Association of sleep quality and dementia among long-lived Chinese older adults

Yue Jirong · Huang Changquan · Wu Hongmei · Dong Bi-Rong

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Abstract In this study, we examined the existence of relationship between sleep quality and dementia in subjects aged 90 years and above. The sample included 216 men and 444 women. Dementia and sleep quality were measured with 30-item mini-mental state examination (MMSE) and the Pittsburgh sleep quality index, respectively. Subjects with dementia had higher sleep quality score (7.83 ± 2.15 vs. 5.22 ± 2.49 ; $P < 0.0001$), longer sleep latency (50.97 ± 21.33 vs. 37.61 ± 12.53 ; $P < 0.0001$), and a lower sleep efficiency percentage (73.95 ± 8.783 vs. 81.32 ± 10.21 ; $P < 0.0001$) and more likely to report poor sleep quality (25.42 vs. 17.13 %; $P = 0.035$). Subjects with poor sleep quality had significantly lower MMSE scores ($P = 0.007$) and higher prevalence of dementia ($P = 0.042$). Multiple logistic regressions were performed by adjusting clinical factors that are thought to be associated with dementia or

sleep quality. We found that poor sleep quality was a risk factor for dementia (unadjusted odds ratio (OR) 1.719, 95 % confidence interval (CI) 1.138–2.597; adjusted OR 1.759, 95 % CI 1.012–3.057). There was no significant difference in MMSE scores (11.25 ± 3.40 , 16.26 ± 5.14 , and 15.43 ± 5.51 ; $P = 0.105$) among participants with daily average sleep durations of <5 , 5 – 9 , and >9 h, respectively. Among Chinese nonagenarians and centenarians, dementia was correlated with poor sleep quality, longer sleep latency, and lower sleep efficiency percentage.

Keywords Dementia · Sleep quality · Sleep duration · Nonagenarians · Centenarians

Introduction

Both sleep disorders and dementia are associated with degenerative neurological disorders (Plassman et al. 2007; Dauvilliers 2007; Wu and Swaab 2007). Dementia, sleep complaints, and sleep-related problems increase with age (Wolkove et al. 2007a, b; Bastos Leite et al. 2004). Many sleep-related disorders occur with increasing frequency among the elderly (Wolkove et al. 2007a, b; Yumino et al. 2009). These conditions are often not appreciated by physicians. Instead, the associated symptoms are ascribed to other coexistent illnesses (Bloom et al. 2009). Degenerative neurological

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disorders that cause dementia, such as Alzheimer's disease and Parkinson's disease, exacerbate age-related changes in sleep, as do many common comorbid medical and psychiatric conditions (Bloom et al. 2009; Poewe 2005). Medications used to treat chronic illnesses and insomnia has many side effects that can further disrupt sleep and decline cognitive function (Aldrich et al. 1989). In addition, dementia, sleep complaints, and sleep-related problems are known to increase with age (Wolkove et al. 2007a, b; Bastos Leite et al. 2004; Plassman et al. 2007; Wu and Swaab 2007). Although there is sufficient evidence from humans and experimental animals on the association between sleep disorders and dementia, these topics have not yet been explored in the very elderly population (Rose et al. 2010; Riegel and Weaver 2009; Yu et al. 2009; Haimov et al. 2008; Benito-León et al. 2009; Hasan et al. 2012). Therefore, it is important to clarify the association between sleep disorders and dementia in this age group.

Methods

Study subjects

Subjects were recruited as part of the “Project of Longevity and Aging in Dujangyan” (PLAD). PLAD was performed in Dujangyan (located outside the urban area of Chengdu, China; with 2,311,709 inhabitants, 870 subjects were found to be aged 90 years or more; women 67.4 %). In April 2005, 870 subjects aged 90 years or more were recruited from this population. The study protocol was approved by the Research Ethics Committee of the Sichuan University. Informed consent was obtained from all participants and their legal proxies. Eligibility criteria and recruitment methods have been previously published (Ji-Rong et al. 2010; Huang et al. 2009). We excluded the subjects with visual or hearing impairment who could not complete the questionnaire, subjects with cancer, terminal stage of a physical disease (e.g., respiratory system disease, cardiovascular disease, kidney disease, and so on), and the subjects being bedridden.

