total population in 2014. In China life expectancy at birth has increased from 69 years in 1990 to 75 years in 2013 [1]. If people do not age successfully, longer life may accompany increasing dependency and poor quality of life. Successful aging is a desirable goal for older people, and includes the absence of disease, high psychological and physical functioning, and active engagement with life [2-3]. This definition of successful aging has been seen as a useful tool for describing the health status of the elderly population, and has become a "calculable gold standard of aging" [4] applied in many empirical studies today [5].

Nighttime sleep is an essential physiological process for good health with vital restorative functions [6-7]. As people age, they experience shortened and less restorative sleep, more frequent night-time awakenings, increased time awake during the night, and more early morning awakenings [8]. Older age is associated with increased sleep problems [9-11] and shorter sleep duration [12-13], which suggests that sleep problems could be particularly salient issues among older adults. Furthermore, older women had poorer sleep quality and shorter sleep duration than men [9, 14], and this gender difference in sleep could be relevant to the gender difference in the association of sleep with health.

Sleep patterns in Chinese older adults may be characterized by going to bed early and waking up early [9]. Recently, studies reported that the prevalence of poor sleep was 41.5% among urban population [15] and 49.7% among rural population [16], and sleep duration was about 5.5-7.5h among Chinese elderly [9, 14, 17]. Poor sleep quality and short or long sleep duration are associated with many diseases or health conditions, such as metabolic syndrome [18], obesity [19], hypertension [20], memory impairment [21], diabetes [22], cardiovascular diseases [23], and mortality [24-25]. In contrast, good sleep is a marker of good functioning across a variety of domains in old age [26]. To date, most studies assessing the association of sleep with health have been focused on single disease or condition. Examining a multidimensional construct such as successful aging, could provide an improved insight into the association between sleep and health. However, the association between sleep and successful aging has not been previously examined. This study aims to examine the association of sleep duration or sleep quality with successful aging using a nationally representative sample from the China Health and Retirement Longitudinal Study (CHARLS). Our study will provide evidence on the association of

sleep with successful aging in the Chinese population.

2. Methods

2.1 Study design

CHARLS collects high quality data on a nationally representative sample of Chinese people aged 45 and over. It is based on the Health and Retirement Study (HRS) in the United States, and similar aging surveys such as the English Longitudinal Study of Aging (ELSA) and the Survey of Health, Aging and Retirement in Europe (SHARE). The pilot survey of CHARLS was conducted in two provinces in 2008, and returned high quality data [27-28]; it was subsequently expanded to the national baseline survey conducted in 2011-2012. Each participant signed an informed written consent form before the survey. Ethics approval for the data collection was obtained from the Biomedical Ethics Review Committee of Peking University (IRB00001052-11015). This paper focuses on the Chinese aged 60 years and over, and their sleep patterns and health indicators. Ethics approval for this paper was obtained from the University of Newcastle HREC (H-2015-0290).

CHARLS adopts multi-stage stratified PPS (probability-proportional-to-size) sampling. The sample was stratified by province, and within province by urban districts or rural counties, and by per capita statistics on gross domestic product. Included were 150 counties and 450 villages/resident committees in 28 provinces, and 10,257 of 12,740 households completed at least one module of the survey with a response rate of 80.5%, with 17,708 individual participants (10,069 main respondents and 7,639 spouses of main respondents) personally interviewed using a face-to-face computer-assisted process. The cohort profile of CHARLS has been described in detail previously [27-29]. Of 7,102 participants who were aged 60 and over in baseline data, 1,459 were excluded because of missing data (1,433 missed successful aging, 24 missed sleep data and 2 missed gender data). We also excluded participants who cannot get into or out of bed ($n=27$), considering that they did not achieve successful aging regardless of their sleep patterns. Subsequently, we had 5,616 subjects in final analysis. The missing data were more likely to be female, older age, lowly educated, other marital status, and more likely to live in an agricultural Hukou, reside in Western China, and be non-smoker and non-drinker.

