

Sleep Quality as an Independent Marker of Prefrailty Among Community-Dwelling Older Adults: Beyond Conventional Physical Performance Measures

Yahiko Takeuchi

ytakeuchi@jiu.ac.jp

Josai International University

Kazumasa Yamane

Josai International University

Ayako Ninomiya

Josai International University

Akane Maruyama

Josai International University

Hironori Ohsugi

Josai International University

Taizan Fukaya

Josai International University

Hidetoshi Nakao

Josai International University

Satomi Kaneya

Research Article

Keywords: Prefrailty, Sleep quality, Pittsburgh Sleep Quality Index, Community-dwelling older adults, Frailty prevention

Posted Date: August 10th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10340173/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.
[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Prefrailty is a transitional, potentially reversible stage between robustness and frailty. Identifying modifiable factors associated with prefrailty is critical for frailty prevention. Although sleep disturbances are associated with frailty, evidence linking subjective sleep quality to prefrailty remains limited, particularly among community-dwelling older adults.

Objective

To determine whether subjective sleep quality is independently associated with prefrailty among community-dwelling older adults.

Methods

This cross-sectional study included 110 community-dwelling older adults aged ≥ 65 years who participated in a community-based physical fitness assessment program. Frailty status was assessed using the revised Japanese Cardiovascular Health Study (J-CHS) criteria. Two participants classified as frail were excluded because of the small sample size. The remaining participants were classified as robust ($n = 70$) or prefrail ($n = 40$). Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI). Physical, respiratory, and cognitive function were also evaluated. Binary logistic regression analysis identified factors independently associated with prefrailty.

Results

The prevalence of prefrailty was 36.4%. The mean PSQI score was 7.96 ± 2.29 points, and 86.4% of participants exceeded the cutoff for poor sleep quality. In binary logistic regression analysis, PSQI score was the only factor independently associated with prefrailty (odds ratio [OR] = 1.38, 95% confidence interval [CI]: 1.10–1.72, $p = 0.005$). Each one-point increase in PSQI score increased the odds of prefrailty by 37.7%. Age, cognitive function, muscle strength, gait speed, balance ability, skeletal muscle mass, and respiratory function were not significantly associated with prefrailty. These findings suggest that subjective sleep quality may identify vulnerability before measurable declines in physical performance.

Conclusions

Poor subjective sleep quality was independently associated with prefrailty among community-dwelling older adults. Sleep quality may represent an early, modifiable marker of vulnerability preceding

measurable declines in physical performance. Incorporating sleep assessment into community-based screening programs may improve early identification of older adults at risk of frailty progression.

Introduction

Population aging is accelerating worldwide, making the extension of healthy life expectancy a major public health priority. Frailty is a geriatric syndrome characterized by reduced physiological reserve and increased vulnerability to stressors, leading to higher risks of falls, disability, hospitalization, institutionalization, and mortality.^{1–4} The frailty phenotype proposed by Fried et al. includes unintentional weight loss, muscle weakness, exhaustion, slow gait speed, and low physical activity.¹

Attention has recently shifted to prefrailty, an intermediate state between robustness and frailty.^{5–9} Prefrailty is clinically important because it is potentially reversible. Longitudinal studies have shown that individuals with prefrailty are more likely to progress to frailty and disability, whereas appropriate interventions may restore robust status.^{7–9} Therefore, identifying modifiable factors associated with prefrailty is a key strategy for promoting healthy aging and preventing frailty.^{9,10}

Physical function is central to frailty assessment. Reduced gait speed, impaired balance, and decreased muscle strength are consistently associated with frailty and adverse health outcomes.^{11,12} Consequently, physical performance measures are widely used in community screening and rehabilitation.

Frailty is influenced not only by physical function but also by behavioral and lifestyle factors. Sleep has emerged as an important determinant of healthy aging. Sleep disturbances are common among older adults and include difficulty initiating sleep, fragmented sleep, reduced sleep efficiency, and daytime dysfunction.^{13,14} Poor sleep quality has been associated with reduced mobility, impaired physical performance, cognitive decline, depression, and chronic inflammation.^{15–21}

Several epidemiological studies have reported associations between sleep disturbances and frailty. Goldman et al. demonstrated that poor sleep quality was associated with poorer physical performance and functional limitations among older female adults.¹⁵ Ensrud et al. reported that sleep disturbances were independently associated with frailty among community-dwelling older adults.¹⁶ Systematic reviews have likewise shown consistent associations between sleep disturbances and frailty-related outcomes.¹⁸

Potential mechanisms linking sleep disturbances and frailty include chronic low-grade inflammation, endocrine dysregulation, impaired muscle recovery, reduced physical activity, and psychological distress.^{20–22} These mechanisms may increase physiological vulnerability before overt frailty develops.