Participants were examined by trained professional physicians according to basic health criteria. Results were recorded on a standardized form, which included a questionnaire on their lifestyles (including 30-item mini-mental state examination (MMSE) and 19-item

Pittsburgh sleep quality index (PSQI) questionnaire). Twenty-one men and 26 women were found to be ineligible for the study because they had already died or moved away from the area. Of 262 men and 561 women who were interviewed, 5 men and 41 women did not complete the MMSE questionnaire, and 36 men and 76 women did not complete PSQI. Overall, we included a total of 660 participants (216 men and 444 women).

Assessment of cognitive function

Cognitive function was measured using the MMSE, a global test with components that addressed orientation, attention, calculation, language, and recall. Dementia is defined as a score of <19 in the MMSE. This score has been shown to be 80 to 90 % sensitive and 80 to 100 % specific for a diagnosis of dementia (Tombaugh and McIntyre 1992). To minimize error and to assure reliability, we: (1) reviewed the MMSE procedure and grading system outlined in a short booklet and video, (2) observed a geriatrician conducting the MMSE procedure on residents not part of the study for training purposes, and (3) were supervised when conducting the MMSE on residents not part of the study. The MMSE test was thereafter applied to the consented study subjects.

In the MMSE test, we categorized subjects according to the following: dementia (scores between 0 and 18), mild cognitive impairment (scores between 19 and 24), and normal (scores between 25 and 30). In the very elderly sample, only 41 subjects had scores higher than 24 (36 in men and 5 in women); therefore, we merged mild cognitive impairment and normal cognitive function into a nondementia group when the data were analyzed.

Measurement of sleep quality

The PSQI is a self-administered questionnaire that assesses sleep quality and quantity during the previous month (Buysse et al. 1989). The PSQI contains 19 items that generate seven “component” scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Every component coded on a four-point scale (0–3) and the sum of scores for these seven components yields one global score from 0 to 21. A higher global PSQI score

indicates a poorer sleep quality. A PSQI score of <5 is considered good sleep quality; scores between 6 and 10 are considered moderate sleep quality, and scores between 11 and 21 are considered poor sleep quality. Respondents are asked to rate their sleep, reflecting on the past month. Psychometric properties have demonstrated good reliability (internal consistency 0.89; test-retest reliability 0.85) and good construct validity for the English language version (Buysse et al. 1989). The PSQI is a widely used tool in research studies and clinical trials and has been translated to several languages, including Chinese, Spanish, German, and Hebrew, with comparable reliability and validity values. Internal consistency in the present study was $\alpha = 0.69$. Outcome measures included the total PSQI score as well as self-report of sleep latency (question 2: How long (in minutes) does it usually take you to fall asleep each night?) and sleep efficiency percentage (SE), computed as the ratio between the hours of actual sleep (question 4: How many hours of actual sleep did you get at night?) and total time in bed (hours computed based on reported bedtime in question 1: What time do you usually go to bed at night? and reported wake-time in question 3: What time do you usually get up in the morning?), multiplied by 100 (Shochat et al. 2007; Zisberg et al. 2010). Sleep duration was defined as hours of actual sleep. To make the information on the sleep durations as reliable as possible, we calculated sleep duration using two methods, reported by question 4 (how many hours of actual sleep did you get at night?) or computed based on reported bedtime in questions 1 (what time do you usually go to bed at night?), 2 (how long (in minutes) does it usually take you to fall asleep each night?), and 3 (what time do you usually get up in the morning?). When there was significant difference in sleep durations, we asked the family member who lived together with the participants on the information.

Assessment of covariates

The baseline examination included information on age (years), gender (male/female), educational levels (illiteracy, primary school, secondary school, college, and postgraduate), smoking habits (yes or no), alcohol consumption (yes or no), tea consumption (yes or no), exercise (yes or no), serum lipid/lipoprotein levels (including serum triglyceride, total cholesterol, high-density lipoprotein cholesterol, and low-density

lipoprotein cholesterol), fasting blood glucose (FBG), serum uric acid (SUA), and BMI. Right arm blood pressure (sitting or recumbent position) was measured twice to the nearest 2 mmHg, using a standard mercury sphygmomanometer (Korotkoff phases I and V), by trained nurses or physicians. Serum lipid/lipoprotein levels, FBG, and SUA were determined using standard laboratory techniques (performed by a technician in the biochemistry laboratory of Sichuan University). The other covariates were collected using a general question.