2.2 Sleep measurements

Nighttime sleep duration was measured by asking: "During the past month, how many hours of actual

sleep did you get at night (average hours for one night)? (This may be shorter than the number of hours you spend in bed.)” It is quite similar to question 4 on the Pittsburgh Sleep Quality Index (PSQI) [30]. We classified self-reported sleep hours into short (<6 hours), somewhat short (6 hours), adequate (7 hours), somewhat long (8 hours) and long (≥ 9 hours). Poor sleep quality was assessed by asking “My sleep was restless” and participants responded to it according to how he/she have felt and behaved during the last week. Response categories included: rarely or none of the time (<1 day), some of the time (1-2 days), much or a moderate amount of the time (3-4 days), and most or all of the time (5-7 days).

2.3 Definition of successful aging

Our criteria for successful aging, according to the definition of Rowe and Kahn [2-3], include the following five indicators (1) no major diseases, (2) no disability, (3) high cognitive functioning, (4) high physical functioning, and (5) active engagement with life. The single indicator of successful aging is operationalized as follows.

(1) No major diseases: CHARLS participants are asked if a doctor has told them that they have any of the following major chronic diseases: cancer, chronic lung disease, diabetes, heart disease, and/or stroke. Depression was evaluated using the 10-item Center for Epidemiologic Studies Depression Scale (CESD-10). Respondents were classified as having no major disease if they neither reported any of the five chronic diseases nor obtained a score of less than 10 on the CESD-10.

(2) No disability: Respondents were classified as having no disability if they did not report difficulties performing any of the six following activities of daily living (ADLs): bathing, dressing, eating, indoor transferring, toileting, or continence.

(3) High cognitive functioning: Participants were considered to have high cognitive functioning if they achieved a median or higher score using the Telephone Interview for Cognitive Status (TICS). This includes both immediate and delayed recall of ten words on a list, serial 7 subtraction from 100 (up to five times), and naming the day of the week, month, day, year, and season.

(4) High physical functioning: Participants were classified as having high physical functioning if they reported no difficulties with the following five instrumental activities of daily living (IADLs): walking 100 m; getting up from a chair; lifting or carrying items weighing 5 kg; stooping, kneeling or crouching;

and climbing several flights of stairs.

(5) Active engagement with life: Respondents were defined as being actively engaged if they reported involvement in “voluntary or charity work”, or having “provided help to family, friends, or neighbors”, or having “gone to a sport, social, or other kind of club” in the month preceding the interview.

The participant was coded as 1 if he/she met the criteria in each indicator, or coded as 0. And then we calculated the total score from the five indicators. The participant who had a total score of 5 (i.e. he/she met all five indicator criteria) was defined as “successful aging” [31-32], or as “non-successful aging” if the total score was less than 5.

2.4 Other variables

Weight and height were measured following standardized procedures. Body Mass Index (BMI) was defined as weight in kilograms divided by height in meters squared (kg/m^2). Education level was allocated into three categories: primary school and below (illiterate; did not finish primary school but capable of reading and/or writing; Sishu/home school; elementary school), high/vocational school (middle school, high school, vocational school), and college and above (two-/three- year college/associate degree, four-year college/bachelor’s degree, master’s degree, and doctoral degree). Marital status was allocated into two categories: married and other (separated, divorced, widowed, and never married). Hukou, a household registration system in China, was used to categorize place of residence into agricultural and non-agricultural area (including unified residency Hukou). Based on the level of economic development, China can be divided into four major regions (East Coast, Central China, Northeast China and Western China). Different regions have different geographical, economic, cultural and social conditions.