Despite growing evidence linking sleep and frailty, relatively few studies have focused on prefrailty, particularly among Japanese community-dwelling older adults. Moreover, whether sleep quality is independently associated with prefrailty after accounting for physical, respiratory, and cognitive function remains unclear.

Therefore, this study aimed to investigate the association between subjective sleep quality and prefrailty among community-dwelling older adults. It was hypothesized that poor sleep quality would be independently associated with prefrailty after adjustment for conventional physical performance measures and cognitive function.

Methods

Study Design

This cross-sectional study was conducted during a community-based health promotion event jointly organized by a local municipality and a university.

The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Participants

A total of 112 community-dwelling older adults aged ≥ 65 years voluntarily participated.

Inclusion criteria were:

- age ≥ 65 years
- independent community living
- ability to complete all assessments

Frailty status was assessed using the revised Japanese Cardiovascular Health Study (J-CHS) criteria.

Because only two participants met the criteria for frailty, they were excluded from inferential analyses. The participant selection process is illustrated in Figure 1.

The final sample included:

- Robust: $n = 70$
- Prefrail: $n = 40$

Total analyzed: $n = 110$

The study protocol was approved by the Ethics Committee of Josai International University (Approval No. 14N230013).

Written informed consent was obtained from all participants.

Frailty Assessment

Frailty status was assessed using the revised Japanese Cardiovascular Health Study criteria developed by Satake et al.^{5,6}

The following components were evaluated:

1. Weight loss
2. Weakness
3. Exhaustion
4. Slow gait speed
5. Low physical activity

Participants were classified as:

- Robust (0 criteria)
- Prefrail (1–2 criteria)
- Frail (≥ 3 criteria)

Sleep Quality Assessment

Sleep quality was evaluated using the Japanese version of the Pittsburgh Sleep Quality Index (PSQI-J).^{13,14}

The PSQI includes seven domains:

- Subjective sleep quality
- Sleep latency
- Sleep duration
- Habitual sleep efficiency
- Sleep disturbances
- Sleeping medication use
- Daytime dysfunction

Higher scores indicate poorer sleep quality. Participants with a PSQI-J score >5.0 were classified as having poor sleep quality.

Physical Function Assessment

The following physical function measures were obtained:

- Grip strength (kg)
- Usual gait speed (m/s)
- One-leg standing time (s)

- Skeletal muscle mass (kg)
- Toe-grip strength (kg)

Respiratory Function Assessment

Respiratory function was assessed using spirometry:

- Percent predicted forced vital capacity (%FVC)
- Forced expiratory volume in one second ratio (FEV1/FVC)

Cognitive Function Assessment

Cognitive function was assessed using the Japanese version of the Montreal Cognitive Assessment (MoCA-J).^{24, 25}

Statistical Analysis

Descriptive statistics were calculated for all variables.

Group comparisons between robust and prefrail participants were performed using independent t-tests. Independent variables for logistic regression were selected based on previous evidence on frailty-related physical, respiratory, cognitive, and sleep-related factors.

Binary logistic regression was performed to identify factors independently associated with prefrailty.

Dependent variable:

- Robust = 0
- Prefrail = 1

Independent variables:

- Age
- MoCA-J
- Grip strength
- Gait speed
- One-leg standing time
- Skeletal muscle mass
- Toe-grip strength
- %FVC
- FEV1/FVC
- PSQI score

Statistical significance was set at $p < 0.05$.

Results

Participant Characteristics

The final analytic sample included 110 participants (85 female and 25 male) with a mean age of 75.4 ± 5.3 years.

Among the participants:

- Robust: 70 (63.6%)
- Prefrail: 40 (36.4%)

The mean PSQI score was 8.0 ± 2.2 points. Overall, 95 participants (86.4%) exceeded the PSQI cutoff for poor sleep quality.

Comparison Between Robust and Prefrail Participants

Table 1 summarizes participant characteristics by frailty status. Prefrail participants had significantly higher PSQI scores than robust participants (Figure 2). No statistically significant differences were observed in age, cognitive function, grip strength, gait speed, one-leg standing time, skeletal muscle mass, toe-grip strength, or respiratory function.