Habits of smoking, alcohol consumption, tea consumption, and exercise, which included former and current, were collected using a general questionnaire. In the questionnaire, every item had two options (yes or no). We defined subjects with such habits as doing it almost every day. Subjects were asked whether they had ever had habits of smoking, alcohol consumption, tea consumption, and exercise; one of three answers was recorded: never, did in the past, or currently. Among those who did, currently or in the past, information was obtained on the average frequency of smoking, using alcohol, drinking tea, and doing exercise and on the number of years they had done it for. The subjects, who did almost every day during the last year, were classified as those with current habits; otherwise, they were classified as without. The subjects, who had haven habits almost every day for more than 2 years as of a year before, were classified as those previously had these habits, otherwise, as without.

Statistical analysis

All of the statistical analyses for this study were performed with the SPSS for Windows software package, version 11.5 (SPSS Inc., Chicago, Illinois, USA). Baseline characteristics were compared between those with and without dementia using Pearson chi-square or Fisher's exact test (where an expected cell counts <5), used for categorical variables and unpaired Student's *t* test for continuous variables. Baseline characteristics were also compared among good, moderate, and poor sleep quality subgroups using one-way for analysis of variance (ANOVA). In addition, baseline characteristics were compared among the sleep duration of <5 , 5–9, and >9 h subgroups using ANOVA. Multiple logistic regression was used to estimate the odds ratio (OR) and 95 % confidence

interval (CI) of sleep quality as a function of increased risk for dementia, and adjusted for the following: age, gender, educational levels, serum lipid/lipoprotein, BMI, blood pressure, blood glucose level, smoking habit, alcohol consumption, tea consumption, and exercise. *P* value of <0.05 was considered to be statistically significant, and all of the *P* values have been two sided.

Results

Baseline characteristics, dementia, sleep duration, and sleep quality

Among the 660 participants, mean age was 93.52 years; 69 were centenarians, and 444 (67.3 %) were women. Ninety percent of participants lived in the countryside. The subjects with dementia were younger in age than those without (93.17 ± 3.28 vs. 93.73 ± 3.40 ; *P* = 0.040). The mean sleep quality score was 6.84 ± 2.15 ; the mean sleep latency was 45.89 ± 16.72 min, and the mean SE was 76.53 ± 8.78 % (Table 1). The mean MMSE score was 15.48 ± 5.44 . In the sample, the prevalence rate of dementia was 62.0 %. There were 385 (58.3 %), 128 (19.4 %), and 147 (22.3 %) with good, moderate, and poor quality sleep, respectively. The subjects with good quality of sleep were younger in age (93.32 ± 3.32 , 93.95 ± 3.59 , and 93.63 ± 3.14 , among subjects with good, moderate, and poor quality sleep, respectively; *P* = 0.016) (see Table 2). The mean sleep duration was 10.23 ± 1.54 h. Only four (0.6 %) participants were from the subgroup with sleep duration of <5 h. A total of 107 (16.2 %) participants were sleeping an average of 5 to 9 h, and 549 (83.2 %) participants were sleeping >9 h. No significant difference was seen in other parameters, e.g., age, gender, sleep quality, blood pressure, and lifestyles among participants with daily average sleep durations of <5, 5–9, and >9 h, respectively (see table 3).

Association of sleep quality and dementia

Subjects with dementia had higher sleep quality score (7.83 ± 2.15 vs. 5.22 ± 2.49 ; *P* < 0.0001), longer sleep latency (50.97 ± 21.33 vs. 37.61 ± 12.53 ; *P* < 0.0001), and a lower sleep efficiency percentage (73.95 ± 8.783 vs. 81.32 ± 10.21 ; *P* < 0.0001) and more likely

reported with poor sleep quality (25.42 vs. 17.13 %; *P* = 0.035) (see Table 1). All of these showed that there was an association between sleep quality and dementia.

In those with poor sleep quality, the lowest MMSE scores (15.86 ± 5.50 , 15.85 ± 5.20 , and 14.24 ± 5.27 , among subjects with good, moderate, and poor quality sleep, respectively; *P* = 0.007) and the higher prevalence rate of dementia (59.0, 60.9, and 70.7 %, among subjects with good, moderate, and poor quality sleep, respectively; *P* = 0.042) (Table 2) were observed. Both unadjusted and adjusted multiple logistic regression showed that poor quality sleep had a function of increased risk for dementia (unadjusted OR = 1.719, 95 % CI = 1.138–2.597; adjusted OR = 1.759, 95 % CI = 1.012–3.057) (Table 4).

