Research Square

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Coexistence of Sleep Disorders and Social Frailty is Associated with Slower Processing Speed Among Community-Dwelling Older Adults

Hiroya Honda
Kanagawa University of Human Services
Nanako Ishizaka
Fuchinobe General Hospital
Sakura Sasaki
Kanagawa University of Human Services
Tatsuya Hirase
hirase-rx7@kuhs.ac.jp
Kanagawa University of Human Services

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Abstract

Processing speed decline is an early indicator of cognitive aging. Although sleep disorders and social frailty are individually associated with cognitive decline and may be interrelated, their combined association with processing speed remains unclear. This cross-sectional study examined the association between the coexistence of sleep disorders and social frailty and slower processing speed among 320 community-dwelling adults aged ≥ 65 years. Sleep disorders were assessed using the Pittsburgh Sleep Quality Index, and social frailty was defined based on five criteria. Participants were categorized into four groups according to the presence or absence of each condition. Processing speed was assessed using the Digit Symbol Substitution Test. Multivariable logistic regression analysis was performed after adjusting for age, sex, body mass index, educational attainment, depression, malnutrition, and chronic pain. Participants with concurrent sleep disorders and social frailty had significantly higher odds of slower processing speed than those without either condition (odds ratio: 2.411, 95% confidence interval 1.013–5.738, p = 0.047). Neither sleep disorders nor social frailty alone was significantly associated with processing speed. The coexistence of sleep disorders and social frailty may help identify older adults at risk of slower processing speed and inform preventive strategies.

Introduction

As the global population continues to age, the prevention of cognitive decline in older adults has become a major public health challenge (Livingston et al. 2024). Processing speed is one of the cognitive functions most vulnerable to aging and has been recognized as a potential early marker of dementia because it is affected early in the course of cognitive aging (Rosano et al. 2016; Salthouse 1996). Moreover, a slower processing speed has been associated with an increased risk of falls and mortality among older adults (Davis et al. 2017; Iwasa et al. 2014). Therefore, modifiable risk factors must be identified for the early detection and prevention of processing speed decline.

Several factors, including cardiovascular disease, diabetes mellitus, and depression symptoms, are reportedly associated with processing speed decline in older adults (Gkotzamanis et al. 2021). Among such factors, sleep disorders and social frailty may warrant particular attention (Holanda and de Almondes 2016; Sakal et al. 2024; Tsutsumimoto et al. 2017). Both these factors are highly prevalent among older adults (Canever et al. 2024; Li et al. 2024), are readily assessed in community settings, and may be improved through appropriate interventions (Gen et al. 2025; Sella et al. 2023). Focusing on these factors may facilitate the early detection of processing speed decline and the development of preventive strategies among community-dwelling older adults.

A longitudinal study has suggested that a long sleep duration and excessive daytime sleepiness are associated with social frailty in community-dwelling older adults (Nakakubo et al. 2019). Additionally, social frailty, particularly not talking to someone every day, has been associated with poorer sleep quality in this population (Noguchi et al. 2021). Taken together, we hypothesize that the coexistence of sleep disorders and social frailty is more strongly associated with processing speed decline than either condition alone. If verified, it may assist with the early identification of community-dwelling older adults at risk of cognitive decline and inform the development of multifaceted prevention strategies. However, to our knowledge, no prior studies have been conducted to test this hypothesis among community-dwelling older adults. Therefore, in the present study, we aimed to specifically examine the association between the coexistence of sleep disorders and social frailty and a slower processing speed among community-dwelling older adults.

Methods

Participants and Study Design

In this cross-sectional study, we used data from a community-based health survey of adults aged 40 years and older living in two municipalities. The survey was conducted between February 2024 and December 2025. Participants were excluded if they: (1) did not provide informed consent; (2) were younger than 65 years; (3) had difficulty walking independently at home; (4) had a Mini–Mental State Examination score of 24 or lower; (5) were unable to communicate because of severe hearing impairment; or (6) had missing or outlying data. This study was approved by the relevant Institutional Review Board. All participants received written and verbal explanations of the study and provided written informed consent prior to participation.