2.5 Statistical analysis

Statistical analyses were performed with SPSS 17.0. Pearson χ^2 test was used to compare categorical variables, and one-way analysis of variance (ANOVA) for continuous variables. Multivariable logistic regression analysis was applied to estimate the odds ratio (OR) and 95% confidence interval (CI) for successful aging based on predictor variables. Duration of seven hours of sleep per day was chosen as the reference to examine the association between sleep duration and successful aging, as it has been shown that people sleeping 7 h/day have the best survival [33-34]. We used the category of <1 day per

week in restlessness as the reference to examine the association between sleep quality and successful aging. Potential confounders were adjusted in final models, including age, gender, education, Hukou, region, BMI, smoke and drink. Considering the gender differences in sleep [9, 14], post hoc analyses stratified by gender were conducted. To further determine whether there were different associations of sleep duration with successful aging between different ages, age was categorized into three groups: 60-65 years (young old), 65-75 years (mid-old) and ≥ 75 years (the oldest), and sleep duration was re-categorized to < 7 h, 7-8 h and ≥ 8 h / night. The interaction between sleep and age group, stratified by gender, was tested. Subjects who were “young old” with 7-8 h of sleep duration were selected as the reference. A p-value less than 0.05 was considered statistically significant.

3. Results

The average number of self-reported hours of sleep was 6.2 ± 2.0 among Chinese ≥ 60 years, with 34.1%, 20.5%, 16.6%, 20.7% and 8.1% reporting < 6 h, 6 h, 7 h, 8 h and ≥ 9 h, respectively. Of the study participants, 47.4% reported poor sleep less than 1 day per week, 16.6% 1-2 days/week, 15.3% 3-4 days/week, and 20.7% 5-7 days/week. Table 1 presents the characteristics of the participants according to the categories of sleep duration and poor sleep quality. Compared with participants with short or long sleep, those who had adequate sleep were more likely to be men, 60-65 years old, married, highly educated, more likely to live in a nonagricultural Hukou, and reside in the East coast region, to have a high BMI, and be a current smoker and current drinker. The distributions of characteristics similarly apply to the participants with poor sleep of less than 1 day/week compared with those who have poor sleep 5-7 days per week.

13.3% of older people achieved all 5 indicators of successful aging, with 41.9% achieving “no major diseases”, 54.5% “high cognitive functioning”, 70.6% “high physical functioning”, 92.6% “no disability” and 46.3% “active engagement with life”, respectively. There were 26.4% (1484) of older people who achieved successful aging in 4 of 5 indicators, 27.7% (1557) in 3 of 5, 20.5% (1149) in 2 of 5, 9.7% (542) in 1 of 5 and 2.5% (139) in 0 of 5 indicators.

The proportion of people who were classified as “successful aging” according to sleep duration categories were 7.8%, 16.3%, 19.1%, 14.7% and 12.8% for participants who slept < 6 h, 6 h, 7 h, 8 h and ≥ 9 h per day, respectively. As shown in Fig.1A, the associations between sleep duration and

successful aging followed an inverse U-shape. The higher prevalence of successful aging was found around 7 h of sleep duration while the lower were in the short sleep (< 6 h) and long (≥ 9 h) sleep duration. This inverse U-shaped association applied to sleep duration and all indicators that define successful aging (Fig.1A). Fig.1B indicates an inverse association between poor sleep and successful aging, and its specific indicators.

The association between sleep duration or sleep quality and successful aging was analyzed using logistic regression, and the results were presented in Table 2. Compared with sleep duration of 7 h per day night, sleep of less than 6 h was found to associate with lower odds of successful aging (OR=0.52, 95% CI 0.40-0.67), “no major diseases” (OR=0.48, 95% CI 0.37-0.54), and “no disability” (OR=0.64, 95% CI 0.45-0.92). People with short sleep or long sleep had lower odds of “high cognitive functioning” (OR=0.77, 95% CI 0.64-0.93; OR=0.73, 95% CI 0.44-0.72, respectively) and “high physical functioning” (OR=0.59, 95% CI 0.48-0.73; OR=0.68, 95% CI 0.51-0.91, respectively). In the crude model, older people with short sleep had significantly lower odds ratios for “active engagement with life” than those with adequate sleep. After multivariate adjustment, however, the differences were small and failed to reach statistical significance.

