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Age Group Differences in the Association Between Sleep Status and Frailty Among Community-Dwelling Older Adults: The SONIC Study

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Abstract

Objective: We aimed to determine whether the association of sleep status with frailty differs between age groups of older adults. **Method:** This cross-sectional study was part of the observational Septuagenarians, Octogenarians, Nonagenarians Investigation with Centenarians (SONIC) study. Subjects were community-dwelling older adults in their 70s and 80s. Frailty was evaluated using the Japanese version of the Cardiovascular Health Study criteria (J-CHS). Pittsburgh Sleep Quality Index (PSQI) was used to assess sleep status. Poor sleep quality was defined as a PSQI global score $\geq$6. Sleep duration was categorized as short ($<$6 hr), normal (6–8), and long ($>$8). We performed multivariable logistic regression to investigate the association between sleep status and frailty separately for each age group adjusted for multiple covariates. **Results:** In those in their 70s, long sleep duration and sleep medication use were independently associated with frailty. In those in their 80s, poor sleep quality was independently associated with frailty. **Conclusions:** The association between sleep status and frailty was different between age groups. The findings underscore the importance of incorporating the evaluation of sleep quantity and non-pharmacological therapies in those in their 70s and the evaluation of sleep quality in those in their 80s to help prevent the onset of frailty.

Keywords

Age group, community-dwelling people, frailty, sleep duration, sleep quality

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Introduction

Frailty is a common geriatric syndrome in older adults, characterized by increased vulnerability to stress due to a declining physiologic reserve and associated with adverse events such as falls, disability, long-term care, hospitalization, and death (Clegg et al., 2013; Fried et al., 2001; Song et al., 2010). However, since frailty is reversible and returns to a healthy condition from a frailty status with appropriate intervention (Clegg et al., 2013), it is important to identify factors associated with it. According to a systematic review conducted by Collard et al. (2012), the prevalence of physical frailty among those aged 75 to 79 years was approximately 10%, while the prevalence among those aged 85 years or older was 26% . According

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to another systematic review conducted by Kojima et al. (2017), the prevalence of frailty among community-dwelling older adults in Japan was 10% among those aged 75 to 79 years, while the prevalence among those aged 85 years or older was 35.1%, higher than that in other countries for those aged 85 years or older. Given that psychological and physical functions change with age (Djernes, 2006; Lauretani et al., 2003), it is important to identify modifiable factors associated with frailty in each age group and establish countermeasures.

Recently, sleep status is reported to be one of important factors associated with frailty in older adults (Balomenos et al., 2021; Cil et al., 2019; Gomez et al., 2022; Sun et al., 2020). In general, the proportions of poor sleep quality (e.g., increased waking after sleep onset, increased sleep latency) and sleep medication use increase with age (Doi et al., 2001). The changes in sleep medication use, sleep duration, and sleep quality with aging have been reported to be associated with various adverse events (Buxton & Marcelli, 2010; Fu et al., 2017; Štefan et al., 2018; Xu et al., 2020), and more attention needs to be paid to sleep status in older adults. A systematic review reported that both short and long sleep durations were significantly correlated with an increased risk of frailty (Pourmotabbed et al., 2020). Furthermore, sleep quality, such as daytime drowsiness and prolonged sleep latency, was also associated with frailty (Pourmotabbed et al., 2020). However, the association between sleep status and frailty remains controversial because some reports showed that only sleep quality and not sleep duration was associated with frailty (Arias-Fernández et al., 2021). Furthermore, there has been insufficient study of age groups, including the super-aged 85 years or older, with a higher prevalence of frailty. It also remains unclear whether these associations differ among age groups in their 70s and 80s.

Given that the sleep status and psychological and physical functions change with age (Djernes, 2006; Lauretani et al., 2003), clarifying the association of sleep duration, sleep quality, sleep medication use, and frailty among age groups could offer useful insight to help prevent the onset of frailty according to each age group. This study aimed to determine whether the association among sleep medication use, sleep duration, sleep quality, and frailty differs after adjustment for sex, body mass index (BMI), educational level, cognitive function, mental health, lifestyle habits, hypertension, and diabetes, as well as histories of stroke, heart disease, and joint disease in age groups in their 70s and 80s among community-dwelling older Japanese adults.