Table 1. Participant Characteristics According to Frailty Status

Variable	Robust (n = 70)	Prefrail (n = 40)	p value
Age (years)	74.99 ± 5.32	76.20 ± 5.34	0.25
MoCA-J score (points)	24.17 ± 2.91	23.55 ± 3.28	0.31
Grip strength (kg)	26.64 ± 6.11	26.01 ± 8.35	0.66
Usual gait speed (m/s)	1.45 ± 0.21	1.37 ± 0.25	0.07
One-leg standing time (s)	41.15 ± 21.60	34.33 ± 21.05	0.10
Skeletal muscle mass (kg)	30.90 ± 15.57	29.77 ± 11.26	0.68
Toe-grip strength (kg)	11.29 ± 4.68	10.30 ± 5.22	0.31
Predicted FVC (%)	90.86 ± 24.08	88.03 ± 31.20	0.60
FEV1/FVC (%)	79.64 ± 6.46	80.53 ± 10.06	0.58
PSQI score (points)	7.51 ± 1.99	8.73 ± 2.41	<0.01

Data are presented as mean $\pm$ standard deviation.

Group differences were analyzed using independent t-tests. Statistical significance was set at $p < 0.05$.

Abbreviations: MoCA-J, Japanese version of the Montreal Cognitive Assessment; FVC, forced vital capacity; FEV1, forced expiratory volume in one second; PSQI, Pittsburgh Sleep Quality Index.

Logistic Regression Analysis

Binary logistic regression identified factors independently associated with prefrailty (Table 2). Among all explanatory variables, only the PSQI score remained significantly associated with prefrailty. As shown in Table 2, each 1-point increase in PSQI score increased the odds of prefrailty by 37.7%. The model explained 17.6% of the variance in prefrailty (Nagelkerke $R^2 = 0.176$) and correctly classified 70.0% of participants.

Table 2. Binary logistic regression analysis for factors associated with prefrailty

Variable	β	OR	95% CI	p value
Age (years)	-0.021	0.98	0.89–1.08	0.682
MoCA-J score (points)	-0.036	0.96	0.82–1.13	0.664
Grip strength (kg)	-0.009	0.99	0.92–1.07	0.814
Usual gait speed (m/s)	-1.274	0.28	0.03–2.30	0.236
One-leg standing time (s)	-0.018	0.98	0.96–1.01	0.142
Skeletal muscle mass (kg)	-0.012	0.99	0.96–1.02	0.437
Toe-grip strength (kg)	0.019	1.02	0.91–1.14	0.746
Predicted FVC (%)	-0.007	0.99	0.98–1.01	0.428
FEV1/FVC (%)	0.017	1.02	0.96–1.08	0.559
PSQI score (points)	0.320	1.38	1.10–1.72	0.005

Model statistics: $-2 \text{ Log Likelihood} = 129.03$; Nagelkerke $R^2 = 0.176$; Classification accuracy = 70.0%.

Abbreviations: OR, odds ratio; CI, confidence interval; MoCA-J, Japanese version of the Montreal Cognitive Assessment; FVC, forced vital capacity; FEV1, forced expiratory volume in one second; PSQI, Pittsburgh Sleep Quality Index.

Statistical significance was set at $p < 0.05$. Significant associations are shown in **bold**.

Discussion

The principal finding of this study was that poor subjective sleep quality was independently associated with prefrailty among community-dwelling older adults. After adjustment for age, physical function,

respiratory function, and cognitive function, the PSQI score remained the only significant explanatory variable. Each 1-point increase in the PSQI score increased the odds of prefrailty by 37.7%. These findings suggest that sleep quality may be an early, modifiable marker of vulnerability before measurable declines in physical performance occur.

Importance of Focusing on Prefrailty

A major strength of this study is its focus on prefrailty rather than established frailty. Recent frailty research has increasingly emphasized prevention and early intervention instead of treatment after frailty develops.⁷⁻¹⁰ Prefrailty is an intermediate state between robustness and frailty, characterized by reduced physiological reserve without overt disability.^{7,8} Longitudinal studies have shown that older adults with prefrailty are at greater risk of progressing to frailty, disability, hospitalization, and mortality than robust individuals.^{7,8} However, transitions from prefrailty to robustness have also been reported, indicating that prefrailty is potentially reversible.⁷

Only two participants met the criteria for frailty, precluding meaningful statistical analysis. Nevertheless, this finding reflects the relatively healthy study population. Importantly, more than one-third of participants were classified as prefrail, indicating that many apparently healthy, independent older adults may already exhibit early physiological vulnerability.

From a public health perspective, identifying risk factors for prefrailty may be more beneficial than identifying those associated with established frailty. Once frailty develops, declines in physical and physiological function are often accompanied by chronic disease, disability, and reduced responsiveness to intervention.^{2,9} In contrast, interventions during the prefrail stage may delay or prevent progression to frailty and reduce future health care burden.^{9,10}

Sleep Quality as a Modifiable Risk Factor

The present findings suggest that sleep quality may be an important modifiable factor associated with prefrailty. Unlike age, sex, or genetic predisposition, sleep quality may be improved through behavioral modification, environmental changes, exercise, and medical treatment.²⁷⁻²⁹ Because Japan is one of the world's most rapidly aging societies, identifying modifiable risk factors for prefrailty has substantial public health importance.