Considering the gender differences in sleep, post hoc analyses stratified by gender were conducted. The results showed short sleep or long sleep was significantly associated with lower odds of “high cognitive functioning” for women (OR=0.75, 95% CI 0.57-0.98 for short sleep; OR=0.65, 95% CI 0.43-0.98 for long sleep), but not men (OR=0.84, 95% CI 0.64-1.10; OR=0.76, 95% CI 0.53-1.11, respectively). Relative to those who slept 7 h per day, women with short sleep had lower odds ratio of “no disability”, 0.57 (95% CI 0.35-0.94), but for men there was no significant association between “no disability” and short sleep (OR=0.74, 95% CI 0.44-1.25).

Multivariate adjusted analyses showed that compared with participants who slept poorly less than once a week, those who reported poor sleep 5-7 days a week had odds ratio of 0.29 (95% CI: 0.21-0.39) for successful aging, 0.15 (95% CI: 0.13-0.18) for “no major diseases”, 0.66 (95% CI: 0.56-0.78) for “high cognitive functioning”, 0.42 (95% CI: 0.36-0.50) for “high physical functioning”, and 0.39 (95% CI: 0.29-0.51) for “no disability”. But participants who reported poor sleep 5-7 days a week had no significant difference in “active engagement with life” (OR=0.96, 95% CI 0.82-1.11) compared with those who slept poorly less than once a week after adjusting for cofounders.

To further determine whether sleep duration has different associations with successful aging between different age groups, we also tested for interaction between sleep and age group stratified by gender (Fig.2). Compared to young old women (60-65years) with 7 h of sleep duration, the mid-old women (65-75 years) had odds ratios of 0.56 (95% CI 0.32-0.99) for ≥ 8 h, 0.35 (95% CI 0.21-0.59) for less than 7 h, and the oldest women had 0.24 (95% CI 0.08-0.72) for ≥ 8 h, 0.18 (95% CI 0.08-0.43) for less than 7 h. As for men, there were no significant differences in successful aging among the mid-old group regardless of sleep duration (OR=0.79, 95% CI 0.50-1.24 for ≥ 8 h and OR=0.72, 95% CI 0.47-1.09 for less than 7 h), but significant differences among the oldest group with OR of 0.34 (95% CI 0.16-0.74) for ≥ 8 h and 0.33 (95% CI 0.17-0.63) for less than 7 h.

4. Discussion

In this study, we investigated daily sleep duration, sleep quality and associated successful aging among older adults in a nationally representative sample in China. Findings indicated that the average sleep duration of the participants was 6.2 h, with 54.6% reporting sleep duration less than 7 h, 28.8% sleep duration more than 8 h and 52.6% poor sleep quality of more than 1 day per week. These findings suggest that the majority of older Chinese are experiencing insufficient sleep and poor sleep quality. Our findings differ from another study [14], which reported that the average sleep duration are 7.5 hours, with 29.3% reporting sleep duration less than 7 h and 61.7% sleep duration more than 8 h among Chinese older people aged 65 and over. This discrepancy is likely related to different measurement of sleep. For instance, we only considered hours of actual sleep each night, and excluded daytime napping, while Gu's research included both hours of daily sleep and napping [14]. Other studies showed that Chinese elders have earlier average wake-up and bed times than their Western counterparts [9, 35]. In traditional Chinese culture, diligence is greatly valued; for instant, two famous old sayings are often quoted to encourage people in China "Pick a light to read for a night" and "Rising up upon hearing the crow of a rooster to practice sword playing". Regular good night's sleep is commonly regarded as the manifestation of laziness [36]. In China, people have different culture or behavior in sleep from those in occidental locations, which could be relevant to different association of sleep with health.