Methods

Participants

This cross-sectional study was part of the ongoing prospective cohort study called Septuagenarians, Octogenarians, Nonagenarians Investigation with Centenarians (SONIC) study, which has identified factors contributing to health and longevity among community-dwelling older adults since 2010, with follow-ups every 3 years (Gondo et al., 2017). We used a narrow age-range cohort design to exclude the effects of aging as much as possible. The eligibility criteria for the study were subjects aged 75 to 78 years (70s age group) and 85 to 87 years (80s age group) who participated in the sleep survey conducted in 2017 to 2018. We excluded the following: (1) those who required long-term care (level 2 or higher) that has been reported to be unhealthy in a survey of long-term care benefit expenses (Ministry of Health, Labour, and Welfare, n.d.); (2) a history of dementia, Parkinson's disease, or depression; (3) those with missing information of sleep, frailty, or other values. The final analyzed number of participants was 866, consisting of 561 in their 70s and 305 in their 80s. The study protocol was approved by the relevant institutional review boards (approval numbers 266, H22-E9, 22 018, and 38, respectively). Informed consent was obtained from all participants for the overall study and the sleep survey.

Assessment of Sleep

We used the Japanese version of the Pittsburgh Sleep Quality Index (PSQI) to assess sleep quality (PSQI global score) and sleep medication use (PSQI component 6). The PSQI is a reliable and valid measure for subjective sleep assessment (Cronbach's alpha = .77) (Doi et al., 2000). It is a self-administered questionnaire that includes seven components of: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, sleep medication use, and daytime dysfunction (Doi et al., 2000). Each component was scored 0 to 3, with higher scores indicating poor sleep quality. Sleep medication use was categorized on a 4-point scale (0: none, 1: less than once a week, 2: 1–2 times a week, 3: more than three times a week) based on PSQI component 6 and poor sleep quality was defined as a PSQI global score ≥ 6 (Doi et al., 2000). Self-reported sleep duration was categorized as short (<6 hr), normal (6–8), and long (>8) (Pourmotabbed et al., 2020). In addition, the subjects were asked whether they regularly took medications prescribed to help them sleep (sleeping pills or anti-anxiety medication) by checking the subject's medication record book. We also divided the types of medications prescribed into benzodiazepines and nonbenzodiazepines.

Assessment of Physical Frailty

We assessed physical frailty according to the Japanese version of the Cardiovascular Health Study criteria based on the phenotype of frailty, which has validity and standardized definition (Fried et al., 2001; Satake & Arai, 2020) and includes five criteria: (1) unintentional weight

loss, (2) weakness (low grip strength), (3) exhaustion, (4) slow gait speed, and (5) low activity. Unintentional weight loss was defined as ≥2 to 3 kg in the past 6 months. Weakness was assessed by grip strength and defined according to a sex-specific cut-off (<28 kg for males and <18 kg for females) (Satake & Arai, 2020). Grip strength was assessed twice by a hand dynamometer (Model YD-100; Yagami, Ltd., Tokyo, Japan) on the dominant side, and the average value was used for analysis. Exhaustion was defined as feeling tired for no reason in the last 2 weeks. Slow gait speed was defined as a usual gait speed <1.0 m/s. Gait speed was measured twice by the 8-feet gait speed test, and the mean gait speed was used for analysis. Low physical activity was defined as neither light physical exercise nor regular physical activity at least once a week. Physical frailty was defined as having three or more of those criteria.

Covariates

Covariates that could confound the association between sleep status and frailty included sex, body mass index (BMI), education, cognitive function, mental health, lifestyle habits (smoking and drinking), hypertension, and diabetes, as well as histories of stroke, heart disease, and joint disease. The data were collected from interviews, self-administered questionnaires, physical examinations, and blood samples. Information on medications prescribed was obtained through interviews and by checking the subject's medication record book. BMI was calculated as the weight in kilograms divided by the square of the height in meters (kg/m^2). We categorized education years into two categories (<10 or ≥10 years). Cognitive function was assessed by the Japanese version of the Montreal Cognitive Assessment (MoCA-J) (Nasreddine et al., 2005). The MoCA-J test is a validated tool used to assess global cognition and was developed to detect mild cognitive impairment (MCI) (Cronbach's alphas = .74) (Fujiwara et al., 2010). The presence of MCI was defined by a score of ≤25. Mental health was assessed by the Japanese version of the WHO Five Well-Being Index (WHO-5-J), which has also been used to screen for depression (Topp et al., 2015) and had sufficient reliability and validity (Cronbach's alpha = .89) (Awata et al., 2007).