Sleep is essential for maintaining physiological homeostasis. During sleep, restorative processes occur, including hormonal regulation, tissue repair, immune modulation, and memory consolidation.^{20,21} Chronic sleep disturbance may impair these processes, reducing physical and cognitive reserve. Consequently, poor sleep quality may serve not only as a marker of vulnerability but also as a contributor to prefrailty.

These findings are consistent with previous studies linking sleep disturbances to frailty-related outcomes. Goldman et al. reported that poor sleep quality was associated with lower physical performance and greater functional limitations among older female adults.¹⁵ Ensrud et al. demonstrated

that sleep disturbances were independently associated with frailty among community-dwelling older adults.¹⁶ Similarly, Wai and Yu concluded that sleep-wake disturbances are consistently associated with frailty and frailty-related outcomes.¹⁸

This study extends previous findings in two ways. First, it focused specifically on prefrailty rather than frailty. Second, sleep quality remained independently associated with prefrailty after adjustment for physical, respiratory, and cognitive function, suggesting that it provides information beyond conventional frailty assessments.

Potential Mechanisms Linking Sleep Quality and Prefrailty

Several biological and behavioral mechanisms may explain the association between poor sleep quality and prefrailty.

First, sleep disturbance has been linked to chronic low-grade inflammation. Experimental and epidemiological studies have shown that poor sleep is associated with elevated inflammatory biomarkers, including interleukin-6, tumor necrosis factor- α , and C-reactive protein.^{20–21} Chronic inflammation is a key mechanism underlying frailty and age-related functional decline.²² Therefore, sleep disturbance may increase physiological vulnerability through inflammatory pathways.

Second, sleep plays a critical role in endocrine regulation. Reduced sleep duration and poor sleep quality have been associated with altered growth hormone secretion, cortisol regulation, insulin sensitivity, and glucose metabolism.²¹ These endocrine changes may impair muscle protein synthesis and accelerate age-related declines in muscle mass and physical function. Because muscle weakness and reduced physical activity are core components of frailty, endocrine dysregulation may link sleep disturbance to prefrailty.¹

Third, poor sleep quality may reduce participation in physical activity. Older adults with poor sleep often experience daytime fatigue, reduced motivation, and decreased social engagement.^{15–17} Reduced physical activity may subsequently decrease muscle strength, mobility, and balance, increasing susceptibility to frailty progression.

Fourth, sleep disturbance is closely associated with depression, anxiety, and perceived stress. Meta-analyses have demonstrated strong associations between depressive symptoms and frailty.¹⁹ Because depression and sleep disturbances frequently coexist, future studies should examine whether psychological factors mediate the relationship between sleep quality and prefrailty.

Why Was Sleep Quality Significant While Physical Function Was Not?

An important finding was that physical function measures, including gait speed, one-leg standing time, and grip strength, were not independently associated with prefrailty in the multivariable model, whereas the PSQI score remained significant.

Statistically, this finding may reflect the relatively healthy study population. Participants voluntarily attended a community fitness assessment program and lived independently. Consequently, variability in physical performance may have been limited. Mean gait speed exceeded values commonly used to define mobility impairment, suggesting a possible ceiling effect. Under these conditions, conventional physical performance measures may have limited sensitivity for detecting subtle physiological vulnerability.

From an epidemiological perspective, prefrailty is heterogeneous. Individuals may be classified as prefrail based on different combinations of weight loss, exhaustion, weakness, slow gait speed, or low physical activity. Therefore, not all prefrail individuals exhibit measurable impairments in gait speed or balance, and individual physical performance tests may not fully capture the broader vulnerability represented by prefrailty.

In contrast, sleep quality may reflect multiple health domains simultaneously. Poor sleep is associated with fatigue, physical inactivity, chronic disease burden, pain, mood disorders, cognitive dysfunction, and inflammatory processes.^{18–21} Consequently, the PSQI may serve as an integrative indicator of early physiological and behavioral vulnerability rather than a sleep-specific measure. Sleep quality may capture multisystem dysregulation across physical, cognitive, psychological, and inflammatory domains, whereas individual performance measures assess only a single aspect of physiological function.

Furthermore, sleep disturbances may precede measurable declines in mobility, balance, or muscle strength. Therefore, sleep quality may identify individuals at risk of frailty progression earlier than conventional physical performance measures.

Clinical Implications for Physical Therapists

The present findings have important implications for physical therapists involved in community-based frailty prevention. Physical therapists traditionally emphasize assessments of gait speed, balance, muscle strength, and physical activity.^{11–12} Although these measures remain fundamental, the findings suggest that sleep quality should also be included in frailty screening.

