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Original Research

Sleep Duration Positively Correlates with Global Cognition in the Non-Demented Older Adults with High School or above Education

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Abstract

Background: Sleep disturbance is common in the elderly. The effect of sleep duration on cognitive function in the non-demented older adults with high school or above education needs to be clarified. Here, we conducted a cross-sectional study to explore the correlation between sleep duration and multi-domain cognitive function in non-demented older adults. **Methods**: A total of 226 adults aged 60 years and over who have an educational background over 9 years, received a battery of neuropsychological evaluations. The Mini-Mental State Examination (MMSE) was used to assess global cognitive function, the Auditory Verbal Learning Test (AVLT), Verbal Fluent Test (VFT), Trial Making Test-A/B (TMT-A/B), Symbol Digit Modalities Test (SDMT), and Rey-Osterriech Complex Figure Test (CFT) were used to assess the memory, language, attention and executive, and visuospatial functions respectively. Sleep characteristics were collected by questionnaire. **Results**: Subjects with sleep disturbance performed worse in visuospatial ability as compared with those with normal sleep. A significant correlation between nocturnal/total sleep duration and MMSE scores and CFT scores was found in overall subjects using linear regression models after adjusting for age, gender, education and BMI. Consistently, the nocturnal/total sleep duration positively correlated with MMSE scores after controlling for age, gender, education, BMI, hypertension, diabetes, hyperlipidemia, coronary artery disease and household conditions. **Conclusions**: The results indicate that shorter sleep duration impairs the global cognition and visuospatial ability in the older adults with high school or above education, even in the very early non-demented stage.

Keywords: sleep duration; cognitive function; MMSE; visuospatial ability; older adults

1. Introduction

Sleep occupies nearly one third length of an individual's life span and sleep duration becomes shorter with increasing age [1]. Many older adults complain of sleep disturbances even they have the opportunity to sleep for longer periods [2]. Sleep disturbances are frequently manifested by difficulties with initiation or maintenance of sleep, multiple and prolonged awakenings during night, and early awakening in the morning [2,3]. If the sleep difficulties become continual and chronic, the diagnostic criterion of insomnia might be made [4].

The incidence of insomnia is much higher in older adults, due to medical and social factors, as well as comorbid disorders in the elderly [5]. The lack of high-quality nocturnal sleep leads to day-time dysfunction, such as fatigue, tiredness, drowsiness, distress and impairment in social, occupational, behavioral, academic, or other functional domains [2,3,6,7].

Accumulating evidence suggests that insomnia contributes to cognitive decline and incidence of dementia [8–10]. A meta-analysis found that insomnia was a risk factor for cognitive disorders, including Alzheimer's disease (AD) [11]. Adults with insomnia exhibited impaired performance for several cognitive functions, including working memory [12], episodic memory [13], and some aspects of executive functioning [14], although these impairments were of mild to moderate magnitude [15]. Xu and his colleagues found that individuals with both elevated amyloid-beta protein (Aβ) and insomnia experienced faster cognitive decline than those with only elevated Aβ or insomnia, suggesting a link between insomnia and the progression of AD [16].

Most older adults experience some types of sleep disturbance, but the condition does not necessarily meet the diagnostic criteria of insomnia. Self-reported sleep disturbance, such as sleep duration, has been reported to reflect poor overall quality of sleep [17–20]. Although self-reported sleep duration is a habitual character with highly individual variation, it has been found to be closely associated with objective polysomnographic data [21] and is widely used in the epidemiological studies. The effect of sleep duration on cognitive function in general population

has been widely reported [22]. A study in Finnic adults showed that short (<7 h) periods of sleep duration were associated with cognitive decline, based on objective testing and self-reporting data [23]. Ohayon and Vecchierini found that self-reported lack of sleep (≤6 h) was associated with impaired self-reported cognitive to impairment in older adults [24]. These studies provide more evidence that insufficient sleep duration is related to impaired cognitive function.