We categorized the WHO-5 score into two categories (low: <12/25 points, high: ≥13/25 points) (Topp et al., 2015). Smoking was evaluated as currently smoking or not. Alcohol consumption was also classified into never, light, and heavy drinkers by ethanol units. Hypertension was defined as having a hypertension history, systolic BP (SBP) ≥ 140 mmHg or diastolic BP (DBP) ≥ 90 mmHg, or antihypertensive drug use (Shimamoto et al., 2014). Diabetes was defined as having a diabetic history, a fasting plasma glucose concentration of ≥126 mg/dL, a casual plasma glucose concentration of ≥200 mg/dL, HbA1c ≥ 6.5%, or antidiabetic drug use (Haneda et al., 2018). Histories of stroke, heart disease, and joint disease were based on yes/no responses in the surveys.

Statistical Analysis

Descriptive data are summarized as means ± standard deviations (SDs) for quantitative variables and as counts and percentages (%) for categorical variables. Student's t-test for quantitative variables and chi-square tests for categorical variables were performed to compare within and between age groups based on the presence or absence of frailty. To investigate the association between sleep status and frailty between age groups, we conducted a logistic regression analysis to obtain odds ratios (ORs) and 95% confidence intervals (CI) for subjects stratified by age group (70s / 80s). Sleep medication use and sleep duration were individually (model 1) and simultaneously (model 2) inputted as independent variables to the adjusted model. In model 3, sleep quality was inputted as an independent variable to the adjusted model, in which sleep medication use and sleep duration were not adjusted because PSQI global score includes components of sleep medication use and sleep duration. All models (model 1, model 2, and model 3) were adjusted for sex, BMI, education, cognitive function, mental health, lifestyle habits, hypertension, and diabetes, as well as histories of stroke, heart disease, and joint disease.

Furthermore, we performed additional analysis to examine the association between sleep status and frailty using the information on sleep medication obtained from the medication record book. In addition, we also separately analyzed benzodiazepines and nonbenzodiazepines among sleep medications. All statistical analyses were performed with SPSS Statistics 25 (IBM Japan, Tokyo, Japan).

Results

Characteristics of the Study Population Aged in Their 70s and 80s

The characteristics of the participants aged in their 70s and 80s are shown in Table 1. The prevalence of frailty in all participants was 19.7%, with that in the 80s was significantly higher than that in the 70s (29.2%vs. 14.6%, respectively). The prevalence of poor sleep quality (PSQI ≥ 6) in all participants was 42.1%, with no difference between age groups. Sleep duration in all participants was classified as <6 hr (13.4%) and >8 hr (12.5%), with those in their 80s showing a rate of a long sleep duration than in those in their 70s (22.0%vs. 7.3%, respectively). Sleep medication use (≥3 times per week) in all participants was 14.0%, with those in their 80s being significantly more likely to use this than those in their 70s (18.4%vs. 11.6%, respectively).

Sleep Characteristics of Participants With or Without Frailty Between Those in Their 70s and 80s

Table 2 shows the sleep characteristics of participants with or without frailty by age group. In subjects in

Table 1. Characteristics of Study Population Aged in Their 70s and 80s.

	All participants ($n=866$)	70s ($n=561$)	80s ($n=305$)	p-Value
Physical frailty	171 (19.7)	82 (14.6)	89 (29.2)	<.001
Sex Female	440 (50.8)	294 (52.4)	146 (47.9)	.202
BMI	22.9 ± 2.9	23.1 ± 3.0	22.5 ± 2.7	.013
Education (≥10 years)	670 (77.4)	446 (79.5)	224 (73.4)	.042
MCI	624 (72.1)	379 (67.6)	245 (80.3)	<.001
Well-Being Index (WHO-5) Low	179 (20.7)	111 (19.8)	68 (22.3)	.384
Current smoking	58 (6.7)	50 (8.9)	8 (2.6)	<.001
Alcohol intake				.002
No	503 (58.1)	308 (54.9)	195 (63.9)	
Moderate	319 (36.8)	215 (38.3)	104 (34.1)	
Ex-drinker	44 (5.1)	38 (6.8)	6 (2.0)	
Hypertension	650 (75.1)	393 (70.1)	257 (84.3)	<.001
Diabetes	140 (16.2)	94 (16.8)	46 (15.1)	.523
History of stroke	56 (6.5)	37 (6.6)	19 (6.2)	.834
Heart disease	121 (14.0)	79 (14.1)	42 (13.8)	.899
Joint disease	311 (35.9)	202 (36.0)	109 (35.7)	.937
Sleep medication use				.044
None	689 (79.6)	461 (82.2)	228 (74.8)	
Less than once per week	23 (2.7)	15 (2.7)	8 (2.6)	
1–2 times per week	33 (3.8)	20 (3.6)	13 (4.3)	
3 or more times per week	121 (14.0)	65 (11.6)	56 (18.4)	
Sleep duration				<.001
Short	116 (13.4)	83 (14.8)	33 (10.8)	
Normal	642 (74.1)	437 (77.9)	205 (67.2)	
Long	108 (12.5)	41 (7.3)	67 (22.0)	
Sleep quality, poor	365 (42.1)	236 (42.1)	129 (42.3)	.948