The PSQI is inexpensive, noninvasive, and easy to administer in community settings.^{13–14} Incorporating sleep assessment into routine health screening may facilitate earlier identification of older adults at risk of progressing from robustness to prefrailty.

Sleep-focused interventions may also complement conventional exercise programs. Exercise improves both sleep quality and physical performance in older adults.²⁸ Therefore, combining exercise with sleep hygiene education may provide synergistic benefits for frailty prevention.

Implications for Community-Based Prevention Programs

The prevalence of poor sleep quality in this study was notably high. More than 80% of participants exceeded the PSQI cutoff despite being relatively healthy community-dwelling older adults. This

prevalence appears higher than that reported in previous Japanese studies.²⁶

One explanation is that subjective sleep disturbances are common even among older adults who remain independent and actively participate in community activities. If so, sleep disturbances may represent an underrecognized public health concern in aging communities.

Current community-based prevention programs typically emphasize exercise, nutrition, and social participation.^{9,10} Although these components remain essential, sleep health receives comparatively little attention. The present findings suggest that routine sleep screening could be incorporated into community health promotion programs as a practical component of frailty prevention.

Because sleep assessment is simple, inexpensive, and scalable, it may be a feasible strategy for identifying individuals who could benefit from preventive intervention before overt frailty develops.

Strengths and Limitations

This study has several strengths. First, participants were community-dwelling older adults, increasing the relevance of the findings to public health and preventive care. Second, frailty status was assessed using the revised J-CHS criteria, which are widely used in Japan. Third, physical function, respiratory function, cognitive function, and sleep quality were assessed simultaneously. A major strength is that sleep quality remained independently associated with prefrailty after adjustment for physical, respiratory, and cognitive variables.

Several limitations should be acknowledged. First, the cross-sectional design precludes causal inference. Second, sleep quality was assessed using a subjective questionnaire rather than objective measures. Third, the number of frail participants was too small to permit analysis of frailty as a separate outcome. Fourth, depressive symptoms, pain, medication use, and comorbidities were not fully evaluated. Finally, participants were volunteers in a community health promotion event and may have been healthier than the general older population.

Future Directions

Longitudinal studies are needed to determine whether poor sleep quality predicts progression from robustness to prefrailty and frailty. Objective sleep measures, such as actigraphy, should be incorporated alongside subjective questionnaires. Furthermore, analyses of individual PSQI components may identify which aspects of sleep are most strongly associated with prefrailty. Intervention studies are also warranted to determine whether improving sleep quality can prevent or reverse prefrailty among community-dwelling older adults. Recent longitudinal studies suggest that sleep disturbances may precede the onset of prefrailty and frailty. Therefore, prospective cohort studies are needed to clarify the causal relationship between sleep quality and frailty progression.

Conclusions

Poor subjective sleep quality was independently associated with prefrailty among community-dwelling older adults. After adjustment for physical, respiratory, and cognitive function, the PSQI score remained the only factor significantly associated with prefrailty, suggesting that sleep quality may reflect early vulnerability before measurable declines in physical performance.

These findings highlight the importance of targeting prefrailty as a potentially reversible stage of the frailty trajectory. Because sleep quality is modifiable, assessing sleep disturbances may provide a practical approach for identifying older adults at risk of future frailty progression.

From clinical and public health perspectives, frailty prevention strategies should consider sleep health in addition to conventional assessments of mobility, balance, and muscle strength. Given the high prevalence of sleep disturbances among relatively healthy older adults, sleep quality assessment may provide a simple, low-cost, and scalable strategy for community-based frailty prevention.

Declarations

Author Contributions

YT conceived and designed the study, collected the data, performed the statistical analyses, interpreted the results, and drafted the manuscript.

KY contributed to the study design, participated in data collection and data analysis, and contributed to the interpretation of the findings.

AN contributed to the study design, assisted with data collection and statistical analyses, and contributed to the interpretation of the findings.

AM contributed to the study design, assisted with data collection and statistical analyses, and contributed to the interpretation of the findings.

HO participated in data collection and contributed to data management.

TF participated in data collection and contributed to data management.

HN participated in data collection and contributed to data management.

SK supervised the study, provided methodological advice throughout the study, contributed to the interpretation of the findings, and critically revised the manuscript for important intellectual content.

All authors read and approved the final manuscript.

Funding

This work was supported by the President's Discretionary Research Fund of Josai International University and the Japan Society for the Promotion of Science (JSPS) KAKENHI (Grant Number

JP24K14427).

Ethics Approval and Consent to Participate

The study was approved by the Ethics Committee of Josai International University (Approval No. 14N230013). Written informed consent was obtained from all participants.

