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Original Article

Sarcopenia and impairment in global cognitive, delayed memory, and olfactory function, among community-dwelling adults, in Jakarta, Indonesia: Active aging study

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Abstract

Objectives: This study aimed to investigate the association of sarcopenia among community-dwelling older adults with chronic conditions, lipid profiles, and cognitive ability measured by multiple assessment tools. **Materials and Methods:** This cross-sectional study involved 398 older adults aged 60 years and older who resided in Jakarta, Indonesia. The study participants were visited and interviewed by trained interviewers in the subdistrict office. Participants were clinically examined using a standardized protocol, which included the participants' medical history, general physical examination, cognitive assessment, and blood test for lipid profile. Sarcopenia was measured using three components that were muscle strength (measured by handgrip strength), physical performance (measured by 6-m walk speed), and appendicular skeletal mass (measured using bioelectrical impedance analysis). Association was tested using multivariate logistic regression and reported as an odds ratio. **Results:** Sarcopenia was significantly associated with older age (adjusted odd ratio [AOR]: 2.91, 95% confidence interval [CI]: 1.22–3.95) and smoking (AOR: 6.53, 95% CI: 2.89–14.73). Global cognitive impairment, word list recall impairment, and olfactory dysfunction have 191% (95% CI: 1.28–6.66), 141% (95% CI: 1.12–5.2), and 100% (95% CI: 1.11–3.61) increase of odds of having sarcopenia, respectively. **Conclusion:** Global cognitive impairment, word list recall impairment, and olfactory dysfunction could be the predictors of sarcopenia. Strategies and implementations directed more toward the improvement of cognitive impairment might improve or prevent sarcopenia. However, the exact causality between both variables still needs to be explored further.

Keywords: *Cognitive impairment, Older adults, Olfactory dysfunction, Sarcopenia*

Introduction

Aging causes many physiological changes in the body, including a decrease in motor strength and a decline in cognitive function. Decreased motor function in aging was caused by various factors, such as nutrition and lifestyle [1]. Likewise, the cognitive function also declines in the elderly group, which is influenced by various factors such as neurodegenerative processes, systemic diseases, and drugs [2].

Age-related loss of skeletal muscle, muscle strength, and/or reduced physical performance without reference to comorbidity is known as sarcopenia [3]. In this aging population, sarcopenia is becoming a serious problem. Although it does not refer to certain comorbid diseases, sarcopenia has an impact that also affects other disease conditions, such as increasing the risk of falling, the risk of disability, hospitalization, and death [4]. Sarcopenia usually occurs in the elderly; however, it may also occur in middle ages who are affected by various conditions.

The Asian Working Group for Sarcopenia (AWGS) provided cutoff values for the appendicular skeletal muscle mass index and for grip strength for Asian people in 2014. Using these criteria, the estimated prevalence of sarcopenia

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varies, ranging from 9.9% to 40.4% in older individuals [5-7]. Pathogenesis of sarcopenia is still poorly explained; however, there are numerous studies reviewed for risk factors. Sarcopenia, which affects physical frailty, is more prevalent in cognitive impairment elderly. Appetite loss and low physical activity are reported to be the main reasons that cognitive impairment leads to sarcopenia [8].

According to Chang *et al*., there is an association between sarcopenia and cognitive impairment, but it still requires cohort studies to elucidate the correlation between sarcopenia and cognitive impairment and suggest biomarkers and other physical examinations [9]. In physiological aging conditions, several cognitive domains, such as attentional function, imitation, movement, or memory procedures, can be maintained and preserved longer than other domains (learning new information, verbal fluency, and reaction time) [10]. Association between dyslipidemia and sarcopenia has several inconsistent results. Du *et al*. and Baek *et al*. found that males with sarcopenic obesity were more likely to have dyslipidemia [11,12]. On the other hand, a study by Han *et al*. showed no correlation between sarcopenia and dyslipidemia [13].

This study aimed to investigate the association of sarcopenia among community-dwelling older adults with chronic conditions, lipid profiles, and cognitive function measured by multiple assessment tools.