Note. 70s, aged 75 to 78 years; 80s, aged 85 to 87 years.
Categorical variables are expressed as numbers (%) and continuous variables are shown as mean ± standard deviation. The WHO-5 is the World Health Organization-5, which is a short self-reported measure of current mental well-being. To compare the two groups, Student's *t*-test for continuous variables and chi square test for categorical variables were used. BMI = body mass index; MCI = mild cognitive impairment; PSQI = the Pittsburgh Sleep Quality Index.

Table 2. Sleep Characteristics of Older Japanese According to Frailty Status Within Each Age Group.

	70s ($n=561$)			80s ($n=305$)		
	Non-frail	Frail	p-Value	Non-frail	Frail	p-Value
Sleep medication use			<.001			.323
None	408 (85.2)	53 (64.6)		167 (77.3)	61 (68.5)	
Less than once per week	11 (2.3)	4 (4.9)		4 (1.9)	4 (4.5)	
1–2 times per week	17 (3.5)	3 (3.7)		8 (3.7)	5 (5.6)	
3 or more times per week	43 (9.0)	22 (26.8)		37 (17.1)	19 (21.3)	
Sleep duration			.161			.883
Short	70 (14.6)	13 (15.9)		23 (10.6)	10 (11.2)	
Normal	378 (78.9)	59 (72.0)		147 (68.1)	58 (65.2)	
Long	31 (6.5)	10 (12.2)		46 (21.3)	21 (23.6)	
Sleep quality, poor	190 (39.7)	46 (56.1)	.005	80 (37.0)	49 (55.1)	.004

Note. 70s, aged 75 to 78 years; 80s, aged 85 to 87 years. Categorical variables are expressed as numbers (%) and continuous variables are shown as mean ± standard deviation. To compare the two groups, Student's *t*-test for continuous variables and chi square test for categorical variables were used.

their 70s, those with frailty had a significantly higher prevalence of sleeping medication use and poor sleep quality than those without frailty. In participants in their 80s, those with frailty had a significantly higher prevalence of poor sleep quality than those without frailty.

Table 3. Associations between sleep medication, sleep duration, sleep quality, and frailty by logistic regression analysis within each age group.

	70s ($n=561$)			80s ($n=305$)		
	Adjusted odds ratio (95% CI)			Adjusted odds ratio (95% CI)		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Sleep medication use (per 1 point)	1.45 [1.18, 1.77]*	1.48 [1.21, 1.82]*		1.14 [0.91, 1.42]	1.17 [0.93, 1.47]	
Sleep duration (ref: normal)						
Short	0.96 [0.48, 1.91]	0.86 [0.42, 1.74]		1.08 [0.46, 2.56]	1.11 [0.47, 2.62]	
Long	2.21 [0.98, 4.98]	2.45 [1.07, 5.60]*		1.37 [0.70, 2.66]	1.51 [0.76, 3.00]	
Sleep quality, poor (ref: not poor)			1.63 [0.97–2.72]			1.78 [1.02, 3.11]*

Note. 70s, aged 75 to 78 years; 80s, aged 85 to 87 years. Model 1: Sleep medication and Sleep duration were individually inputted as independent variables to the adjusted model. Model 2: Sleep medication and Sleep duration were simultaneously inputted as independent variables to the adjusted model. Model 3: Sleep quality was inputted as an independent variable to the adjusted model. CI = confidence interval; Ref. = reference; All models were adjusted for sex, BMI, education, cognitive function, mental health, lifestyle habits (smoking and drinking), hypertension, and diabetes, as well as histories of stroke, heart disease, and joint disease.
*$p < .05$.