Consent for Publication

Not applicable.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability Statement

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

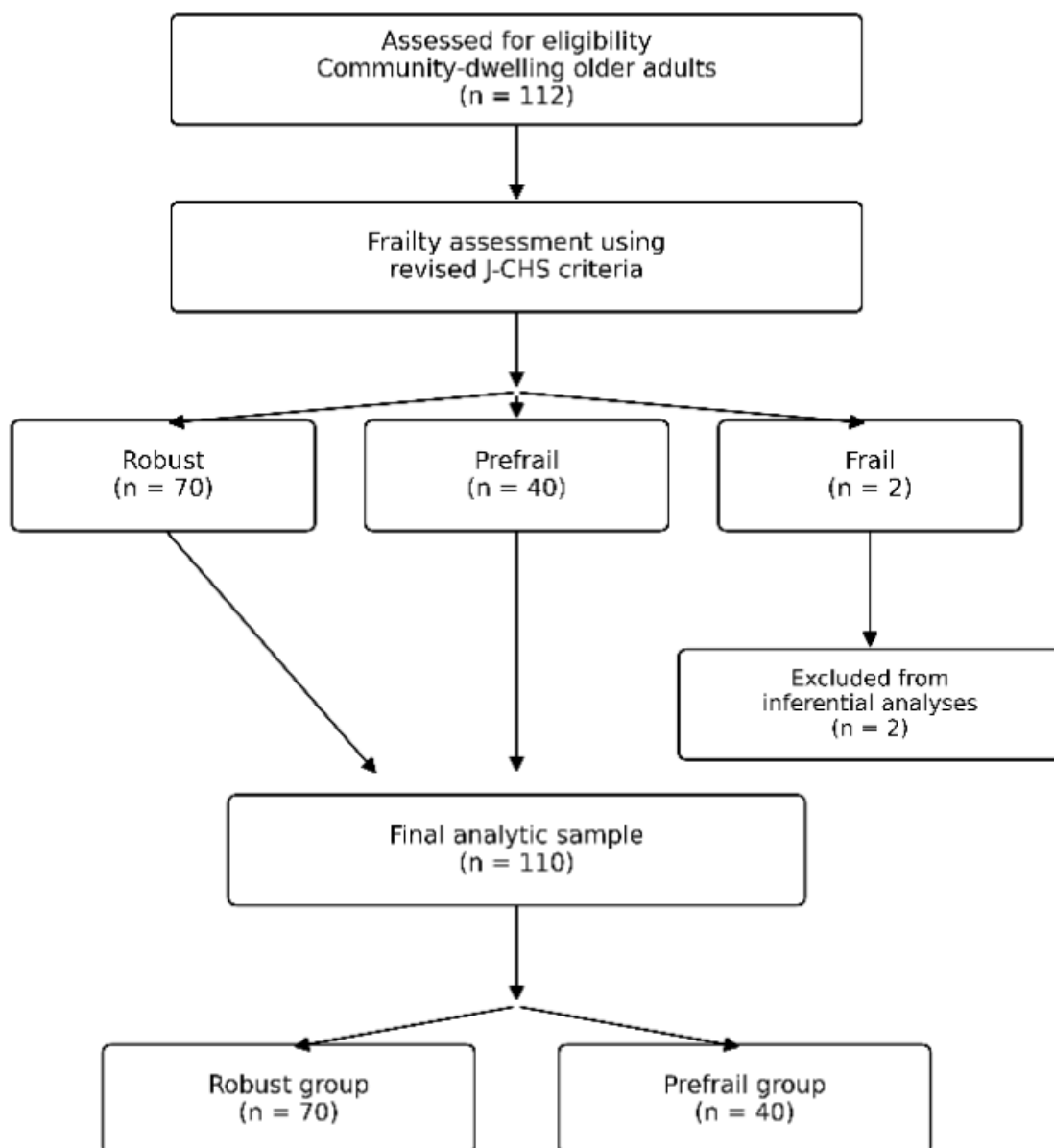
References

1. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J et al. Frailty in older adults: evidence for a phenotype. *J Gerontol Biol Sci Med Sci*. 2001;56(3).
2. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. *Lancet*. 2013;381(9868):752–62.
3. Vermeiren S, Vella-Azzopardi R, Beckwee D, Habbig AK, Scafoglieri A, Jansen B et al. Frailty and the prediction of negative health outcomes: a meta-analysis. *J Am Med Dir Assoc*. 2016;17(12):1163.e1-1163.e17.
4. Kojima G. Frailty as a predictor of future falls among community-dwelling older people: a systematic review and meta-analysis. *J Am Med Dir Assoc*. 2015;16(12):1027–33.
5. Satake S, Arai H. The revised Japanese version of the Cardiovascular Health Study criteria. *Geriatr Gerontol Int*. 2020;20(10):992–3.
6. Satake S, Shimada H, Yamada M, Kim H, Yoshida H, Gondo Y, et al. Prevalence of frailty among community-dwellers and outpatients in Japan as defined by the Japanese version of the Cardiovascular Health Study criteria. *Geriatr Gerontol Int*. 2017;17(12):2629–34.
7. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. *Arch Intern Med*. 2006;166(4):418–23.
8. Lang PO, Michel JP, Zekry D. Frailty syndrome: a transitional state in a dynamic process. *Gerontology*. 2009;55(5):539–49.
9. Dent E, Morley JE, Cruz-Jentoft AJ, Woodhouse L, Rodríguez-Mañas L, Fried LP, et al. Physical frailty: ICF SR international clinical practice guidelines for identification and management. *J Nutr Health*