We observed an inverse U-shaped relationship between sleep duration and prevalence of successful aging. The highest prevalence of successful aging was observed at sleep duration of 7 h/day. This finding is in accordance with recommended sleep duration of seven hours per day for older people. It

has been also shown that people sleeping 7 h/day have the best survival [33-34]. The lowest prevalence of successful aging was found at shorter sleep. However, some studies showed that the relationship between sleep duration and mortality was U-shaped, but higher mortality was reported in long sleep duration rather than short sleep duration [25, 37]. The association between long sleep and mortality may not be causal, but rather reflect residual confounding due to poor health. In the present study, we only provided insight into successful aging among survivors in current cross-sectional analyses and did not take into account mortality. We also observed an inverse association between poor sleep and successful aging. The prevalence of successful aging decreased with the number of nights older people experienced poor sleep. Self-reported frequent sleep difficulties strongly predicted a continuation of this level of sleep difficulty over a decade [38]. Thus sleep pattern in early life may associate with successful aging in late life.

This study found that insufficient or excessive sleep was associated with poor cognitive function. Adequate sleep is recuperative and also exerts an immensely important influence on maintaining optimal cognitive ability in the short and long term [39]. Furthermore, mid-life sleep duration and sleep quality are associated with late-life cognitive function [40]. Thus maintaining adequate sleep is essential for good cognitive function. However, the association between sleep and cognitive function applied to women but not men. There are gender differences in cognition with female superiority on verbal domain as well as visual memory and male superiority on visual spatial ability as well as mental rotation of spatial stimuli [41-42]. This gender differences in the association of sleep with cognition may be associated with gender differences in cognition and sleep pattern [9, 14].

Sleep was also associated with chronic diseases, physical functioning and activities of daily living. Poor sleep quality and insufficient or excessive sleep may cause poor health [43-44]. Improving sleep quality among older people can improve their health and quality of life [45]. Among older adults, the decline in physical function is associated with poor sleep [46-48]. The association of short sleep with disability was observed only in women, not in men. Interestingly, sleep deprivation is independently associated with falls in women but not in men [49], and falling is a major geriatric syndrome where short sleep may play a role as a significant source of disability. In an unadjusted model, short sleep was associated with low “active engagement with life”. After multivariate adjustment, the association became weak and failed to reach statistical significance. This is likely related to demographic

characteristics, e.g. there was a higher percentage of participants from agricultural Hukou and low education at short sleep who seem to have relatively low social life.

Although aging itself does not result in increased sleep disorders, changes in sleep pattern do occur with age [50]. In the present study, we observed the association of sleep duration with successful aging among different age groups. The strong association was more likely to be at older ages -and for women. With increasing age, the sleep pattern of older people becomes more fragmented, resulting in less energy and motivation to perform the activities of daily living [11]. In addition, age-related sleep difficulties contribute to decline in cognition, which can further aggravate the negative impact of physical functioning due to lack of sleep [51].

There are several limitations to the present study. Firstly, sleep measurement was assessed just by self-reported question. Some studies indicated that self-reported sleep duration is moderately correlated with actigraphy-measured sleep, but biased by systematic over-reporting [52-53]. Absence of objective sleep measurement and other sleep problems assessment (e.g. snoring, obstructive sleep apnea syndrome) are limitations for the present study. Secondly, we assessed the successful aging using the well-known Rowe and Kahn framework, but with some limitations to our definition of successful aging. For example, the indicator “no major disease” just excludes cancer, chronic lung disease, diabetes, heart disease, stroke, and depression, but does not consider other diseases such as hypertension, musculoskeletal problems. Consequently, the prevalence of successful aging could be lower among older people in China. A third limitation is that there is possibility of residual confounding due to factors not measured which affect the association of sleep and health in the present study. For example, we did not have a measure of physical activity for all participants, and therefore could not adjust for associations between physical activity, sleep and health in the multivariate analyses. Finally, because this is a cross-sectional study, we can not establish the causal relationship between sleep and successful aging. It is possible that successful aging may not be due to good sleep; instead, good sleep may be due to successful aging. Further longitudinal research is needed to investigate whether interventions to maintain adequate sleep or protect good sleep quality promote successful aging.