No association between sleep duration and dementia

There was no significant difference in MMSE scores (11.25 ± 3.40 , 16.26 ± 5.14 , and 15.43 ± 5.51 ; *P* = 0.105) among participants with daily average sleep durations of <5, 5–9, and >9 h, respectively. There was no significant difference in the prevalence of dementia also (*P* = 0.159) (see Table 3). All of these showed that, among long-lived participants, average sleep duration might not play a role in increasing risk for dementia. Since there were only four subjects in the subgroup of sleep duration of <5 h, multiple logistic regression could not be used to estimate OR and 95 % CI of sleep duration as a function of increased risk for dementia.

Discussion

This study evaluated the association between sleep quality, sleep duration, and dementia among nonagenarians and centenarians. In the cross-sectional observation, there was an association between sleep quality and dementia. The present study found that poor sleep quality, longer sleep latency, and lower sleep efficiency were correlated with dementia. However, sleep duration were found to not be correlated with dementia. In the present study, participants with poor sleep quality had a higher prevalence rate of dementia, and those with dementia had also a higher prevalence of poor sleep quality. These were consistent with the previous studies (Wu and Swaab 2007; Riegel and Weaver 2009; Rose et al.

Table 1 Baseline characteristics according to dementia ($n = 660$)

Characteristics	All ($n = 660$)	Nondementia ($n = 251$)	Dementia ($n = 409$)	χ^2 or t	P value
Age (years)	93.52 $\pm$ 3.37	93.73 $\pm$ 3.40	93.17 $\pm$ 3.28	2.058*	0.040
Female (%)	444 (67.3)	125 (49.8)	319 (78.0)	56.16**	<0.0001
Sleep quality					
PSQI score	6.84 $\pm$ 2.15	5.22 $\pm$ 2.49	7.83 $\pm$ 2.15	7.368**	<0.0001
Good/moderate/poor	385/128/147	158/50/43	227/78/104	6.726*	0.035
SE (%)	76.53 $\pm$ 8.78	81.32 $\pm$ 10.21	73.95 $\pm$ 8.78	4.245**	0.006
SL (min)	45.89 $\pm$ 16.72	37.61 $\pm$ 12.53	50.97 $\pm$ 21.33	7.827**	<0.0001
DBP (mmHg)	72.59 $\pm$ 12.06	72.08 $\pm$ 12.08	72.91 $\pm$ 12.05	0.864	0.388
SBP (mmHg)	139.71 $\pm$ 23.31	139.71 $\pm$ 23.31	140.07 $\pm$ 22.63	0.199	0.862
TG (mmol/L)	1.22 $\pm$ 0.64	1.19 $\pm$ 0.54	1.24 $\pm$ 0.70	1.074	0.283
TC (mmol/L)	4.15 $\pm$ 0.85	4.06 $\pm$ 0.86	4.20 $\pm$ 0.84	2.098*	0.036
HDL (mmol/L)	1.58 $\pm$ 0.59	1.59 $\pm$ 0.66	1.57 $\pm$ 0.54	0.759	0.222
LDL (mmol/L)	2.28 $\pm$ 0.97	2.27 $\pm$ 0.59	2.28 $\pm$ 1.17	0.240	0.810
FBG (mmol/L)	4.46 $\pm$ 1.45	4.45 $\pm$ 1.52	4.47 $\pm$ 1.40	0.147	0.883
SUA (μ mol/L)	318.72 $\pm$ 87.01	321.17 $\pm$ 92.73	316.88 $\pm$ 82.53	0.623	0.534
BMI	19.05 $\pm$ 3.64	18.93 $\pm$ 3.25	19.11 $\pm$ 3.85	0.629	0.530
Smoking habits					
Former (%)	247 (37.4)	91 (36.3)	156 (38.1)	0.236	0.627
Current (%)	367 (55.6)	138 (55.0)	229 (56.0)	0.064	0.800
Alcoholic					
Former (%)	386 (58.5)	138 (55.0)	154 (60.6)	2.049	0.152
Current (%)	176 (26.7)	72 (28.7)	104 (25.4)	0.844	0.358
Tea habits					
Former (%)	291 (44.1)	136 (37.9)	155 (54.2)	16.736**	<0.0001
Current (%)	271 (41.1)	130 (51.8)	141 (34.5)	19.277**	<0.0001
Exercise habits					
Former (%)	217 (32.9)	86 (34.3)	131 (32.0)	0.352	0.553
Current (%)	269 (40.8)	111 (44.2)	158 (38.6)	2.015	0.156
Educational levels					
Illiteracy	479	128	351		
Primary school	118	76	42		
Secondary school	46	34	12		
College and postgraduate	12	9	3	95.32**	<0.0001