Instruments

All assessments were conducted by a licensed physical therapist or research collaborator who had received standardized training in the measurement procedures from the principal investigator.

Basic Information and Confounding Factors

Data on participant characteristics, including age, sex, body mass index (BMI), educational attainment, depression, nutritional status, and chronic pain, were collected. Age, sex, educational attainment, height, and weight were assessed using a questionnaire; the BMI was calculated as weight (kg) divided by height squared (m^2). Depression was assessed using the 15-item Geriatric Depression Scale, with a score of ≥ 5 indicating depression (Nyunt et al. 2009). Malnutrition was assessed using the Mini Nutritional Assessment–Short Form, with a score of ≤ 11 indicating malnutrition (Kaiser et al. 2009). Chronic pain was defined as pain that persisted or recurred for more than 3 months (Treede et al. 2015) and was assessed using a self-administered questionnaire.

Exposure Factors: Sleep Disorders and Social Frailty

Sleep disorders were assessed using the Pittsburgh Sleep Quality Index (PSQI), a widely used self-report questionnaire for the evaluation of subjective sleep quality over the previous month. The PSQI consists of 19 items and generates a global score ranging from 0 to 21, with higher scores indicating poorer sleep quality. Based on previous studies, participants with a score of 6 or higher were classified as having sleep disorders (Doi et al. 2000).

Social frailty was assessed using the criteria proposed by Makizako et al. (2015). It was defined based on five social domains: 1) going out less frequently than the previous year, 2) rarely visiting friends, 3) feeling unhelpful to friends or family, 4) living alone, and 5) not talking with someone every day. Participants who met two or more of these criteria were classified as socially frail.

Outcome: Processing Speed

Processing speed was assessed using the Digit Symbol Substitution Test (DSST). Participants had to write as many corresponding symbols as possible within a specified time limit, using a reference key that matched numbers and symbols. This test primarily reflects processing speed and has an attentional component. In this study, the test was administered for 90 s according to standardized procedures; the number of correct responses was used as the score

(Jaeger 2018). Participants with DSST scores within the lowest quartile of the study sample were classified as having a slower processing speed, as previously reported (Iwasa et al. 2014; Rosano et al. 2016).

Statistical Analysis

This study was based on an existing cross-sectional dataset, and the sample size was determined by the number of eligible participants. Participants were categorized into four groups according to the presence or absence of sleep disorders and social frailty. Group 1 had neither sleep disorders nor social frailty (neither condition); group 2 had sleep disorders only; group 3 had social frailty only; and group 4 had both sleep disorders and social frailty (both conditions).

Baseline characteristics and the prevalence of a slower processing speed were compared among the four groups using the chi-square test for categorical variables and the Kruskal–Wallis test for continuous variables. Multivariable logistic regression analysis was performed to examine the association between the four-group classification and slower processing speed. A slower processing speed (yes/no) was treated as the dependent variable, and the four-group classification was included as an independent variable. Model 1 was unadjusted. Model 2 was adjusted for age, sex, and BMI. Model 3 was additionally adjusted for educational attainment, depression, malnutrition, and chronic pain. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using group 1 as the reference category. All analyses were performed using IBM SPSS Statistics version 28 (IBM Corporation, Armonk, NY). Statistical significance was set at $p < 0.05$.

Results

A flowchart of participant selection in this study is shown in Figure 1. Of the 355 individuals initially assessed for eligibility, 320 participants were included in the final analysis.

Table 1 presents the baseline characteristics of the participants and comparisons among the four groups defined according to the presence or absence of sleep disorders and social frailty. Of the 320 participants, 159 (49.7%) were classified into group 1 (neither condition), 77 (24.1%) into group 2 (sleep disorders only), 46 (14.4%) into group 3 (social frailty only), and 38 (11.9%) into group 4 (both conditions). Significant differences among the four groups were observed for depression ($p < 0.001$), malnutrition ($p = 0.030$), and a slower processing speed ($p = 0.011$).