Higher levels of education has been shown to be protective against the onset of dementia [25–27], while lower education level (≤8 years) have been reported to increase the risk of dementia or lower cognitive impairment by 80% [26]. Several studies observed that short sleep was seen among subjects with lower education levels as compared to college graduates [1,28–33]. However, whether self-reported sleep duration impacts cognitive function in the non-demented older adults with a higher education level (≥9 years) is still unclear. Clarifying the impact of sleep duration on cognitive function in non-demented older adults may help to determine potential risk factors and provide better preventive strategies against cognitive disorders at an earlier stage. Therefore, we conducted a cross-sectional study to explore the relationship between sleep duration and cognitive function in non-demented older adults with high school or above education.

2. Materials and Methods

2.1 Participants and Data Collection

Participants who live in Xujiahui Street Community, Xuhui District, Shanghai, China were voluntarily recruited from the Physical Examination Department of the Zhongshan Hospital. All the participants were aged 60 years or older and had an educational background over 9 years to assure they could accomplish a battery of neuropsychological scales. All the participants had no self-reported cognitive impairments in their daily life. Participants were excluded if they had any serious neuropsychiatric illness that could lead to cognitive impairment, such as severe cerebrovascular disease, depression, schizophrenia, intellectual disability, drug abuse, and severe visual or hearing impairment that may not be compatible with neuropsychological testing. A structured questionnaire was used to collect basic demographic data including age, gender, educational background (year), household conditions (lived with and without a family), body mass index (BMI), medical history and medication, tobacco use and consumption of alcohol, and daily physical activities.

We designed a questionnaire to record sleep duration (the self-reported number of hours slept per night or day on average in the past month), sleep disturbances including difficulty in initiating or sustaining sleep and waking up earlier than desired, day-time dysfunction and the use of medication related to insomnia (**Supplementary File**). The participants were asked: (1) How many hours do you usually sleep (including sleep at night and during the day time)? (2) Do you have any sleep problems including difficulty in initiating or sustaining sleep and waking up earlier than desired? (3) Have you ever been diagnosed with rapid eye movement sleep behavior disorder (RBD)? (4) Do you have day-time dysfunction related to insomnia or lack of sleep, such as daytime napping, fatigue, tiredness, drowsiness, distress and impairment in social, occupational, behavioral, academic, or other important areas of functioning? (5) Do you use any medication related to insomnia? If yes, please tell me the name of the drug and the time of day that it is used?

The participants reported the number of hours and minutes of sleep duration, which were then rounded by the interviewer to the nearest hour [22,23]. The total sleep duration was obtained by adding the nocturnal and the daytime sleep duration and recorded as hours. Following the answers obtained from the questionnaire, subjects who answered "no" to both the second and fourth questions in the questionnaire were classified as the normal sleep subgroup, and subjects who complained of dissatisfied sleep duration or sleep problems were classified as the sleep disturbance subgroup.

2.2 Neuropsychological Assessment

All participants underwent a standardized assessment of cognitive function through face-to-face interviews. (1) The global cognitive abilities were measured by the Mini-Mental State Examination (MMSE) test with scores ranging from 0 (severe impairment) to 30 points (no impairment) [34]. MMSE has been used extensively to assess general cognitive functioning or screen for dementia in the elderly [12,15,35]. (2) Memory function: the Auditory Verbal Learning Test (AVLT), including trials 1–5 total recall (AVLT total) and 30-min delayed recall (RAVLT-delayed recall, N5), which is consistently considered as a sensitive and efficient method to assess the ability of word memory in elderly Chinese patients [36]. (3) Language function: Verbal Fluent Test (VFT, vegetable, animal and fruit fluency) [37], which requires patients to name as many vegetables or animals or fruits as possible within 60 sec, with one point given for each unique name. Scores <15 points have demonstrated high sensitivity and specificity (88% and 96%, respectively) for the presence of AD in the memory clinic setting [38]. (4) Attention and executive function: the Trail Making Test-A and B (TMT-A/B) [39], Symbol Digit Modalities Test (SDMT) [40], both which present executive cognitive domain and are widely used for attention in patients with insomnia [41,42]. (5) Visuospatial ability: the Rey-Osterrieth Complex Figure Test (CFT) [43], a commonly used neuropsychological assessment tool, is widely used to assess the visuo-constructional ability and visual memory of neuropsychiatric disorders, including copying and recall tests [44]. Here, we used the copy part of CFT to measure visuospatial perception ability [41,42].

