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Association Between Nap and Reported Cognitive Function and Role of Sleep Debt: A Population-Based Study

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Background and Purpose The relationship between napping and cognition remains controversial. This study aimed to investigate the association between napping and cognition according to sleep debt in the Korean adult population.

Methods A population-based nationwide cross-sectional survey was conducted in 2018. A two-stage stratified random sample of Koreans aged ≥19 years was selected and evaluated using questionnaires by trained interviewers. Cognitive function was assessed using the Mail-In Cognitive Function Screening Instrument (MCFSI). Sleep habits on weekdays and weekends, napping, and subjective sleep requirements were assessed using the questionnaires. Accumulated sleep debt was calculated by subtracting the weekly average sleep duration from subjective sleep requirements. Sleep quality, daytime sleepiness, insomnia, depression, demographics, and comorbidities were assessed. Participants were grouped into those with sleep debt ≤60 min and those with sleep debt >60 min. Multiple linear regression was used to estimate the independent association between the factors and cognition.

Results In total, 2,501 participants were included in the analysis. Naps were reported in 726 (29.0%) participants (nappers). The mean MCFSI score was higher in nappers (3.4±3.6) than in non-nappers (2.3±3.0) ($p<0.001$). Multiple linear regression controlling for age, alcohol, smoking, depression, insomnia, daytime sleepiness, sleep quality, and education revealed that 30 to 60 min of napping was associated with worse cognitive function in participants with sleep debts ≤60 min, while >60 min of napping was associated with better cognitive function in participants with sleep debts >60 min.

Conclusions In general, naps are associated with worse cognitive function in the Korean adult population. However, for those with sleep debt of >60 min, naps for >60 min were associated with better cognitive function.

Keywords napping; cognition; sleep duration; sleep debt; epidemiology.

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INTRODUCTION

Nap is generally referred to as short sleep, which is distinct from and substantially shorter than an individual's normal sleep episode.[1] People take a nap for a variety of reasons, such as making up for insufficient sleep, preparing for anticipated sleep loss, or taking it for enjoyment.[1,2] The duration of naps can range from a few minutes to several hours, on average 1 h.[1,2] Nap not only relieves sleepiness and enhances alertness, but also affects cognitive function, especially in strengthening short-term memory.[1-3] Previous studies on the relationship between nap and cognition have shown controversial results. Daytime naps have been shown to improve alertness and enhance executive functions,[4-6] while associated with cognitive decline, especially in older populations.[3,6,7]

It is reasonable to hypothesize that the benefits and risks of naps are associated with the motivation of naps. For example, naps to compensate for sleep loss could affect cognition differently from naps of those who enjoy sufficient sleep. In this study, we aimed to investigate the association between napping and cognitive function in the Korean adult population according to sleep sufficiency.

METHODS

This was a nationwide population-based cross-sectional survey study. The subjects in our study were adults aged ≥19 years who resided in Korea. The survey was conducted from October 2018 to November 2018 in Gallup, Korea. Trained interviewers conducted the structured interviews. Before the interviews, the interviewers explained the purpose of the study to all eligible individuals and requested their participation. The respondents provided informed consent before beginning the survey. This study was approved by the Institutional Review Board of Chungnam National University Hospital (IRB no. CNUH 2018-04-005-002).

Study population and survey methods

The estimated population of Korea in 2018 was 51,817,851 of whom approximately 42,394,045 were aged 19 years and older.[8] Korea is geographically partitioned into 15 administrative divisions (metropolis/province), except Jeju Island. Each administrative division is further divided into "si," "gun," and "gu" as the basic administrative units. In total, there were 75 si (small to medium cities), 82 gun (rural areas), and 69 gu (metropolitan areas) in 15 Korean administrative divisions. We sampled 2,501 individuals based on their population structure. We adopted a two-stage systematic random-sampling method. First, 15 administrative divisions were designated as primary sampling units. We assigned appropriate sample numbers for each primary sampling unit according to the population distribution. In the second stage, representative basic administrative units (si, gun, and gu) were selected for each primary sampling unit. In total, 60 representative basic administrative units were selected for this study. For each representative basic administrative unit, we assigned a target sample number based on sex and age groups (19−29, 30−39, 40−49, 50−59, 60−69, and ≥70). In total, 2,501 participants completed the survey. Therefore, the sampling rate in this study was approximately 5.9 individuals per 100,000.