Associations of Sleep Status With Frailty Aged in 70s and 80s

Table 3 shows the results of analysis of the associations of sleep with frailty by age group. In the 70s, sleep medication use ($OR=1.45$, 95% CI [1.18, 1.77]) was independently associated with frailty (Model 1), sleep medication use ($OR=1.48$, 95% CI [1.21, 1.82]) and long sleep duration ($OR=2.45$, 95% CI [1.07, 5.60]) were independently associated with frailty (Model 2), and sleep quality was not associated with frailty (Model 3). In those in their 80s, sleep medication use and sleep duration were not associated with frailty (Model 1 or 2), and poor sleep quality ($OR=1.78$, 95% CI [1.02, 3.11]) was independently associated with frailty (Model 3).

Furthermore, when we examined the association between sleep status and frailty using information obtained from the medication record book, similar trends were observed in the results using information obtained on sleep medication use from PSQI (Supplemental Table 1). In addition, benzodiazepine use was independently associated with frailty in those in their 70s ($OR=2.63$, 95% CI [1.29, 5.34], while nonbenzodiazepine use was not associated with frailty ($OR=2.60$, 95% CI [0.83, 8.13]) (Supplemental Table 1).

Discussion

The present study aimed to investigate whether the association with sleep status such as sleep duration and sleep quality and frailty was different between those in their 70s and 80s among community-dwelling older Japanese adults. We found that the association between sleep status and frailty was different between the age groups, revealing that sleep medication use and long sleep duration were significantly correlated with frailty in those in their 70s, and poor sleep quality was significantly correlated with frailty in those in their 80s even after controlling for sex, BMI, education, cognitive function, mental health, lifestyle habits, hypertension, and diabetes, as well as histories of stroke, heart disease, and joint disease.

In those in their 70s, sleep medication use was independently associated with frailty ($OR=1.48$, 95% CI [1.21, 1.82]). Previous studies reported associations between sleep medication use and an increased risk of frailty (Arias-Fernández et al., 2021; Cil et al., 2019; Gomez et al., 2022). Another study of older adults also reported an association between sleep medication use and each component of frailty, such as decreased grip strength (Nurminen et al., 2014), decreased physical activity (Liu & Yang, 2020), and fatigue (Endeshaw, 2015), which was consistent with our results. The mechanism linking sleep medication use with frailty was expected to be mainly caused by inactivity after taking drugs because there were some previous reports that sleep medication use was associated with decreased participation in physical activity (Liu & Yang, 2020) and persistent fatigue that limits activity (Endeshaw, 2015). Moreover, benzodiazepines, different from nonbenzodiazepines, have muscle-relaxant effects due to inhibition of the central nervous system (Sigel & Ernst, 2018) and were reported to be associated with decreased grip strength (Nurminen et al., 2014). Hence, sleep medication use may lead to inactivity and muscle weakness, resulting in frailty. Another possibility is that sleep medication use may be a marker for sleep disturbance associated with subclinical Alzheimer's or Parkinson's pathology (Bhat et al., 2018; Hanke et al., 2022), which are associated with increased risk of frailty.

Additionally, long sleep duration was independently associated with frailty in those in their 70s ($OR=2.45$, 95% CI [1.07, 5.60]). A previous study reported that both long sleep duration (≥9 hr) ($OR=2.39$, 95% CI

[1.90, 3.00]) and short sleep duration (≤6 hr) (*OR* = 1.53, 95% CI [1.26, 1.87]) were associated with physical frailty in a Japanese cohort study with a mean age of 73.6 years, with long sleep duration showing a greater odds ratio than short sleep duration (Nakakubo et al., 2018). The present study showed no association between short sleep duration and frailty but showed an association with long sleep duration. The association between sleep duration and frailty remains controversial because some reports suggested that both short and long sleep durations were associated with frailty (Moreno-Tamayo et al., 2021), while others reported that only long sleep duration was associated with frailty (Sun et al., 2020). Some reasons for these differences between the results may be that the assessment of sleep duration and age range differs among the studies. However, one previous study showed that only long sleep duration was associated with frailty, and short sleep duration (<6 hr) showed no such association (Kang et al., 2019). Moreover, a longitudinal study reported that long sleep duration was associated with the incidence of frailty (Chen et al., 2022). In addition, long sleep duration was reported to be associated with lower daytime physical activity (Morgan & Hartescu, 2019). The present study suggests that long sleep duration may be a useful indicator of the increased likelihood of frailty in the 70s. The mechanism linking long sleep duration with physical frailty is not clear, but long sleepers were reported to show elevated levels of inflammatory factors such as C-reactive protein (CRP) and interleukin-6 (IL-6) (Dowd et al., 2011), suggesting that these inflammatory factors were associated with physical frailty (Soysal et al., 2016). The inflammation induced by long sleep may thus alter metabolic pathways, such as increasing muscle breakdown, leading to loss of muscle mass and strength and resulting in frailty (Clegg et al., 2013).