2.3 Statistical Analysis

Statistical analyses were performed using SPSS software (version 21.0; IBM Corp., Chicago, IL, USA). All p values were two-sided the level of statistical significance set at <0.05. Demographic data were compared between subjects with sleep disturbance and subjects with normal sleep using Student's t-test or nonparametric Mann–Whitney U test for continuous variables. Chi-square test was utilized for dichotomous variables (such as gender, comorbidities including hypertension, diabetes, hyperlipidemia, coronary artery disease, and household conditions).

Further, linear regression was used to evaluate the association between nocturnal or total sleep duration and cognitive assessment variables (MMSE, AVLT total, AVLT N5, VFT, TMT-A/B, SDMT and CFT) adjusted by age, gender, education and BMI in model 1, and adjusted by age, gender, education, BMI, comorbidity with hypertension, diabetes mellitus, hyperlipidemia, coronary artery disease and household conditions in model 2.

3. Results

3.1 Clinical Characteristics of the Participants

A total of 226 subjects were enrolled in the study, including 56 with complaints of sleep disturbance, and 170 with normal sleep condition. The demographic information of the participants was shown in Table 1. The average age of the subjects was 68.09 $\pm$ 5.43 years, with an average education year of 12.30 $\pm$ 2.91, and 62.83% were female. There were no significant differences in age (67.91 $\pm$ 5.64 *vs* 68.16 $\pm$ 5.34, $p = 0.773$), educational background (12.27 $\pm$ 2.54 *vs* 12.31 $\pm$ 3.03, $p = 0.922$), comorbidity with hypertension (57.14% *vs* 53.53%; $p = 0.638$), diabetes mellitus (16.07% *vs* 19.41%, $p = 0.577$), hyperlipidemia (55.36% *vs* 40%, $p = 0.054$), coronary artery disease (5.36% *vs* 2.35%, $p = 0.260$) and household conditions (7.14% *vs* 8.24%, $p = 0.793$) between sleep disturbance and normal sleep subgroups. However, the female proportion was higher higher and BMI was smaller in the sleep disturbance subgroup than in those with normal sleep condition (85.71% *vs* 55.29%, $p < 0.001$ for gender; 22.89 $\pm$ 3.79 *vs* 24.10 $\pm$ 3.92; $p < 0.05$ for BMI). The nocturnal, day-time and total sleep duration in sleep disturbance subgroup was significantly shorter than those in the normal sleep subgroup (nocturnal: 5.29 $\pm$ 1.46 *vs* 6.77 $\pm$ 1.11 hours, $p < 0.001$; day-time: 0.29 $\pm$ 0.48 *vs* 0.48 $\pm$ 0.58 hours, $p < 0.05$; Total: 5.55 $\pm$ 1.51 *vs* 7.24 $\pm$ 1.26 hours, $p < 0.001$) (Table 1).