Questionnaires

Cognition

Cognition was assessed using Mail-In Cognitive Function Screening Instrument (MCFSI) to detect subjective cognitive impairment.[9] The MCFSI was developed by the Alzheimer's Disease Cooperative Study Prevention Instrument Project and designed to capture information related to the cognitive and functional status of nondemented individuals in a large population. The MCFSI consists of 14 questions that ask whether responders feel that their everyday functioning (such as memory, recalling names, driving, managing money, social activities, following stories, and using household appliances) has declined compared to one year ago. We thoroughly discussed the suitability of the MCFSI in this study and concluded that all questions could be appropriately answered by participants of all age groups. The maximum score is 14, with lower MCFSI scores indicating better cognitive functioning.

Quantity of nocturnal sleep and sleep debt

All participants were asked about their sleep habits, including time to go to bed, time to get ready to fall asleep, sleep latency, and wake-up time for both work days and free days. Average nocturnal sleep duration across the week was weighted by the number of work days and free days in a week and calculated as follows:

Nocturnal sleep duration, weekly average = [(sleep duration on work days × number of work days in a week) + (sleep duration on free days × number of free days in a week)]/7.

Subjective sleep requirements were assessed by the question, "How much night sleep do you feel is enough?" Sleep debt was calculated by subtracting the weekly average nocturnal sleep duration from the subjective sleep requirement to acquire accumulated sleep debt that was uncompensated with catch-up sleep on free days. As previous reports have defined significant sleep debt as sleep debt >60 min,[10,11] participants were divided into two groups according to sleep debt: those with sleep debt >60 min and those with sleep debt ≤60 min.

Sleep quality

Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI),[12] with a maximum score of 21. A score over 8.5 indicates poor sleep quality.[13]

Nap behavior

All participants were asked the question, "Do you take naps?" Napping behavior was evaluated using the Napping Behavior Questionnaire in those who answered "Yes."[14] Napping Behavior Questionnaire is a six-item questionnaire that asks subjects if they nap and includes items regarding the frequency (number of days during a typical week), reason (mostly planned, some planned/some spontaneous, or mostly spontaneous), time of day, duration, and mode of ending of the nap.

Covariates

Demographics, education status, comorbidities, depression, daytime sleepiness, and insomnia were considered covariates in this study. Education was categorized into four groups: less than six years, six to nine years, nine to twelve years, and more than twelve years. Smoking status, alcohol consumption status, and body mass index (BMI) were also included. Depression was evaluated using the Patient Health Questionnaire-9 (PHQ-9).[15] Significant depression was defined as a PHQ-9 score ≥10. Subjective daytime sleepiness was measured using the Epworth Sleepiness Scale (ESS), and excessive daytime sleepiness (EDS) was defined as an ESS score ≥11.[16] Insomnia was assessed using the Insomnia Severity Index (ISI). Clinical insomnia was defined as an ISI score ≥15.[17]

Statistical analysis

Comparisons of sleep patterns and other variables between nappers and non-nappers were conducted using an independent *t*-test or one-way ANOVA, according to the nature of the variables. To determine the variables associated with cognition in participants with and without sleep debt, we divided the participants into those with sleep debt ≤60 min and those with sleep debt >60 min. In the univariate analysis, to assess the correlation between independent factors and MCFSI score, we used the independent *t*-test, one-way ANOVA, or Pearson's chi-square test, according to the nature of the variables. Multiple linear regression was used to estimate the independent association between naps and cognition. The analysis was adjusted for age, alcohol consumption, smoking, depression, insomnia, daytime sleepiness, sleep quality, and education level. The results of the multiple linear regression analysis are presented using β coefficients and corresponding *p* values. All statistical analyses were performed using SPSS version 25 (IBM Corp., Armonk, NY, USA), and to be statistically significant, the probability of significance (*p*-value) must be <0.05.