Baseline characteristics were compared between dementia and nondementia groups, using χ^2 or Fisher's exact test (where an expected cell count was <5) for categorical variables and unpaired Student's t test for continuous variables. In the testing, a P value of <0.05 was considered to be statistically significant

PSQI the Pittsburgh sleep quality index, *SL* sleep latency, *SE* sleep efficiency percentage, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *TG* triglyceride, *TC* total cholesterol, *HDL* high-density lipoprotein, *LDL* low-density lipoprotein, *FBG* fasting blood glucose, *SUA* serum uric acid, *BMI* body mass index

* $P < 0.05$; ** $P < 0.01$

2010). Although the PSQI is a general measure of sleep quality, participants' responses to various questions can also be used to measure difficulty initiating sleep

(latency) and sleep efficiency (percent of time spent in bed that the individual was actually asleep). The present study found that sleep latency and efficiency were

Table 2 Baseline characteristics according to sleep quality ($n = 660$)

Characteristics	All ($n = 660$)	Good sleep quality ($n = 385$)	Moderate sleep quality ($n = 128$)	Poor sleep quality ($n = 147$)	χ^2 or t	P value
Age (years)	93.52 $\pm$ 3.37	93.32 $\pm$ 3.32	93.95 $\pm$ 3.59	93.63 $\pm$ 3.14	1.882*	0.016
Female (%)	444 (67.3)	247 (64.2)	92 (71.9)	105 (71.4)	4.083	0.130
MMSE scores	15.48 $\pm$ 5.44	15.86 $\pm$ 5.50	15.85 $\pm$ 5.20	14.24 $\pm$ 5.27	6.972**	0.007
Dementia (%)	409 (62.0)	227 (59.0)	78 (60.9)	104 (70.7)	6.343*	0.042
DBP (mmHg)	72.59 $\pm$ 12.06	72.77 $\pm$ 12.30	72.50 $\pm$ 10.92	72.23 $\pm$ 12.65	0.106	0.889
SBP (mmHg)	139.71 $\pm$ 23.31	140.21 $\pm$ 23.20	138.35 $\pm$ 22.24	140.37 $\pm$ 22.78	0.353	0.703
TG (mmol/L)	1.22 $\pm$ 0.64	1.23 $\pm$ 0.70	1.18 $\pm$ 0.51	1.25 $\pm$ 0.58	0.405	0.667
TC (mmol/L)	4.15 $\pm$ 0.85	4.05 $\pm$ 0.84	4.09 $\pm$ 0.86	3.97 $\pm$ 0.88	0.831	0.436
HDL (mmol/L)	1.58 $\pm$ 0.59	1.56 $\pm$ 0.39	1.57 $\pm$ 0.35	1.63 $\pm$ 1.02	1.358	0.222
LDL (mmol/L)	2.28 $\pm$ 0.97	2.23 $\pm$ 0.59	2.30 $\pm$ 0.64	2.40 $\pm$ 0.97	1.658	0.191
FBG(mmol/L)	4.46 $\pm$ 1.45	4.44 $\pm$ 1.32	4.40 $\pm$ 1.48	4.57 $\pm$ 1.68	0.536	0.585
SUA (μ mol/L)	318.72 $\pm$ 87.01	318.34 $\pm$ 84.83	316.75 $\pm$ 83.66	321.45 $\pm$ 93.10	4.993**	0.007
BMI	19.05 $\pm$ 3.64	19.02 $\pm$ 3.25	18.91 $\pm$ 3.85	19.20 $\pm$ 3.85	0.219	0.803
Smoking habits						
Former (%)	247 (37.4)	142 (36.9)	58 (45.3)	47 (32.0)	5.315	0.070
Current (%)	367 (55.6)	207 (53.8)	74/ (57.8)	86 (58.5)	1.280	0.572
Alcoholic						
Former (%)	386 (58.5)	218 (56.6)	89 (69.5)	79 (53.7)	8.344*	0.015
Current (%)	176 (26.7)	123 (31.9)	20 (15.6)	33 (22.4)	14.81**	0.001
Tea habits						
Former (%)	291 (44.1)	172 (44.7)	55 (43.0)	64 (43.5)	0.137	0.934
Current (%)	271 (41.1)	170 (44.2)	50 (39.1)	51 (44.2)	4.197	0.123
Exercise habits						
Former (%)	217 (32.9)	128 (33.2)	42 (32.8)	47 (32.0)	0.079	0.961
Current (%)	269 (40.8)	153 (39.7)	56 (43.8)	60 (40.8)	0.640	0.726
Educational levels						
Illiteracy	479	270	94	115		
Primary school	118	74	22	22		
Secondary school	46	31	9	6		
College and postgraduate	12	10	1	1	15.30*	0.041