Table 1
Characteristics of participants according to sleep disorders and social frailty

Age, years[a]	**All** **(N = 320)**	**Group 1** **Neither condition** **(n = 159)**	**Group 2** **Sleep disorders only** **(n = 77)**	**Group 3** **Social frailty only** **(n = 46)**	**Group 4** **Both conditions** **(n = 38)**	**p-value**
	75.0 **(72.0–78.0)**	**75.0** **(72.0–78.0)**	**76.0** **(73.0–78.0)**	**73.0** **(70.0–77.0)**	**76.5** **(71.0–79.0)**	**0.151**
Sex, n (%)[b]						0.096
Male	92 (28.8)	52 (32.7)	14 (18.2)	16 (34.8)	10 (26.3)	
Female	228 (71.3)	107 (67.3)	63 (81.8)	30 (65.2)	28 (73.7)	
Body mass index, (kg/m^{2}[a]	22.0 (20.1–24.1)	22.2 (20.2–24.1)	21.5 (19.9–24.0)	21.9 (19.8–24.0)	22.3 (19.9–25.4)	0.911
Educational attainment, n (%)[b]						
≤Junior high	19 (5.9)	10 (6.3)	3 (3.9)	2 (4.3)	4 (10.5)	0.078
High school	142 (44.4)	66 (41.5)	37 (48.1)	18 (39.1)	21 (55.3)	
≥College	159 (49.7)	83 (52.2)	37 (48.1)	26 (56.5)	13 (34.2)	
Depression, n (%)[b]	47 (14.7)	9 (5.7)	10 (13.0)	10 (21.7)	18 (47.4)	< 0.001*
Malnutrition, n (%)[b]	103 (32.2)	42 (26.4)	33 (42.9)	12 (26.1)	16 (42.1)	0.030*
Chronic pain, n (%)[b]	107 (33.4)	46 (28.9)	34 (44.2)	13 (28.3)	14 (36.8)	0.103
Slower processing speed, n (%)[b]	91 (28.4)	43 (27.0)	16 (20.8)	13 (28.3)	19 (50.0)	0.011*

*Statistically significant. Data are presented as medians (quartiles 1–3), unless otherwise indicated. [a]Kruskal–Wallis test. [b]Chi-square test.

Table 2 presents the results of the logistic regression analysis in which we examined the association of the coexistence of sleep disorders and social frailty with a slower processing speed. In model 1, compared with group 1, group 4 was significantly associated with a slower processing speed (OR = 2.698, 95% CI: 1.305–5.575, p = 0.007). In model 2 (model 2), the association between group 4 and a slower processing speed remained significant (OR = 2.493, 95% CI: 1.139–5.456, p = 0.022). Similarly, in model 3, group 4 continued to be associated with significantly higher odds of a slower processing speed than group 1 (OR = 2.411, 95% CI: 1.013–5.738, p = 0.047). In contrast, no significant associations with a slower processing speed were observed for groups 2 or 3 in any of the models.

Table 2
Results of the logistic regression analysis

	Model 1			Model 2			Model 3		
	Odds ratio	**95% confidence interval**	**p-value**	**Odds ratio**	**95% confidence interval**	**p-value**	**Odds ratio**	**95% confidence interval**	**p-value**
Age (years)				1.168	1.104–1.236	< 0.001*	1.151	1.086–1.219	< 0.001*
Sex				1.142	0.626–2.084	0.665	0.955	0.511–1.784	0.886
Body mass index				1.004	0.921–1.095	0.926	1.043	0.938–1.159	0.439
Educational attainment							0.560	0.358–0.877	0.011*
Depression							0.740	0.320–1.710	0.481
Malnutrition							1.783	0.881–3.608	0.108
Chronic pain							1.130	0.634–2.014	0.679
Group 1 (Reference) Neither condition	1.000			1.000			1.000		
Group 2 Sleep disorders only	0.708	0.369–1.359	0.299	0.628	0.316–1.248	0.184	0.577	0.282–1.180	0.132
Group 3 Social frailty only	1.063	0.512–2.207	0.870	1.220	0.557–2.675	0.619	1.311	0.582–2.955	0.513
Group 4 Both conditions	2.698	1.305–5.575	0.007*	2.493	1.139–5.456	0.022*	2.411	1.013–5.738	0.047*