RESULTS

General characteristics

Among 2,501 participants, 726 (29.0%) reported taking a nap during the daytime (nappers). The duration of napping was less than 15 min in 75 (10.3%), 15–30 min in 202 (27.8%), 30–45 min in 187 (25.8%), 45–60 min in 133 (18.3%), and >60 min in 129 (17.8%) participants. The nap was mostly planned in 100 (13.8%) patients, some planned and some spontaneous in 300 (41.3%), and mostly spontaneous in 326 (44.9%). The reasons for napping were feeling sleepy during the day in 418 (57.7%), refreshment in 227 (31.3%), spare time in 61 (8.4%), and avoiding feeling sleepy later in the day in 11 (1.5%). When the nappers were asked how often they napped, 321 (44.2%) reported napping 1–2 days per week, 169 (23.3%) reported napping less than one day per week, 136 (18.7%) reported napping 3–4 days per week, and 100 (13.8%) reported napping more than 4 days per week. The majority of naps occurred during the "postlunch dip" period, with 506 (69.7%) nappers reporting they typically took naps between 2 PM and 5 PM and 150 (20.7%) between 11 AM and 2 PM.

When compared to non-nappers, nappers showed older age (52.6±17.2 vs. 46.0±15.6, $p<0.001$), higher BMI (23.4 ± 2.8 vs. 23.0±2.8, $p=0.001$), higher PHQ-9 score (3.6±4.0 vs. 2.8±3.6, $p<0.001$), higher ESS score (7.9±3.9 vs. 6.2±3.9, $p<0.001$), higher ISI score (6.0±4.7 vs. 4.7±4.6, $p=0.008$), higher PSQI score (4.4±2.5 vs. 3.6±2.4, $p=0.009$), shorter nocturnal sleep duration (424.9±69.1 vs. 429.7±66.9, $p=0.024$), and higher MCFSI score (3.4±3.6 vs. 2.3±3.0, $p<0.001$) (Table 1). Nappers were more prevalent in patients with hypertension, diabetes, and hyperlipidemia. Education also differed between nappers and non-nappers. Sex, smoking, and alcohol drinking status were not different between nappers and non-nappers. The subjective sleep requirement and sleep debt of nappers were also comparable to those of non-nappers.

Univariate correlation analysis between cognition and various factors

A univariate correlation analysis with the MCFSI score as a dependent variable showed that in participants with sleep debt ≤60 min, all variables except nocturnal sleep duration were significantly correlated with the MCFSI score (Table 2). In contrast, in participants with sleep debt >60 min, only subjective sleep requirement, smoking, and alcohol consumption were not correlated with MCFSI scores. Older age, female sex, lower educational status, never drinking alcohol, presence of comorbidities (hypertension, diabetes, and dyslipidemia), higher BMI, significant depression, EDS, clinical insomnia, and poor sleep quality were significantly associated with higher MCFSI in both groups. Among participants with a sleep debt of ≤60 min, the MCFSI score was lowest in non-nappers. Conversely, among participants with sleep debt >60 min, the MCFSI score was lowest in those who napped for >60 min. The MCFSI score did not differ across groups with different reasons for napping or groups with different nap timings.