3.2 Cognitive Function and Sleep Disturbance

Multiple domains of cognitive function assessed by a battery of neuropsychological tests in this study were listed in Table 2. Subjects with sleep disturbance performed worse in visuospatial function (CFT, 29.71 $\pm$ 3.04 *vs* 30.63 $\pm$ 2.84, $p < 0.05$) as compared with those in normal sleep subgroup. There were no significant differences in performance on MMSE (27.69 $\pm$ 1.37 *vs* 27.94 $\pm$ 1.39, $p = 0.241$), AVLT total (30.73 $\pm$ 7.18 *vs* 29.91 $\pm$ 6.95, $p = 0.452$), AVLT N5 (6.07 $\pm$ 1.87 *vs* 5.91 $\pm$ 1.93, $p = 0.602$), VFT (42.64 $\pm$ 6.91 *vs* 43.71 $\pm$ 6.64, $p = 0.302$), TMT-A (57.66 $\pm$ 14.52 *vs* 54.04 $\pm$ 12.75, $p = 0.076$), TMT-B (152.00 $\pm$ 50.37 *vs* 144.70 $\pm$ 39.51, $p = 0.265$), or SDMT (39.70 $\pm$ 8.03 *vs* 39.08 $\pm$ 7.32, $p = 0.599$) between the two subgroups (Table 2).

Since there was a significant difference in gender and BMI between the two subgroups, we further analyzed the effect of sleep duration on cognitive function in all the subjects using the linear regression model. The results showed a significant correlation between nocturnal sleep duration and the scores of MMSE as well as CFT on age, gender, education and BMI were adjusted (model 1, MMSE: B = 0.210, $p = 0.002$; CFT: B = 0.326, $p = 0.024$; n = 226), and the scores of MMSE if age, gender, education, BMI, comorbidity with hypertension, diabetes, hyperlipidemia, coronary artery disease and household conditions (Model 2, B = 0.221, $p = 0.002$; n = 226) (Table 3). A significant association was also found between total sleep duration and the scores of MMSE and CFT if age, gender, education and BMI were adjusted (model 1, MMSE: B = 0.125, $p = 0.048$; CFT: B = 0.283, $p = 0.033$; n = 226), and the scores of MMSE if age, gender, education, BMI, comorbidity with hypertension, diabetes, hyperlipidemia, coronary artery disease and household conditions were adjusted (Model 2, B = 0.139, $p = 0.031$; n = 226) (Table 4). There were no significant correlations between nocturnal or total sleep duration and the scores of AVLT (total), AVLT N5, VFT, TMT-A/B, and SDMT by linear regression analysis.

4. Discussion

In this study, we explored the correlation between sleep duration and multiple domains of cognitive function in the non-demented older adults with high school or above education. The CFT scores measuring visuospatial ability in subjects with sleep disturbance were significantly lower than those in subjects with normal sleep. There were no significant differences in global cognition as measured by MMSE, or memory function as measured by AVLT total and AVLT N5, or language ability as measured by VFT, or attention and executive function as measured by TMT-A/B and SDMT between the two subgroups. However, we noticed that there were more females and participants with smaller BMI in sleep disturbance group, which contributed to cognition [45,46]. We further analyzed the correlation between sleep duration and multiple domains of cognitive function using linear regression controlling these cofounders which may affect cognitive 214 function. After adjusting for age, gender, education and BMI (in model 1), both the nocturnal sleep duration and total sleep duration exhibited a significant positive correlation with global cognitive function as measured by MMSE scores. A similar result was observed after adjusting comorbidity with

Table 1. Demographic characteristics of participants (mean ± SD).

Characteristics	Total	Sleep disturbance		*p* value
	n = 226	Yes (n = 56)	No (n = 170)	
Age (year)	68.09 ± 5.43	67.91 ± 5.64	68.16 ± 5.34	0.773
Gender n (female%)	142 (62.83%)	48 (85.71)	94 (55.29)	**<0.001**
Education (year)	12.30 ± 2.91	12.27 ± 2.54	12.31 ± 3.03	0.922
BMI (Kg/m^2)	23.80 ± 3.92	22.89 ± 3.79	24.10 ± 3.92	**<0.05**
Nocturnal sleep duration (h)	6.41 ± 1.37	5.29 ± 1.46	6.77 ± 1.11	**<0.001**
Day-time sleep duration (h)	0.44 ± 0.56	0.29 ± 0.48	0.48 ± 0.58	**<0.05**
Total sleep duration	6.83 ± 1.51	5.55 ± 1.51	7.24 ± 1.26	**<0.001**
Hypertension n (%)	123 (54.42)	32 (57.14)	91 (53.53)	0.638
Diabetes mellitus n (%)	42 (18.58)	9 (16.07)	33 (19.41)	0.577
Hyperlipidemia n (%)	99 (43.81)	31 (55.36)	68 (40.00)	0.054
Coronary artery disease n (%)	7 (3.10)	3 (5.36)	4 (2.35)	0.260
Household conditions (single %)	18 (7.96)	4 (7.14)	14 (8.24)	0.793