Baseline characteristics were compared between different sleep quality groups, using χ^2 or Fisher's exact test (where an expected cell count was <5) for categorical variables and ANOVA for continuous variables. In the testing, a P value <0.05 was considered to be statistically significant

MMSE mini-mental state examination, SBP systolic blood pressure, DBP diastolic blood pressure, TG triglyceride, TC total cholesterol, HDL high-density lipoprotein, LDL low-density lipoprotein, FBG fasting blood glucose, SUA serum uric acid, BMI body mass index

* $P < 0.05$; ** $P < 0.01$

correlated with cognitive function. Subjects with dementia had longer sleep latency and lower sleep efficiency (Shochat et al. 2007; Zisberg et al. 2010).

In contrast to almost all previous studies, the standard used in this study was the MMSE rather than the clinical diagnosis of dementia, because an extensive clinical evaluation of 870 nonagenarians/centenarians

in their home in the community with 2,311,709 inhabitants was impractical. The MMSE was only a screening test for dementia, also widely used to detect cognitive function. Although the MMSE score did not always reflect the exact cognitive function because it had been shown that it was sometimes influenced by age, gender, and the level of education of the subject,

Table 3 Baseline characteristics according to sleep duration ($n = 660$)

Characteristics	All ($n = 660$)	Sleep duration			χ^2 or F	P value
		<5 h ($n = 4$)	5–9 h ($n = 107$)	>9 h ($n = 549$)		
Age (years)	93.52 $\pm$ 3.37	96.75 $\pm$ 3.86	93.32 $\pm$ 3.19	93.47 $\pm$ 3.33	2.057	0.129
Female (%)	444 (67.3)	3 (75.0)	62 (57.9)	379 (69.0)	5.112	0.078
MMSE scores	15.48 $\pm$ 5.44	11.25 $\pm$ 3.40	16.26 $\pm$ 5.14	15.43 $\pm$ 5.51	2.260	0.105
Dementia (%)	409 (62.0)	4 (100.0)	57 (57.0)	336 (62.7)	3.683	0.159
Sleep quality						
Score	6.84 $\pm$ 2.15	7.12 $\pm$ 3.12	6.75 $\pm$ 1.96	6.93 $\pm$ 2.54	0.751	0.227
Good/moderate/poor	385/128/147	1/1/2	59/19/29	325/108/116	3.68	0.451
SE (%)	76.53 $\pm$ 8.78	79.36 $\pm$ 4.17	78.26 $\pm$ 9.17	75.35 $\pm$ 8.66	1.065	0.199
SL (min)	45.89 $\pm$ 16.72	21.99 $\pm$ 7.96	47.12 $\pm$ 18.27	44.39 $\pm$ 21.15	0.991	0.238
DBP (mmHg)	72.59 $\pm$ 12.06	68.25 $\pm$ 7.68	72.95 $\pm$ 12.18	72.48 $\pm$ 0.51	0.320	0.726
SBP (mmHg)	139.71 $\pm$ 23.31	128.00 $\pm$ 23.07	140.32 $\pm$ 22.88	139.72 $\pm$ 22.87	0.559	0.556
TG (mmol/L)	1.22 $\pm$ 0.64	1.43 $\pm$ 0.70	41.08 $\pm$ 0.45	81.24 $\pm$ 0.66	2.872	0.057
TC (mmol/L)	4.15 $\pm$ 0.85	4.64 $\pm$ 0.69	4.04 $\pm$ 0.74	4.16 $\pm$ 0.86	1.638	0.195
HDL (mmol/L)	1.58 $\pm$ 0.59	1.56 $\pm$ 0.46	1.55 $\pm$ 0.37	1.58 $\pm$ 0.63	0.106	0.889
LDL (mmol/L)	2.28 $\pm$ 0.97	2.55 $\pm$ 0.59	2.37 $\pm$ 0.64	2.25 $\pm$ 1.02	0.585	0.558