Multivariate analysis

Multiple linear regression analysis showed that older age, higher PHQ-9 scores, higher ISI scores, higher ESS scores, higher PSQI scores, and lower educational status were independent contributing factors for higher MCFSI scores in both groups with different sleep debts (Table 3). In participants

Table 1. Demographics and characteristics of participants

	Overall (n=2,501)	Napper (n=726, 29%)	Non-napper (n=1,775, 71%)	p
Age (yr)	47.9±16.4	52.6±17.2	46.0±15.6	<0.001
Age group				<0.001
<30 years	434 (17.4)	103 (14.2)	331 (18.6)	
30–49 years	923 (36.9)	211 (29.1)	712 (40.1)	
50–69 years	843 (33.7)	254 (35.0)	589 (33.2)	
≥70 years	301 (12.0)	158 (21.8)	143 (8.1)	
Female	1,259 (50.3)	376 (51.8)	883 (49.8)	0.353
Education				<0.001
≤ 6 years	163 (6.5)	74 (10.2)	89 (5)	
>6 and ≤9 years	230 (9.2)	99 (13.6)	131 (7.4)	
>9 and ≤2 years	1,063 (42.5)	294 (40.5)	769 (43.3)	
>12 years	1,045 (41.8)	259 (35.7)	786 (44.3)	
Smoking				0.067
Current/former	946 (37.9)	295 (40.6)	651 (36.7)	
Never	1,553 (62.1)	431 (59.4)	1,122 (63.3)	
Alcohol consumption				0.129
Current/former	1,965 (78.6)	585 (80.6)	1,380 (77.8)	
Never	534 (21.4)	141 (19.4)	393 (22.2)	
Comorbidity				
Hypertension	437 (17.5)	197 (27.1)	240 (13.5)	<0.001
Diabetes	221 (8.8)	110 (15.2)	111 (6.3)	<0.001
Hyperlipidemia	164 (6.6)	72 (9.9)	92 (5.2)	<0.001
BMI (kg/m^2)	23.1±2.8	23.4±2.8	23.0±2.8	0.001
PHQ-9 score	3.02±3.8	3.6±4.0	2.8±3.6	<0.001
ESS score	6.7±4.0	7.9±3.9	6.2±3.9	<0.001
ISI score	5.1±4.6	6.0±4.7	4.7±4.6	0.008
PSQI score	3.8±2.4	4.4±2.5	3.6±2.4	0.009
Nocturnal sleep duration (min)	428.3±67.5	424.9±69.1	429.7±66.9	0.024
Subjective sleep requirement (min)	452.7±64.1	452.4±66.6	452.8±63.1	0.911
Sleep debt (min)	24.3±77.7	26.0±80.9	23.6±76.3	0.062
MCFSI score	2.7±3.2	3.4±3.6	2.3±3.0	<0.001

Variables are presented as means±standard deviations or numbers (weighted column percentage).
BMI, body mass index; ESS, Epworth Sleepiness Scale; ISI, Insomnia Severity Index; MCFSI, Mail-In Cognitive Function Screening Instrument; PHQ-9, Patient Health Questionnaire-9; PSQI, Pittsburgh Sleep Quality Index.

with sleep debt of ≤60 min, 30 to 60 min napping was an independent contributing factor for higher MCFSI scores (β=0.431, p=0.029). In participants with sleep debt of >60 min, however, a nap >60 min was an independent contributing factor of lower MCFSI scores, indicating a better cognitive state (β=-1.243, p=0.002).

DISCUSSION

This population-based cross-sectional study investigated the association between napping and cognition in the Korean adult population. Of the participants, 29.0% were nappers. Previous population studies in France, Japan, and China reported that 20.9% to 45.6% of the adult population were nappers.[10,18,19] When compared to non-nappers, nappers had unfavorable characteristics such as older age; lower educational level; higher prevalence of hypertension, diabetes, and dyslipidemia; higher BMI; higher PHQ-9 score; higher ISI score; shorter nocturnal sleep duration; and higher MCFSI score (thus relatively unfavorable cognitive state). However, sleep debt did not differ between the nappers and non-nappers. Multivariate analyses revealed that for both participants with sleep debt ≤60 min and those with sleep debt >60 min, older age, higher PHQ-9 scores, higher ISI scores, higher ESS scores, higher PSQI scores, and lower educational levels were independent contributors to an unfavorable cognitive state. Naps for 30−60 min were an independent contributor to an unfavorable cognitive state in participants with a sleep debt of ≤60