*Statistically significant. Model 1: unadjusted for confounding factors. Model 2: adjusted for age, sex, and body mass index. Model 3: model 2 and additional adjustment for educational attainment, depression, malnutrition, and chronic pain.

Discussion

In this study, neither sleep disorders nor social frailty alone were significantly associated with a slower processing speed, whereas the coexistence of both conditions was. This association remained significant after adjustment for age, sex, BMI, educational attainment, depression, malnutrition, and chronic pain. These findings suggest that the

coexistence of sleep disorders and social frailty may be more strongly associated with processing speed decline than either condition alone.

Previous researchers have reported that sleep disorders and social frailty are each associated with a slower processing speed (Sakal et al. 2024; Tsutsumimoto et al. 2017). Regarding sleep disorders, neuroinflammation and increased levels of inflammation-related metabolites within the frontoparietal regions have been suggested as potential contributors to a slower processing speed (Mueller et al. 2024). In addition, reduced cognitive stimulation, hormonal changes such as elevated cortisol levels associated with social isolation and stress, and increased allostatic load have been proposed as potential mechanisms that link social frailty to a slower processing speed (Sakal et al. 2024). Therefore, the association of the coexistence of sleep disorders and social frailty with a slower processing speed may be explained by the combination of neuroinflammation and stress-related physiological responses.

One explanation for why neither factor in isolation was associated with a slower processing speed in this study is that they may be interrelated. Previous studies have suggested a bidirectional relationship between sleep disorders and social frailty (Jia et al. 2024; Nakakubo et al. 2019; Noguchi et al. 2021). In the sleep disorder- and social frailty-only groups, participants with coexisting sleep disorders and social frailty were excluded by definition. As a result, the associations between either condition alone and a slower processing speed may have been attenuated. In contrast, participants with both conditions were likely exposed to a greater number of risk pathways, thereby rendering their association with a slower processing speed more apparent.

A key strength of this study is its focus on the coexistence of sleep disorders and social frailty. Traditionally, these factors have often been considered as separately associated with a slower processing speed in older adults. Considering their coexistence may facilitate the early identification of community-dwelling older adults at risk of processing speed decline and inform the development of comprehensive preventive strategies targeting both sleep disorders and social frailty.

This study has some limitations. First, because of its cross-sectional design, the causality of relationships could not be established. Longitudinal studies are needed to clarify such causality among sleep disorders, social frailty, and processing speed. Second, residual confounding may have been present. Although we adjusted the analysis for age, sex, BMI, educational attainment, depression, malnutrition, and chronic pain, unmeasured factors may still have affected the observed associations. Future researchers should consider additional adjustment for physical activity, comorbidities, and other potential confounders. Third, the generalizability of the findings may be limited. The study sample comprised older adults who participated in community-based health screenings; therefore, they likely had no major health problems, and caution is warranted when these findings are applied to the broader population of older adults. Fourth, a slower processing speed was defined using the lowest quartile of DSST scores within the study sample because no established clinical cutoff for processing speed is available for this test. Therefore, the cutoff score we used may not be directly applicable to other populations. Future studies are needed to examine whether these findings can be replicated using alternative definitions of a slower processing speed.