5. Conclusion

The primary challenge posed by the increasing numbers of older people in China is the promotion of

successful aging, increasing healthy life expectancy and compressing functional comorbidity at the end of life. However, most Chinese elderly are experiencing sleep problems. In addition, there is a close association between sleep and successful aging. Older people who have good nocturnal sleep quality can cope actively with the challenges of growing old. Learning how to protect sleep in later life may be important to continued successful aging.

Conflict of interest

None

Acknowledgments

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Figure legends

Fig.1 The prevalence of successful aging and its specific indicators according to sleep duration (A) and sleep quality (B).

Fig.2 Interaction of sleep duration and age on successful aging stratified by gender. Odds ratio was estimated by multivariate logistic regression model adjusted for marital status, education, Hukou, region, BMI, smoking and drinking. The reference is subject who is young old (60-65 years) with 7-8h of sleep duration. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 1 Basic characteristics of the participants according to sleep duration and sleep quality (Data are expressed by n (%))

Characteristics	Sleep duration (hours)					Poor sleep (days/week)			
	<6	6	7	8	≥9	<1	1-2	3-4	5-7
<i>n (%)</i>	1917(34.1)	1154(20.5)	930(16.6)	1161(20.7)	454(8.1)	2661(47.4)	933(16.6)	859(15.3)	1163(20.7)
<i>Age (years)</i> ^a	68.7(6.7)	67.9(6.3)	67.4(6.0)	68.1(6.3)	69.3(6.8)	68.2(6.4)	67.7(6.2)	68.5(6.6)	68.5(6.7)
<i>Gender (male)</i>	898(46.8)	640(55.5)	506(54.4)	676(58.2)	246(54.2)	1632(61.3)	482(51.7)	352(41.0)	500(43.0)
<i>Marital status (married)</i>	1476(70.0)	947(82.1)	761(81.8)	954(82.2)	341(75.1)	2181(82.0)	739(79.2)	669(77.9)	890(76.5)
<i>Education</i>									
Primary school and below	1613(84.2)	816(70.8)	700(75.3)	892(76.8)	396(87.2)	1990(74.8)	735(83.1)	714(83.1)	978(84.2)
High/vocational school	208(10.9)	196(17.0)	126(13.5)	159(13.7)	41(9.0)	396(14.9)	118(12.6)	98 (11.4)	118(10.2)
College and above	95(5.0)	141(12.2)	104(11.2)	110(9.5)	17(3.7)	274(10.3)	80(8.6)	47(5.5)	66(5.7)
<i>Hukou (Agricultural)</i>	1514(79.0)	760(65.9)	613(66.1)	841(72.5)	371(81.7)	1889(71.1)	661(70.8)	650((75.7)	899(77.3)
<i>Region</i>									
East Coast	457(23.8)	381(33.0)	340(36.6)	376(32.4)	130(28.6)	888(33.4)	284(30.4)	217(25.3)	295(25.4)
Central China	608(31.7)	310(26.9)	246(26.5)	351(30.2)	117(25.8)	772(29.0)	228(24.4)	261(30.4)	371(31.9)
Northeast China	177(9.2)	167(14.5)	130(14.0)	121(10.4)	47(10.4)	292(11.0)	121(13.0)	101(11.8)	128(11.0)
Western China	675(35.2)	296(25.6)	214(23.0)	313(27.0)	160(35.2)	709(26.6)	300(32.2)	280(32.6)	369(31.7)
<i>BMI (kg/m²)</i> ^a	22.6(4.0)	23.2(4.0)	23.5(4.3)	23.4(5.8)	22.6(3.8)	23.2(5.0)	23.0(3.9)	23.0(4.4)	22.6(3.8)
<i>Current smoker</i>	560(29.2)	354(30.7)	308(33.1)	390(33.6)	139(30.6)	926(34.8)	259(27.8)	223(26.0)	343(29.5)
<i>Current drinker</i>	553(28.9)	364(31.5)	319(34.3)	363(31.3)	139(30.6)	912(34.3)	288(30.9)	236(27.5)	302(26.0)