Table 2. Univariate correlation between MCFSI score and various factors of in participants with sleep debt ≤60 min and those with sleep debt >60 min

Variable	Sleep debt ≤60 min			Sleep debt >60 min		
	MCFSI, mean±SD	R	*p*	MCFSI, mean±SD	R	*p*
Age		0.459	<0.001		0.453	<0.001
Sex			<0.001			0.042
Male	2.3±3.1			2.6±3.0		
Female	2.9±3.4			3.1±3.4		
Education			<0.001			<0.001
≤6 years	5.5±4.0			6.4±3.9		
>6 and ≤9 years	4.7±3.7			4.6±3.7		
>9 and ≤12 years	2.8±3.2			2.9±3.0		
>12 years	1.4±2.3			2.1±2.7		
Smoking			0.045			0.181
Current/former	2.4±2.7			2.7±3.0		
Never	2.7±3.4			3.0±3.3		
Alcohol consumption			<0.001			0.120
Current/former	2.4±3.1			2.7±3.0		
Never	3.3±3.8			3.3±3.8		
Hypertension			<0.001			<0.001
Present	4.7±3.7			5.2±3.6		
Absent	2.1±3.0			2.4±2.9		
Diabetes			<0.001			<0.001
Present	4.8±3.7			5.1±3.8		
Absent	2.4±3.1			2.6±3.0		
Dyslipidemia			<0.001			<0.001
Present	5.5±3.8			4.7±3.6		
Absent	2.4±3.1			2.7±3.1		
Nap duration			<0.001			0.001
None	2.3±3.0			2.6±3.1		
Nap, <30 min	3.5±3.7			3.8±3.6		
Nap, 30–60 min	3.7±3.8			3.9±3.5		
Nap, > 60 min	2.6±3.4			1.7±1.7		
Nap frequency			<0.001			0.001
None	2.3±3.0			2.5±3.0		
<1/week	2.9±3.8			2.8±2.8		
1–2/week	3.0±3.3			3.4±3.2		
3–4/week	4.5±4.0			3.9±3.7		
>4/week	4.3±4.2			4.3±3.9		
Body mass index		0.089	<0.001		0.101	0.011
PHQ-9			<0.001			<0.001
≥10	4.6±3.5			5.6±3.9		
<10	2.4±3.2			2.5±2.9		
ESS			<0.001			<0.001
≥11	4.4±4.0			5.0±4.0		
<11	2.3±3.0			2.4±2.8		
ISI			<0.001			<0.001
≥15	5.5±4.3			6.0±4.3		
<15	2.5±3.2			2.5±2.9		

Table 2. Univariate correlation between MCFSI score and various factors of in participants with sleep debt ≤60 min and those with sleep debt >60 min (continued)

Variable	Sleep debt ≤60 min			Sleep debt >60 min		
	MCFSI, mean±SD	R	*p*	MCFSI, mean±SD	R	*p*
PSQI			<0.001			<0.001
≥8.5	5.4±4.3			5.5±4.3		
<8.5	2.5±3.2			2.5±2.8		
Nocturnal sleep duration, week average		-0.012	0.605		-0.192	<0.001
Subjective sleep requirement		-0.080	0.001		-0.032	0.426
Sleep debt		-0.069	0.003		0.167	<0.001

Relationship with categorical variables was presented as differences of mean. Relationship with continuous variables is presented as the Pearson correlation coefficient (R).
ESS, Epworth Sleepiness Scale; ISI, Insomnia Severity Index; MCFSI, Mail-In Cognitive Function Screening Instrument; PHQ-9, Patient Health Questionnaire-9; PSQI, Pittsburgh Sleep Quality Index.