In conclusion, the coexistence of sleep disorders and social frailty was significantly associated with a slower processing speed among community-dwelling older adults, whereas neither condition alone was. These findings suggest that the coexistence of sleep disorders and social frailty may be a useful measure to identify older adults at risk of processing speed decline and may inform the development of multifaceted preventive strategies.

Declarations

Author Contribution

Author Contributions: Conceptualization: HH and TH; Data curation: HH, NI, SS, and TH; Investigation: HH, NI, SS, and TH; Methodology: HH and TH; Project administration: TH; Supervision: TH; Writing–original draft: HH; Writing–review & editing: TH.

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References

1. Canever, J. B., Zurman, G., Vogel, F., Sutil, D. V., Diz, J. B., Danielewicz, A. L., Moreira, B. S., Cimarosti, H. I., & de Avelar, N. C. (2024). Worldwide prevalence of sleep problems in community-dwelling older adults: a systematic review and meta-analysis. *Sleep Medicine*, *119*, 118–134. https://doi.org/10.1016/j.sleep.2024.03.040
2. Davis, J. C., Best, J. R., Khan, K. M., Dian, L., Lord, S., Delbaere, K., Hsu, C. L., Cheung, W., Chan, W., & Liu-Ambrose, T. (2017). Slow processing speed predicts falls in older adults with a falls history: 1-year prospective cohort study. *Journal of the American Geriatrics Society*, *65*(5), 916–923. https://doi.org/10.1111/jgs.14830
3. Doi, Y., Minowa, M., Uchiyama, M., Okawa, M., Kim, K., Shibui, K., & Kamei, Y. (2000). Psychometric assessment of subjective sleep quality using the (Japanese version) of the Pittsburgh Sleep Quality Index (PSQI-J) in psychiatric disordered and control subjects. *Psychiatry Research*, *97*(2–3), 165–172.
4. Gen, A., Higuchi, Y., Ueda, T., Hashimoto, T., Kozuki, W., Murakami, T., & Ishigami, M. (2025). Intervention for social frailty focusing on physical activity and reducing loneliness: a randomized controlled trial. *Clinical Interventions in Aging*, *20*, 43–53. https://doi.org/10.2147/CIA.S491979
5. Gkotzamanis, V., Koliopanos, G., Sanchez-Niubo, A., Olaya, B., Caballero, F. F., Ayuso-Mateos, J. L., Chatterji, S., Haro, J. M., & Panagiotakos, D. (2021). Determinants of processing speed trajectories among middle aged or older adults, and their association with chronic illnesses: the English longitudinal study of aging. *Life*, *11*(4), 357. https://doi.org/10.3390/life11040357
6. Holanda, F. W., & de Almondes, K. M. (2016). Sleep and executive functions in older adults: a systematic review. *Dementia & Neuropsychologia*, *10*(3), 185–197. https://doi.org/10.1590/S1980-5764-2016DN1003004
7. Iwasa, H., Kai, I., Yoshida, Y., Suzuki, T., Kim, H., & Yoshida, H. (2014). Information processing speed and 8-year mortality among community-dwelling elderly Japanese. *Journal of Epidemiology*, *24*(1), 52–59. https://doi.org/10.2188/jea.JE20120210
8. Jaeger, J. (2018). Digit Symbol substitution test: the case for sensitivity over specificity in neuropsychological testing. *Journal of Clinical Psychopharmacology*, *38*(5), 513–519. https://doi.org/10.1097/JCP.0000000000000941
9. Jia, B., Wang, Z., Zhang, T., Yue, X., & Zhang, S. (2024). Prevalence of social frailty and risk factors among community-dwelling older adults: a systematic review and meta-analysis. *Archives of Gerontology and Geriatrics*, *123*, 105419. https://doi.org/10.1016/j.archger.2024.105419
10. Kaiser, M. J., Bauer, J. M., Ramsch, C., Uter, W., Guigoz, Y., Cederholm, T., Thomas, D. R., Anthony, P., Charlton, K. E., Maggio, M., Tsai, A. C., Grathwohl, D., Vellas, B., Sieber, C. C., & MNA-International Group. (2009). Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. *Journal of Nutrition Health and Aging*, *13*(9), 782–788. https://doi.org/10.1007/s12603-009-0214-7