- Aging. 2019;23(9):771–87.
10. Morley JE, Vellas B, van Kan GA, Anker SD, Bauer JM, Bernabei R, et al. Frailty consensus: a call to action. *J Am Med Dir Assoc*. 2013;14(6):392–7.
 11. Studenski S, Perera S, Patel K, Rosano C, Faulkner K, Inzitari M, et al. Gait speed and survival in older adults. *JAMA*. 2011;305(1):50–8.
 12. van Abellan G, Rolland Y, Andrieu S, Bauer J, Beauchet O, Bonnefoy M, et al. Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people. *J Nutr Health Aging*. 2009;13(10):881–9.
 13. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193–213.
 14. Doi Y, Minowa M, Uchiyama M, Okawa M, Kim K, Shibui K, et al. Psychometric assessment of subjective sleep quality using the Japanese version of the Pittsburgh Sleep Quality Index in psychiatric disordered and control subjects. *Psychiatry Res*. 2000;97(2–3):165–72.
 15. Goldman SE, Stone KL, Ancoli-Israel S, Blackwell T, Ewing SK, Boudreau R, et al. Poor sleep is associated with poorer physical performance and greater functional limitations in older women. *Sleep*. 2007;30(10):1317–24.
 16. Ensrud KE, Blackwell TL, Redline S, Ancoli-Israel S, Paudel ML, Cawthon PM, et al. Sleep disturbances and frailty status in older community-dwelling men. *J Am Geriatr Soc*. 2009;57(11):2085–93.
 17. Stenholm S, Kronholm E, Bandinelli S, Guralnik JM, Ferrucci L. Self-reported sleep duration and time in bed as predictors of physical function decline: results from the InCHIANTI study. *Sleep*. 2011;34(11):1583–93.
 18. Wai JL, Yu DSF. The relationship between sleep-wake disturbances and frailty among older adults: a systematic review. *J Adv Nurs*. 2020;76(1):96–108.
 19. Soysal P, Veronese N, Thompson T, Kahl KG, Fernandes BS, Prina AM, et al. Relationship between depression and frailty in older adults: a systematic review and meta-analysis. *Ageing Res Rev*. 2017;36:78–87.
 20. Irwin MR. Sleep and inflammation: partners in sickness and in health. *Nat Rev Immunol*. 2019;19(11):702–15.
 21. Besedovsky L, Lange T, Haack M. The sleep-immune crosstalk in health and disease. *Physiol Rev*. 2019;99(3):1325–80.
 22. Chen CY, Gan P, How CH. Approach to frailty in the elderly in primary care and the community. *Singap Med J*. 2018;59(5):240–5.
 23. Uchmanowicz I, Lee CS, Vitale C, Manulik S, Denfeld QE, Uchmanowicz B, et al. Frailty and the risk of all-cause mortality and hospitalization in chronic heart failure: a meta-analysis. *ESC Heart Fail*. 2020;7(6):3427–37.

24. Fujiwara Y, Suzuki H, Yasunaga M, Sugiyama M, Ijuin M, Sakuma N, et al. Brief screening tool for mild cognitive impairment in older Japanese: validation of the Japanese version of the Montreal Cognitive Assessment. *Geriatr Gerontol Int*. 2010;10(3):225–32.
25. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal Cognitive Assessment: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc*. 2005;53(4):695–9.
26. Kim K, Uchiyama M, Okawa M, Liu X, Ogihara R. An epidemiological study of insomnia among the Japanese general population. *Sleep*. 2000;23(1):41–7.
27. Morin CM, Benca R. Chronic insomnia. *Lancet*. 2012;379(9821):1129–41.
28. Reid KJ, Baron KG, Lu B, Naylor E, Wolfe L, Zee PC. Aerobic exercise improves self-reported sleep and quality of life in older adults with insomnia. *Sleep Med*. 2010;11(9):934–40.
29. Li J, Vitiello MV, Gooneratne NS. Sleep in normal aging. *Sleep Med Clin*. 2018;13(1):1–11.