Table 3. Multiple linear regression analysis to predict MCFSI in participants grouped according to sleep dept

	Sleep debt ≤60 min*		Sleep debt >60 min†	
	β	*p*	β	*p*
Age	0.060	<0.001	0.058	<0.001
Alcohol	-0.081	0.624	0.010	0.969
Smoking	-0.258	0.060	-0.131	0.526
PHQ-9	0.125	<0.001	0.199	<0.001
ISI	0.130	<0.001	0.074	0.010
ESS	0.100	<0.001	0.093	0.001
PSQI	0.052	0.172	0.117	0.028
Education				
>12 years	Ref		Ref	
>9 and ≤12 years	0.790	0.015	1.231	0.024
>6 and ≤9 years	0.867	0.002	0.146	0.731
≤6 years	0.258	0.094	-0.111	0.641
Nap duration				
Non-napper	Ref		Ref	
<30 min	-0.024	0.905	0.155	0.629
30–60 min	0.431	0.029	0.382	0.180
>60 min	-0.015	0.593	-1.243	0.002

Negative β indicates better cognitive function.
*R^2=0.343; †R^2=0.427.
ESS, Epworth Sleepiness Scale; ISI, Insomnia Severity Index; MCFSI, Mail-In Cognitive Function Screening Instrument; PHQ-9, Patient Health Questionnaire-9; PSQI, Pittsburgh Sleep Quality Index.

min. However, in participants with sleep debt >60 min, naps >60 min were an independent contributor to favorable cognitive states.

Naps of various durations have been shown to benefit cognition with variable timing and duration.[1] However, it is controversial as to how long a nap is most beneficial. The effects of naps on cognition can be divided into immediate and long-term effects. In a study, longer 120-min naps rather than short 15-min naps in a healthy population with total sleep deprivation were shown to be beneficial to the level of alertness immediately after napping.[20] In contrast, when a 15-min nap and a 45-min nap were compared after adequate sleep for more than 7 h without night sleep restriction, a 15-min nap was associated with better subjective alertness after 30 min, while a 45-min nap was associated with better subjective alertness after 3 h.[21] Better level of alertness and cognitive performance after shorter naps compared to longer naps could be attributed to less sleep inertia after naps. This was in line with a study that compared recuperative effects of naps for 5, 10, 20, and 30 min.[4] In this study, 5-min naps produced few benefits while 10-min naps produced immediate improvements in alertness and cognitive performance. The 30-min nap produced impaired alertness and cognitive performance immediately after napping, followed by improvements lasting up to 155 min after napping.

Most studies that have examined the association between naps and long-term cognitive outcomes have been conducted in the elderly. A longitudinal study in old age found that a nap longer than 120 min is associated with greater cognitive decline.[22] The association between napping and cognitive impairment was more pronounced among those with higher sleep efficiency and average sleep duration. Three other studies indicated that the group taking a nap of moderate duration (30 to 60 min) had better cognitive function than the group not taking a nap or taking a longer nap.[3,6,7] Our study demonstrated that moderate 30- to 60-min napping in adult populations without more than 1 h of sleep debt was associated with an unfavorable cognitive state. In participants aged 65 years or older, the MCFSI score was 6.4±3.8 in those who nap 30−60 min which was significantly higher than the score of non-nappers (5.0±3.7, *p*=0.02), those who napped <30 min (5.1±4.2, *p*=0.031), and those who napped >60 min (4.2±3.6, *p*=0.012). An unfavorable cognitive state may affect napping in the absence of significant sleep debt or vice versa. The discrepancy between the three aforementioned studies may arise from differences in methodology. The three studies did not evaluate the overall napping behavior, but only the nap duration in the post-lunch period.[3,6,7] Racial and cultural differences may have affected the results, as the three studies were conducted on the Chinese population.