11. Li, J., Zhu, L., Yang, Y., Li, Y., Fu, P., & Yuan, H. (2024). Prevalence and potential influencing factors for social frailty among community-dwelling older adults: a systematic review and meta-analysis. *BMC Geriatrics*, *24*(1), 762. https://doi.org/10.1186/s12877-024-05365-8
12. Livingston, G., Huntley, J., Liu, K. Y., Costafreda, S. G., Selbæk, G., Alladi, S., Ames, D., Banerjee, S., Burns, A., Brayne, C., Fox, N. C., Ferri, C. P., Gitlin, L. N., Howard, R., Kales, H. C., Kivimäki, M., Larson, E. B., Nakasujja, N., Rockwood, K., Samus, Q., Shirai, K., Singh-Manoux, A., Schneider, L. S., Walsh, S., Yao, Y., Sommerlad, A., & Mukadam, N. (2024). Dementia prevention, intervention, and care: 2024 report of the Lancet standing Commission. *Lancet*, *404*(10452), 572–628. https://doi.org/10.1016/S0140-6736(24)01296-0
13. Makizako, H., Shimada, H., Tsutsumimoto, K., Lee, S., Doi, T., Nakakubo, S., Hotta, R., & Suzuki, T. (2015). Social frailty in community-dwelling older adults as a risk factor for disability. *Journal of the American Medical Directors Association*, *16*(11), 1003e7–100311. https://doi.org/10.1016/j.jamda.2015.08.023
14. Mueller, C., Nenert, R., Catiul, C., Pilkington, J., Szaflarski, J. P., & Amara, A. W. (2024). Brain metabolites are associated with sleep architecture and cognitive functioning in older adults. *Brain Communications*, *6*(4), fcae245. https://doi.org/10.1093/braincomms/fcae245
15. Nakakubo, S., Doi, T., Makizako, H., Tsutsumimoto, K., Kurita, S., Kim, M., Ishii, H., Suzuki, T., & Shimada, H. (2019). Association of sleep condition and social frailty in community-dwelling older people. *Geriatrics and Gerontology International*, *19*(9), 885–889. https://doi.org/10.1111/ggi.13734
16. Noguchi, T., Nojima, I., Inoue-Hirakawa, T., & Sugiura, H. (2021). Association between social frailty and sleep quality among community-dwelling older adults: a cross-sectional study. *Physical Therapy Research*, *24*(2), 153–162. https://doi.org/10.1298/ptr.E10085
17. Nyunt, M. S., Fones, C., Niti, M., & Ng, T. P. (2009). Criterion-based validity and reliability of the Geriatric Depression Screening Scale (GDS-15) in a large validation sample of community-living Asian older adults. *Aging and Mental Health*, *13*(3), 376–382. https://doi.org/10.1080/13607860902861027
18. Rosano, C., Perera, S., Inzitari, M., Newman, A. B., Longstreth, W. T., & Studenski, S. (2016). Digit Symbol Substitution test and future clinical and subclinical disorders of cognition, mobility and mood in older adults. *Age and Ageing*, *45*(5), 688–695. https://doi.org/10.1093/ageing/afw116
19. Sakal, C., Li, T., Li, J., Yang, C., & Li, X. (2024). Association between sleep efficiency variability and cognition among older adults: cross-sectional accelerometer study. *JMIR Aging*, *7*, e54353. https://doi.org/10.2196/54353
20. Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review*, *103*(3), 403–428. https://doi.org/10.1037/0033-295X.103.3.403
21. Sella, E., Toffalini, E., Canini, L., & Borella, E. (2023). Non-pharmacological interventions targeting sleep quality in older adults: a systematic review and meta-analysis. *Aging and Mental Health*, *27*(5), 847–861. https://doi.org/10.1080/13607863.2022.2056879
22. Treede, R. D., Rief, W., Barke, A., Aziz, Q., Bennett, M. I., Benoliel, R., Cohen, M., Evers, S., Finnerup, N. B., First, M. B., Giamberardino, M. A., Kaasa, S., Kosek, E., Lavand'homme, P., Nicholas, M., Perrot, S., Scholz, J., Schug, S., Smith, B. H., Svensson, P., Vlaeyen, J. W. S., & Wang, S. J. (2015). A classification of chronic pain for ICD-11. *Pain*, *156*(6), 1003–1007. https://doi.org/10.1097/j.pain.0000000000000160
23. Tsutsumimoto, K., Doi, T., Makizako, H., Hotta, R., Nakakubo, S., Makino, K., Suzuki, T., & Shimada, H. (2017). Association of social frailty with both cognitive and physical deficits among older people. *Journal of the American Medical Directors Association*, *18*(7), 603–607. https://doi.org/10.1016/j.jamda.2017.02.004