Figures



J-CHS, Japanese version of the Cardiovascular Health Study criteria.

Figure 1

Participant flow diagram.

Flowchart illustrating participant recruitment, frailty classification using the J-CHS criteria, exclusion of frail participants (n = 2), and inclusion of robust (n = 70) and prefrail (n = 40) participants.

Comparison of PSQI scores by frailty status

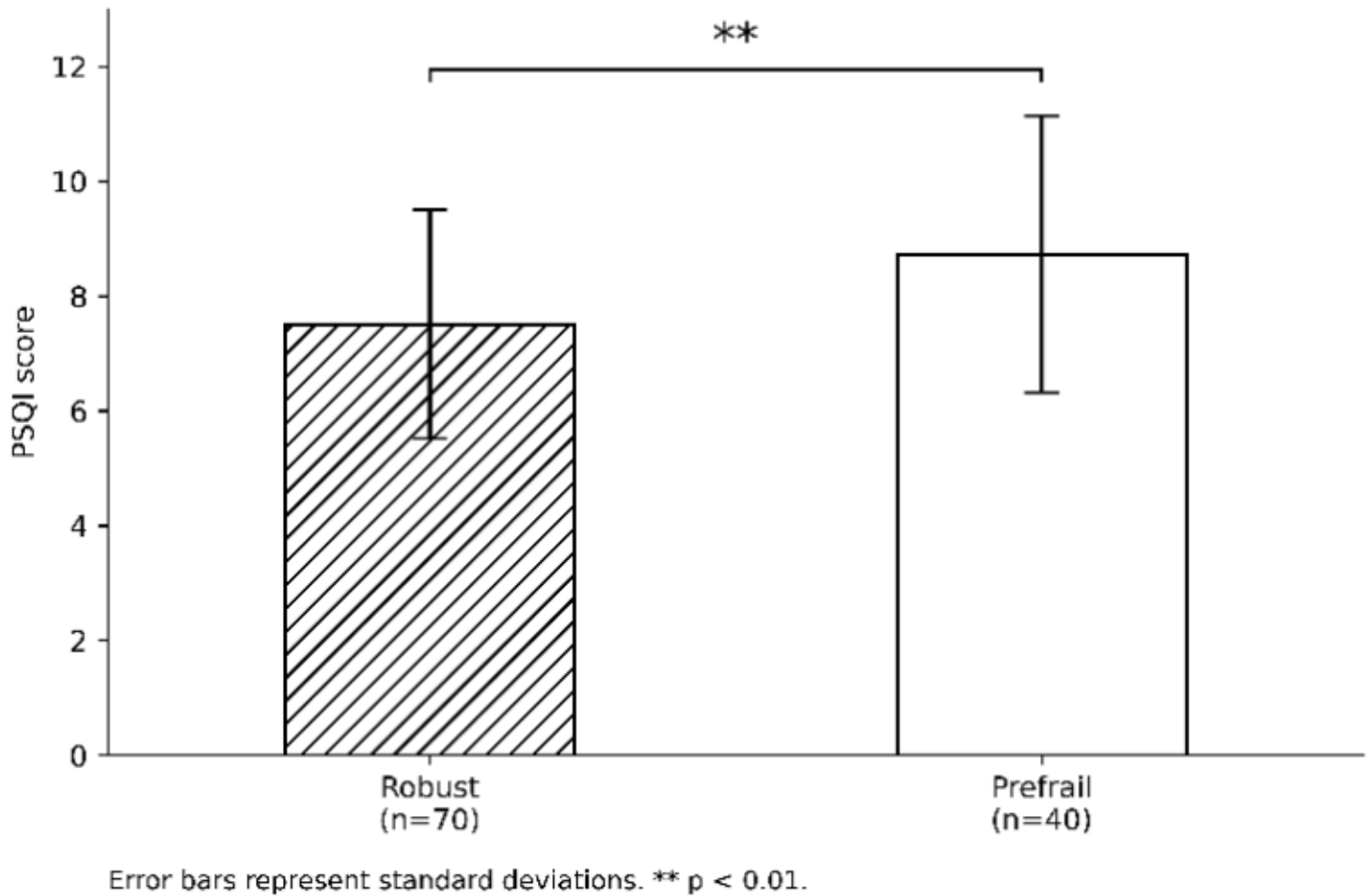


Figure 2

Comparison of Pittsburgh Sleep Quality Index (PSQI) scores between robust and prefrail participants.

Values are presented as mean $\pm$ standard deviation(SD). Prefrail participants had significantly higher PSQI scores than robust participants (8.73 ± 2.41 vs. 7.51 ± 1.99), indicating poorer subjective sleep quality. Error bars represent SD. **p < 0.01.