It is well-known that sleep is critical to cognition including memory processing.[23] Sleep deprivation reduces attention and psychomotor vigilance.[24] Even short-term sleep deprivation affects overall domains of cognition, including attention, working memory, processing speed, short-term memory, and reasoning.[25] One of the reasons for taking a nap is to reduce drowsiness in response to sleep deprivation or to compensate anticipated sleep deprivation in advance. Naps taken for these reasons are called compensatory naps.[1,2] These naps are commonly seen in shift workers or people with sleep disorders related to EDS.[1] Other naps are appetitive or recreational naps, in which people take a nap because of boredom or pleasure without sleep loss.[1,2] We hypothesized that compensatory naps would, at least partially, alleviate the detrimental effects of chronic sleep deprivation on cognition in the general population. Our results showed that in adults who were deprived of nocturnal sleep for more than an hour, napping for more than an hour was an independent contributor to favorable cognition. To the best of our knowledge, this is the first study to analyze the association between compensatory naps and cognition in the adult population. In line with our results, a cross-sectional study of Chinese elderly showed that compared to those who sleep 7–8.9 h a night and nap 1 to 30 min, those who sleep 9 h or more a night and nap 1–30 min or more than 60 min, and those who sleep 5–6.9 hours a night and do not nap were associated with a high risk of cognitive impairment, indicating that naps in those with sleep deprivation would be associated with alleviation of the risk of cognitive impairment associated with sleep deprivation.[6]

According to the classical two-process model that includes homeostatic sleep drive (Process S) and circadian phase (Process C), the benefits of a nap would be dependent on the decrease of homeostatic sleep drive.[26] The decrease of homeostatic sleep drive during a nap depends on the amount of slow wave activity during a nap.[27] Slow wave activities increase gradually during the first ultradian cycle which has an approximately 90-min period length. Our results showing that only naps of more than 60 min were associated with a favorable cognition suggest that this dissipation of remnant homeostatic sleep drive in sleep-deprived adults could be associated with positive effects on their cognition from a long-term perspective.

Clinically, cognitive function is evaluated by domains such as memory, attention, language, visuospatial function, and executive function. We assessed cognitive function using the MCFSI, which provides information related to the overall cognitive and functional status in the non-demented population. MCFSI scores are well-correlated with Mini-Mental Status Examination scores and the Clinical Dementia Rating Scores in healthy elderly individuals.[9] Well-known risk factors for cognitive impairment and dementia include lower educational level, hypertension, diabetes, heavy alcohol consumption, cigarette smoking, obesity, and depression.[28] Chronic insomnia is also an independent risk factor for cognitive decline.[29] In our study, lower educational level, higher BMI, and depression were associated with worse cognitive function as expected. Poor sleep quality and insomnia were also associated with poor cognition.

This study had the following limitations. Since all the variables including nap duration and cognitive function were evaluated based on subjective questionnaires rather than objective measurements, as exemplified by reports suggesting that self-reported habitual sleep duration is longer than actual sleep duration,[30,31] the possibility that the responder's memory distortion and truthfulness biased the results cannot be excluded. Sleep debt in this study is accumulated sleep debt based on the reported subjective sleep requirements. As sleep debt can also be calculated as the difference between average workday sleep duration and average free day sleep duration, care should be taken in interpretation. Sleep disorders, other than insomnia, can also affect cognition. Obstructive sleep apnea is common and has been associated with cognitive impairment in several studies; hence, it can be a confounding factor in the correspondence between napping and cognition.[32] As we did not evaluate obstructive sleep apnea, this could be another limitation. Finally, as this study is cross-sectional in nature, this study only found a relationship between napping and cognition and could not infer a causal relationship.

Nevertheless, this study was not limited to the elderly, but included a relatively large sample representing the adult population of all ages, and the relationship between nap and cognitive function could be estimated relatively accurately. In the future, this study is expected to be the basis for estimating the ideal duration of napping for positive effects on cognitive function and analyzing its mechanism.

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

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Conflicts of Interest

Min Kyung Chu, an associate editor of the *Journal of Clinical Neurology*, was not involved in the editorial evaluation or decision to publish this article. All remaining authors have declared no conflicts of interest.

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