A possible reason why sleep quality was not associated with frailty in the 70s could be as follows. Previous studies showed a strong effect of age in the association between sleep quality and frailty, especially after age 80, where the proportion of frailty was higher among those with poor sleep quality (Del Brutto et al., 2016). This result may explain why there was no association between sleep quality and frailty in the 70s. Therefore, our findings suggested that sleep medication use and long sleep duration should be carefully managed to prevent frailty in the 70s and that non-pharmacological therapies, such as physical activity and exercise, and evaluation of sleep quantity should be taken into account.

Meanwhile, in those in their 80s, poor sleep quality was independently associated with frailty (*OR* = 1.78, 95% CI [1.02, 3.11]). A previous study of subjects over 80 years old reported that poor sleep quality assessed by PSQI was associated with frailty (Çavuşoğlu et al., 2021), which was consistent with our results. Another study reported that sleep duration was not associated with frailty but with sleep quality (Arias-Fernández et al., 2021). In addition, associations between individual measures of sleep quality, such as decreased sleep efficiency and prolonged sleep latency, and the incidence of frailty were reported (Ensrud et al., 2009).

A possible reason why only sleep quality was associated with frailty in the 80s could be as follows. First, previous studies showed a strong effect of age in the association between sleep quality and frailty, especially after age 80 (Del Brutto et al., 2016). It was also reported that sleep structure changes with aging, such as changes in sleep duration, increased waking after sleep onset, increased sleep latency, and increased sleep medication use (Doi et al., 2001, 2005; Gao et al., 2021; Nakakubo et al., 2022; Ohayon et al., 2004). In the present study, sleep medication use and percentage of long sleep duration were higher in the 80s than in the 70s group, which was consistent with previous studies (Doi et al., 2005; Nakakubo et al., 2022). Since sleep medication use to cope with sleep problems and longer sleep duration became more common in those in their 80s, sleep quality evaluated from multidimensional perspectives, including sleep medication use, may be associated with frailty. Also, since the decline in physical function and muscle strength, which are components of frailty, has been reported to be strongly influenced by age (Lauretani et al., 2003), it is possible that the effects of age, rather than the sleep medication use alone, may be associated with frailty in the 80s.

The mechanism linking poor sleep quality with frailty was also suggested to be related to increased levels of inflammatory factors (Irwin et al., 2016). Poor sleep quality, as well as long sleep duration, have been reported to be associated with inflammation. Since long sleep duration generally increases in the 80s than in the 70s (Nakakubo et al., 2022), poor sleep quality, rather than long sleep duration, may lead to increased levels of inflammation factors in the 80s.

Therefore, our results suggest that sleep assessment should be conducted from not only one aspect of sleep but also a multidimensional aspect of sleep, such as overall sleep quality, to prevent frailty in the 80s, and that sleep intervention, such as sleep hygiene education, should be taken into account.

A strength of this study is that we used a narrow age range of subjects and identified the association between sleep status and frailty among two age groups in their 70s and 80s, including the super-aged 85 years or older. We also used a reliable and valid PSQI questionnaire to assess sleep status. On the other hand, a limitation of this study was that we could not elucidate the causal relationship due to the cross-sectional nature of the study. In addition, we conducted a subjective sleep assessment using a questionnaire. In the future, we should conduct objective sleep assessments such as actigraphy and clarify the association between sleep status and frailty by a longitudinal study.

Conclusion

The association between sleep status and frailty was different between age groups. The findings underscore the importance of incorporating the evaluation of sleep quantity and non-pharmacological therapies, such as physical activity and exercise, in those in their 70s and the evaluation of sleep quality and sleep interventions, such as guidance for good sleep, in their 80s to help prevent the onset of frailty.

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Supplemental Material

Supplemental material for this article is available online.

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