FBG (mmol/L)	4.46 $\pm$ 1.45	4.89 $\pm$ 1.70	4.61 $\pm$ 1.43	4.44 $\pm$ 1.46	0.787	0.456
SUA (μ mol/L)	318.72 $\pm$ 87.01	381.75 $\pm$ 99.62	318.63 $\pm$ 83.66	317.38 $\pm$ 88.56	1.078	0.342
BMI	19.05 $\pm$ 3.64	19.97 $\pm$ 4.65	18.98 $\pm$ 3.98	19.04 $\pm$ 3.57	0.107	0.898
Smoking habits						
Former (%)	247 (37.4)	1 (25.0)	39 (36.4)	207 (37.7)	0.326	0.850
Current (%)	367 (55.6)	3 (75.0)	58 (54.2)	306 (55.7)	0.698	0.705
Alcoholic						
Former (%)	386 (58.5)	2 (50.0)	53 (49.5)	331 (60.3)	4.388	0.111
Current (%)	176 (26.7)	1 (25.0)	27 (25.2)	148 (27.0)	0.142	0.932
Tea habits						
Former (%)	291 (44.1)	1 (25.0)	49 (45.8)	241 (43.9)	0.726	0.696
Current (%)	271 (41.1)	1 (25.0)	43 (40.2)	227 (41.3)	0.479	0.787
Exercise habits						
Former (%)	217 (32.9)	0 (0)	38 (35.5)	179 (32.6)	2.315	0.314
Current (%)	269 (40.8)	0 (0)	42 (39.3)	227 (41.3)	2.932	0.231
Educational levels						
Illiteracy	479	3	68	408		
Primary school	118	1	29	88		
Secondary school	46	2	6	38		
College and postgraduate	12	1	5	6	11.95	0.153

Baseline characteristics were compared between different sleep duration groups, using χ^2 or Fisher's exact test (where an expected cell count was <5) for categorical variables and ANOVA for continuous variables. In the testing, a P value of <0.05 was considered to be statistically significant

MMSE mini-mental state examination, SL sleep latency, SE sleep efficiency percentage, SBP systolic blood pressure, DBP diastolic blood pressure, TG triglyceride, TC total cholesterol, HDL high-density lipoprotein, LDL low-density lipoprotein, FBG fasting blood glucose, SUA serum uric acid, BMI body mass index

in the present study, the subjects with better education had lower dementia. This finding was consistent with

that of previous reports (Tombaugh and McIntyre 1992; Uhlmann and Larson 1991). However, in the

Table 4 Association between sleep quality and odds of dementia

Characteristics	Dementia	
	Unadjusted ^a OR (95 % CI)	Adjusted ^b OR (95 % CI)
Sleep quality		
Good	1.000 (reference)	1.000 (reference)
Moderate	1.561 (0.940–2.591)	1.540 (0.980–2.420)
Poor	1.719 (1.138–2.597)*	1.759 (1.012–3.057)*

OR odds ratio

^aUnadjusted, Wald Chi-square test with $df = 1$ was used

^bAdjusted multiple logistic regression was used to adjust for covariates; adjustment was made with the following: age, gender, educational levels, serum lipid/lipoprotein, BMI, blood pressure, blood glucose level, smoking habit, alcohol consumption, tea consumption, and exercise

present study, after adjusted with age, gender, and the level of education, poor sleep quality still had a significantly increased OR for dementia. These results strongly suggest that sleep quality was an important determinant factor of cognitive function in aged individuals.