Abbreviations: BMI, body mass index. Bold numbers indicate a significance of $p < 0.05$.

Table 2. The clinical data of different cognitive assessment in total subjects and subgroups divided by sleep disturbance.

Characteristics	total	Sleep disturbance		*p* value
	n = 226	Yes (n = 56)	No (n = 170)	
MMSE	27.89 ± 1.92	27.69 ± 1.37	27.94 ± 1.39	0.241
AVLT (total)	30.12 ± 7.00	30.73 ± 7.18	29.91 ± 6.95	0.452
AVLT N5	5.96 ± 1.91	6.07 ± 1.87	5.91 ± 1.93	0.602
VFT	43.45 ± 6.71	42.64 ± 6.91	43.71 ± 6.64	0.302
TMT-A (s)	54.93 ± 13.27	57.66 ± 14.52	54.04 ± 12.75	0.076
TMT-B (s)	146.51 ± 42.46	152.00 ± 50.37	144.70 ± 39.51	0.265
SDMT	39.23 ± 7.48	39.70 ± 8.03	39.08 ± 7.32	0.599
CFT	30.40 ± 2.91	29.71 ± 3.04	30.63 ± 2.84	**<0.05**

Abbreviations: MMSE, Mini-mental state examination; AVLT, Auditory Verbal Learning Test; VFT, Verbal Fluent Test; TMT-A, Trail Making Test A; TMT-B, Trail Making Test B; SDMT, Symbol Digit Modalities Test; CFT, Rey-Osterrieth Complex Figure Test; Total, total score; Values are means ± SD. Bold numbers indicate a significance of $p < 0.05$.

hypertension, diabetes, hyperlipidemia, coronary heart disease and household conditions (model 2). The visuospatial function as measured by CFT was also correlated with nocturnal and total sleep duration after adjusting age, gender, education and BMI in linear regression analysis of model 1, but not in model 2.

The effect of insomnia on cognitive function in the general population has been explored [3], but the results are still inconsistent. A few studies reported no significant differences in cognitive performance between subjects with insomnia and good sleepers [41,47]. However, more observational studies reported that, as compared with good sleepers, insomniacs exhibited impaired function in episodic memory [12,13], attention networks, vigilance and executive function [41,47]. Yaffe and his colleagues reported that individuals with sleep disturbance had a 27% increased risk of dementia during the 8-year follow-up [48]. Another study using Taiwan's National Health Insurance Research Database discovered that patients (aged 50 years and over) with long-term use of hypnotics have more than a 2-fold increased risk of dementia after 3 years of follow-up [49]. These 230 conflicting results may be attributed to the sample size, the definition criteria of insomnia [2], the sensitivity and specificity of cognitive assessment scales, and the statistical methodology used in these studies.

Since numerous observational studies were conducted in the general population which contains demented patients, we sought to explore the effect of insomnia on cognition in subjects without cognitive impairment to determine potential therapeutic interventions to prevent dementia. MMSE has been used to assess general cognitive functioning or screen dementia in elderly individuals [15,50–52]. In the present study, global cognitive function as measured by MMSE, initially did not exhibit a significant difference between subjects with self-reported sleep disturbance and normal sleepers (Table 1). But after controlling for age, gender, education and BMI, comorbidity and household conditions, there was a significant positive correlation between sleep

Table 3. Association between nocturnal sleep duration and cognitive assessment analyzed by linear regression.