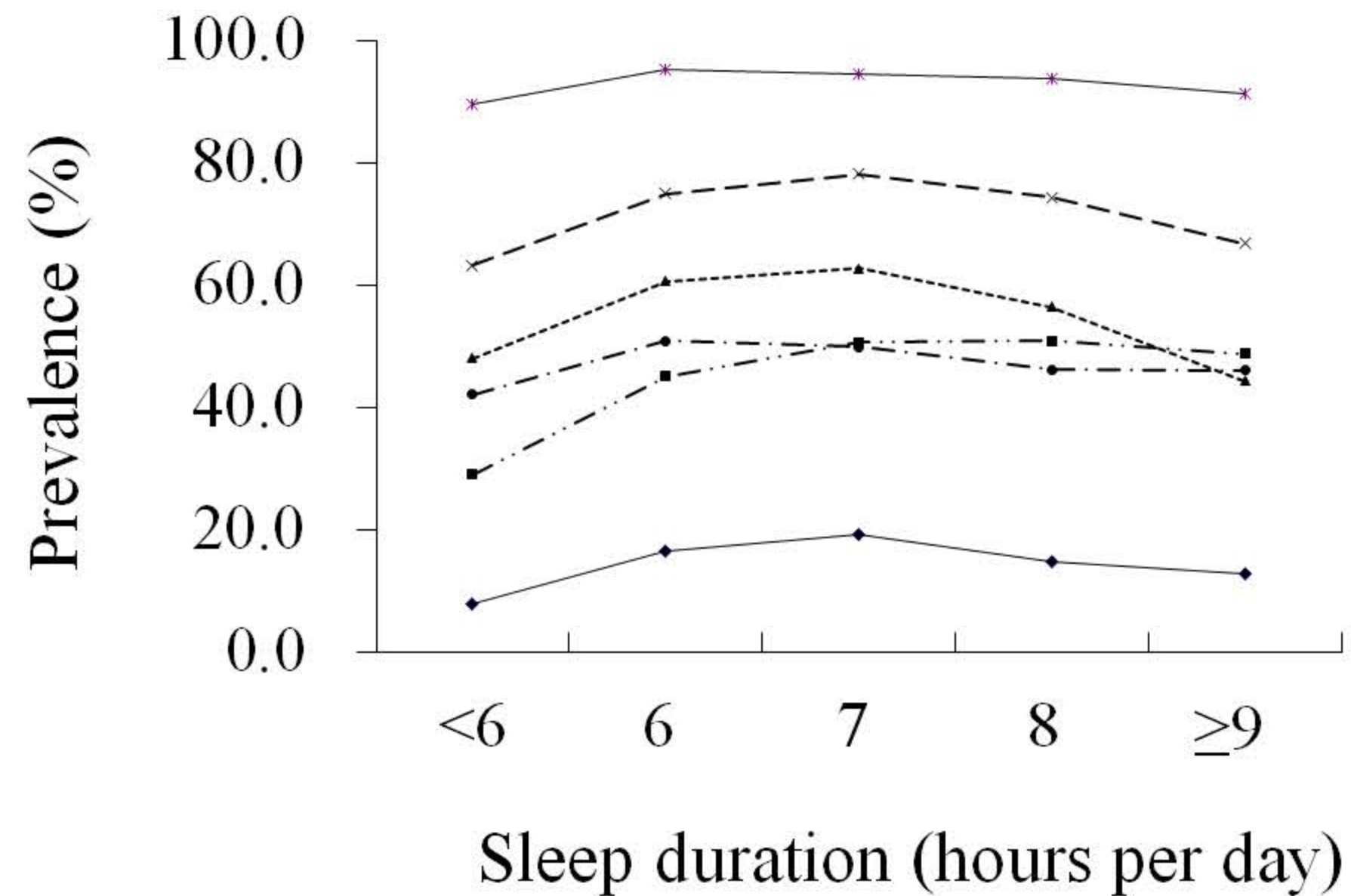
^a Data are expressed by mean (standard deviation).

Table 2 Association of sleep with total successful aging and its specific indicators.