Figures

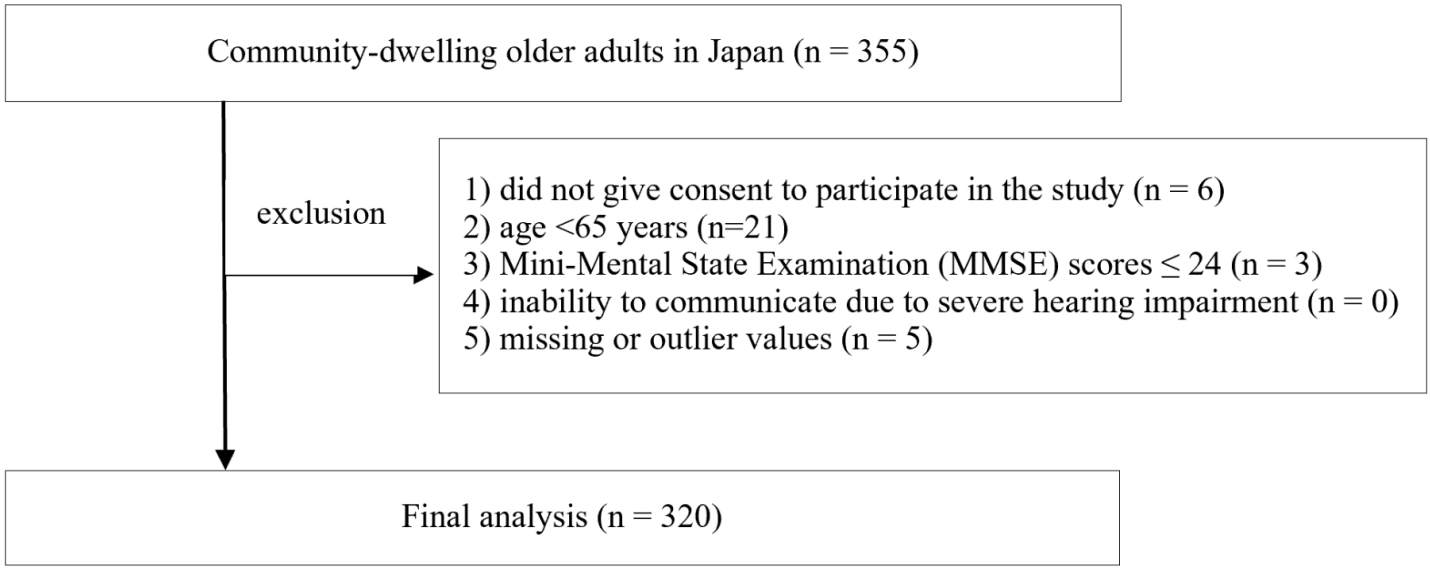

Figure 1

Flowchart of participant selection