Cognitive function		Model 1 (n = 226)		Model 2 (n = 226)	
		B, (95% CI)	*p* value	B, (95% CI)	*p* value
Global cognition	MMSE	0.210 (0.077∼0.343)	**0.002**	0.221 (0.085∼0.358)	**0.002**
Memory function	AVLT (total)	0.189 (–0.488∼0.865)	0.583	0.122 (–0.567∼0.811)	0.727
	AVLT N5	0.467 (–0.118∼0.258)	0.467	0.069 (–0.121∼0.259)	0.473
Language function	VFT	–0.126 (–0.773∼0.521)	0.701	–0.104 (–0.774∼0.566)	0.760
Attention/Executive function	TMT–A	0.736 (–0.484∼1.957)	0.236	0.852 (–0.407∼2.112)	0.184
	TMT–B	1.345 (–2.493∼5.182)	0.491	1.865 (–2.110∼5.839)	0.356
	SDMT	–0.168 (–0.880∼0.554)	0.642	–0.283 (–1.014∼0.449)	0.447
Visuospatial skills	CFT	0.326 (0.043∼0.609)	**0.024**	0.247 (–0.042∼0.536)	0.094

Abbreviations: MMSE, Mini-mental state examination; AVLT, Auditory Verbal Learning Test; VFT, Verbal Fluent Test; TMT-A, Trail Making Test A; TMT-B, Trail Making Test B; SDMT, Symbol Digit Modalities Test; CFT, Rey-Osterrieth Complex Figure Test; Total, total score; Bold numbers indicate a significance of $p < 0.05$.

Table 4. Association between total sleep duration and cognitive assessment analyzed by linear regression.

Cognitive function		Model 1 (n = 226)		Model 2 (n = 226)	
		B, (95% CI)	*p* value	B, (95% CI)	*p* value
Global cognition	MMSE	0.125 (0.001∼0.250)	**0.048**	0.139 (0.013∼0.265)	**0.031**
Memory function	AVLT (total)	0.081 (–0.545∼0.708)	0.798	0.040 (–0.588∼0.668)	0.900
	AVLT N5	0.060 (–0.113∼0.234)	0.492	0.561 (–0.122∼0.225)	0.561
Language function	VFT	0.003 (–0.594∼0.601)	0.992	–0.010 (–0.621∼0.600)	0.973
Attention/Executive function	TMT–A	0.685 (–0.444∼1.814)	0.233	0.773 (–0.374∼1.920)	0.185
	TMT–B	1.967 (–1.565∼5.499)	0.274	2.051 (–1.567∼5.668)	0.265
	SDMT	–0.069 (–0.726∼0.589)	0.837	–0.159 (–0.824∼0.506)	0.637
Visuospatial skills	CFT	0.283 (0.024∼0.542)	**0.033**	0.241 (–0.022∼0.504)	0.072

Abbreviations: MMSE, Mini-mental state examination; AVLT, Auditory Verbal Learning Test; VFT, Verbal Fluent Test; TMT-A, Trail Making Test A; TMT-B, Trail Making Test B; SDMT, Symbol Digit Modalities Test; CFT, Rey-Osterrieth Complex Figure Test; Total, total score; Bold numbers indicate a significance of $p < 0.05$.

duration and MMSE scores. The CFT scores measuring visuospatial ability in subjects with sleep disturbance were also significantly lower than those in good sleepers. Our data further supports the premise that short sleep duration is harmful to cognition even in non-demented older adults.

Sleep duration direct reflects the quantity of sleep. The mean sleep duration of the elderly participants without sleep disturbance in our study (7.24 h) was similar to that reported in older individuals in France (6–8 h) [24] or the United States (7 h) [53]. Faubel *et al.* [22] reported that sleep duration over 11h per day is associated with poorer cognitive function in older adults.