Successful aging	Sleep duration (hours)					Poor sleep (days/week)			
	<6	6	7	8	≥9	<1	1-2	3-4	5-7
Successful aging									
Crude model	0.36(0.28-0.45)***	0.82(0.66-1.03)	1.00	0.73(0.58-0.92)**	0.62(0.50-0.85)**	1.00	0.70(0.57-0.87)**	0.30(0.22-0.40)***	0.24(0.18-0.32)***
Adjusted model ^a	0.52(0.40-0.67)***	0.91(0.70-1.18)	1.00	0.83(0.64-1.08)	0.94(0.65-1.35)	1.00	0.80(0.63-1.01)	0.34(0.25-0.47)***	0.29(0.21-0.39)***
No major diseases									
Crude model	0.40(0.34-0.47)***	0.80(0.67-0.95)*	1.00	1.01(0.85-1.20)	0.93(0.74-1.16)	1.00	0.52(0.45-0.60)***	0.21(0.17-0.24)***	0.15(0.13-0.18)***
Adjusted model ^a	0.48(0.37-0.54)***	0.87(0.72-1.06)	1.00	1.07(0.89-1.29)	1.12(0.87-1.43)	1.00	0.56(0.47-0.66)***	0.22(0.18-0.26)***	0.15(0.13-0.18)***
High cognition functioning									
Crude model	0.55(0.47-0.65)***	0.91(0.77-1.09)	1.00	0.77(0.65-0.92)**	0.47(0.38-0.59)***	1.00	0.91(0.79-1.06)	0.59(0.50-0.68)***	0.55(0.47-0.63)***
Adjusted model ^a	0.77(0.64-0.93)**	0.95(0.77-1.17)	1.00	0.88(0.72-1.08)	0.73(0.44-0.72)*	1.00	1.04(0.86-1.24)	0.67(0.56-0.80)***	0.66(0.56-0.78)***
High physical functioning									
Crude model	0.48(0.40-0.58)***	0.84(0.68-1.03)	1.00	0.81(0.66-0.99)*	0.56(0.45-0.77)***	1.00	0.91(0.76-1.08)	0.48(0.40-0.56)***	0.39(0.34-0.45)***
Adjusted model ^a	0.59(0.48-0.73)***	0.92(0.73-1.16)	1.00	0.85(0.68-1.07)	0.68(0.51-0.91)**	1.00	0.98(0.80-1.20)	0.51(0.42-0.61)***	0.42(0.36-0.50)***
No disability									
Crude model	0.50(0.36-0.69)***	1.16(0.78-1.71)	1.00	0.88(0.61-1.27)	0.60(0.39-0.92)*	1.00	0.85(0.62-1.16)	0.59(0.44-0.78)***	0.38(0.30-0.48)***
Adjusted model ^a	0.64(0.45-0.92)*	1.32(0.85-2.05)	1.00	0.94(0.62-1.40)	0.86(0.52-1.42)	1.00	0.79(0.55-1.14)	0.74(0.52-1.06)	0.39(0.29-0.51)***
Active engagement with life									
Crude model	0.73(0.62-0.86)***	1.04(0.88-1.24)	1.00	0.86(0.73-1.03)	0.86(0.69-1.08)	1.00	1.04(0.89-1.21)	0.95(0.82-1.11)	0.84(0.73-0.96)*
Adjusted model ^a	0.89(0.75-1.06)	1.10(0.91-1.33)	1.00	0.91(0.75-1.10)	1.07(0.84-1.38)	1.00	1.13(0.95-1.33)	1.05(0.87-1.25)	0.96(0.82-1.11)

Data are expressed by odds ratios (OR) and 95% confidence interval. Multiple logistic regression analysis was applied to estimate the OR for successful aging in predictor variables. Duration of 7 hours of sleep/day was used as the reference in sleep duration analyses, and the category of rarely or none of the time was used as the reference in sleep quality analyses. ^a adjustment for age, gender, marital status, education level, Hukou, region, BMI, smoking and drinking. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

A



B