In our study, there is significant difference in age among different sleep quality groups. Participants with poor sleep quality were older in age. Sleep is a vital physiologic process with important restorative functions. Notable qualitative and quantitative changes in sleep occur with age (Nevitt et al. 1989; Ohayon et al. 2004; Redline et al. 2004). Aging is associated with several well-described changes in sleep patterns (Jean-Louis et al. 2000). It is possible that the decline in sleep quality was associated with age. However, this conclusion is not in agreement with other studies. Gu et al. (2010) found that quality of sleep of the very elderly did not differ substantially from that of the young elders. Tafaro et al. (2007) also reported that long-lived individuals showed better self-rated sleep quality. This disagreement could be explained by the following factors: (1) these two studies (Gu et al. 2010; Tafaro et al. 2007) used self-rated quality of sleep, which is a subjective measurement; (2) the participants included in these two studies were healthier than those included in our study; and (3) the healthy long-lived participants might have their own perception of what is “acceptable” sleep and, therefore, did not report poor sleep quality even if objective quality of sleep does in fact change with advancing age.

It is interesting that, in our study, the participants with dementia were younger than those without.

Mortality increased with age, and subjects with dementia demonstrated a higher mortality rate. Consequently, mortality leads to omission of those with dementia in older age, and thus leaves us with a population of younger elderly with dementia. Mortality might account for the difference between poor sleep quality and dementia in association with age, but it needed to be further confirmed. Another possible reason is the genetic factor of individuals with exceptional longevity. The closer to a centenarian one can get, the more likely one carries exceptional genetic traits, preventing the development of dementia and other problems.

In the present study, the mean sleep duration was 10.23 (SD 1.54), which is longer than a local study of elders in China that reported the average sleeping hour of 7.1 (SD 1.6) (Liu and Liu 2005). Although we excluded bedridden subjects or those with terminal illnesses who had longer sleep duration, sleep duration in the long-lived individuals was still >9 h, and more than 60 % of them were found to sleep for >9 h. This indicates a change in sleep quality with age. Our finding is consistent with that from previous reports (Ohayon et al. 2004; Redline et al. 2004). This observed longer sleep duration could be explained by the high percentage of participants with underlying dementia in the present study. There was a low mean MMSE score in the sample, and the sleep quality was related with MMSE score.

Loerbroks and Benito-León reported that increase in sleep duration is associated with cognitive impairment in older adults (Loerbroks et al. 2010; Benito-León et al. 2009). Our findings found no association between sleep durations and dementia and are thus

inconsistent with these previous findings. Given that our study is unique in enrolling the very elderly aged greater than 90 years and exclusively of the Chinese race, either one of both of these factors may account for the differences in our findings. Therefore, further studies of different age groups and ethnicity need to be conducted for more conclusive findings.

In contrast to previous findings, we found that the participants with good sleep quality have the highest percentage of current alcohol consumption, and the participants with poor sleep quality have the lowest percentage of previous history of alcohol consumption. A possible explanation for this paradox could be that we did not differentiate level of drinking nor the type of alcohol consumed. Lifestyle factors, including exercise, smoking, and tea consumption, which had been previously confirmed to be related to sleep quality, were not different among our sleep quality groups. The association of sleep quality with these lifestyles also changed with age, and the mechanism of which remains unclear and should be further explored.

Our study also has several limitations that deserve mention. First, 870 subjects aged 90 years or older volunteered for the PLAD Study. Of these, only 660 were included in the statistical analysis. There might have been selection biases, because MMSE relied heavily on visual and auditory abilities, especially at advanced age. Among nonagenarians and centenarians, there was a high prevalence of visual or hearing impairment. We excluded those with visual or hearing impairment, who could not complete the questionnaire, subjects with cancer, terminal stage of a physical disease, and the subjects being bedridden. However, our sample was from the community, not from a hospital or nursing home; the information from them (excluded from the sample) might be unable to influence the practical implications of the present study. Second, there was a gender imbalance in our population, a common characteristic of very old populations. Of the 870 long-living individuals (≥ 90 years) in the Dujiangyan district (2005), 409 women and 251 men were included in this study. Third, we did not adjust for other potential confounding factors, such as socioeconomic status and family history of sleep disorders. Further research that controls for these confounders is warranted.

In conclusion, to our knowledge, we found an association between dementia and sleep quality in long-lived subjects. Among longevity subjects, poor

sleep quality and dementia are associated with each other.

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