Tsapanou *et al.* [54] reported that longer sleeper (>480 min per day) performed worse in memory assessment in adults without dementia and MCI. A meta-analysis by Xu *et al.* [11] recently found that insufficient (<4 hours per night or total daily) or extensive (>10 hours per night and >12.5 h for total daily) sleep duration could elevate the risk of all-cause cognitive disorders or AD dementia. Several studies have demonstrated that both acute total and cumulative partial sleep loss lead to deteriorations in a wide range of cognitive performance, such as sustained attention, executive and memory functions [55,56]. These studies suggest that short sleepers in the general population may show inferior cognitive functions when compared with 7–8 h sleepers [23]. In our study, the mean total sleep duration per day was 5.55 h in the sleep disturbance subgroup and 7.24 h in normal sleep subgroup respectively. Although the two values of sleep duration were distributed in the reported normal range (4–10 h) [11], our results suggest that there is a significant positive correlation between sleep duration and global cognition within this sleep duration range (5.55–7.24 h) in non-demented older adults.

Visuospatial ability refers to the ability to understand what we see around us and how we interpret spatial relationships, which is affected in multiple types of dementia, including the early stages of AD. We used the copy part of CFT to evaluate visuo-constructional ability and memory function. Worse CFT scores in sleep disturbance group were observed as compared with those in normal sleeper, even after controlling several covariates in the linear regression analysis. Van Dijk *et al.* [57] reported poorer performance on the tests of visuospatial function and executive of the working memory in subjects with sleep problems.

Our data further indicated that visuospatial ability was impaired in subjects with sleep disturbance even in the very early non-demented stage.

An elevated risk of sleep disturbance was seen in women in the present study, which was consistent with a previous study [58]. Women have a 1.5 times higher risk of sleep disorders than men, which may be the result of a complicated interplay of biological, psychological, and social factors that play different roles throughout the life span [59]. These potential mechanism require further investigations.

Several limitations should be noted in the current study. First, the potential for selection bias exists 275 since the participants included in this cohort have a higher level of education that may not be found in 276 other study participants involved in this type of research. Second, the relatively small population size may limit our interpretation of the results, a larger sample size will be necessary in future studies. Third, other objective clinical techniques such as Pittsburgh sleep quality index and polysomnography, will need to be included in future insomnia studies. Fourth, the study could not 280 evaluate non-rapid eye movement (NREM) or rapid eye movement (REM) sleep disturbances, which have been associated with cognitive deficits in elderly adults [60].

5. Conclusions

In summary, the present results confirmed the effect of sleep duration on cognitive performance in non-demented elderly adults with high school or above education, and highlight the potential beneficial role of sleep duration on global cognitive performance in preclinical stages.

Abbreviations

Aβ, amyloid-beta protein; AD, Alzheimer's disease; AVLT, the Auditory Verbal Learning Test; AVLT N5, RAVLT-delayed recall; BMI, body mass index; CFT, Rey-Osterriech Complex Figure Test; MMSE, Mini-Mental State Examination; NREM, non-rapid eye movement; RBD, rapid eye movement sleep behavior disorder; REM, rapid eye movement; SDMT, Symbol Digit Modalities Test; TMT-A/B, the Trail Making Test-A and B; VFT, Verbal Fluent Test.

Author Contributions

All authors contributed significantly to this research and preparation of the manuscript. Conceived and designed the experiments and wrote the manuscript—XP, XD, CZ, GF. Performed the experiments and analyzed the data—XD, XP, XC, JZ, LW, SS, CZ, GF. The corresponding authors—GF, CZ. All authors have been involved in the drafting, critical revision and final approval of the manuscript for publication. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

The study was approved by the Committee on Medical Ethics of Zhongshan Hospital, Fudan University, code 2009-013. Participants provided written informed consent before beginning the study.

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/j.jin2106168.

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