Materials and Methods

Setting and study population

This was cross-sectional study involving 398 older adults aged 60 and older living in several urban villages in West Jakarta, Indonesia, including Kalianyar, Meruya Hilir, and Kalideres, from August to September 2020. The study participants were visited and interviewed by trained interviewers in the subdistrict office. Before the interview was conducted, we obtained informed consent from each participant.

Study variables

The study participants were clinically examined using a standardized protocol, which included the participants' medical history, general physical examination, cognitive assessment, and blood test for lipid profile (total cholesterol, triglycerides, low-density lipoprotein cholesterol [LDL cholesterol], and high-density lipoprotein [HDL cholesterol]) measurement. We analyzed all variables as dichotomous, except for body mass index (BMI) as polychotomous.

We defined sarcopenia based on AWGS 2019 Consensus, using algorithm in Acute to Chronic Health Care or Clinical Research Settings [3]. Sarcopenia was measured using three components, which were muscle strength (measured by handgrip strength), physical performance (measured by 6-m walk speed), and appendicular skeletal mass (ASM) measured using bioelectrical impedance analysis (BIA). Low muscle strength was considered if the strength was below 28 kg (male) or 18 kg (female). Low physical performance was defined if the 6-m walk speed was below 1.0 m/s for both sexes. Low ASM was defined as having ASM measured by BIA lower than 7.0 kg/m^2 (male) or 5.7 kg/m^2 (female). Sarcopenia was diagnosed if the participant has low ASM and low muscle strength or low physical performance; severe sarcopenia was diagnosed if the participant has low ASM, low muscle strength, and low physical performance; both will be classified into one group as sarcopenia.

Participants' age was grouped into two categories: 60–69 years and ≥70 years. Educational status was classified into <9 years of education and ≥9 years. The participants were asked about smoking status, exercise frequency and duration, and chronic condition statuses (based on healthcare provider diagnosis). Doing exercise was defined as the participant exercising with a minimum duration of 30 min and a frequency of 3 days per week [14]. Chronic conditions asked by the interviewer were a history of diabetes, hypertension, and heart disease. BMI was calculated using measured body weight and height; the participant was classified into normal, underweight, and overweight/obese according to the Asia Pacific World Health Organization BMI Classification [15].

Total cholesterol, triglycerides, and LDL cholesterol were considered high if the values were ≥200 mg/dL, ≥150 mg/dL, and ≥130 mg/dL, respectively. HDL cholesterol was considered low if it was <40 mg/dL in male or <50 mg/dL in female. Dyslipidemia was defined if there is abnormal value in any parameter.

The cognitive assessment used Consortium to Establish a Registry for Alzheimer's Disease Neuropsychological Battery Test, which included verbal fluency, modified Boston Naming Test (BNT), Mini-Mental State Examination (MMSE), constructional praxis, word list memory, word list recall, and word list recognition. Verbal fluency consists of verbally naming animals as many words from a single category as possible in 60 s, with a score lower than 16 defined as impaired [16,17]. The modified BNT assessment tool consisting of 15 items was used with a score of 14 as a cutoff; the lower score was considered impaired. Constructional praxis contained four geometric structures (circle, diamond, rectangle, and cube), and the participants were asked to draw the shown structures. A specific score was given according to the indicator of resemblance with the standard picture. A score lower than 11 was considered impaired [17]. MMSE consisted of 30 items and was considered abnormal if the score was below 24 [18]. The word list memory assessment tool contains 10 words, and the participants were asked to repeat the words at the end after showing each of the ten words [Supplementary Material 1]. Every word was shown for 2 s and given 90 s to recall. This assessment was repeated three times, with a total score of 30; a score of 19 served as a cutoff. Word list recall and recognition were assessed by recalling and recognizing the ten words mentioned in word list memory at the end of the cognitive assessment. A score of 7 and 10 served as a cutoff, respectively [16].

Olfactory test examination of olfactory nerve function was performed using 10 odors commonly found in Indonesia: cajuput oil, coffee, jasmine, menthol, tobacco, kerosene, pandan, camphor, chocolate, and orange. The odors were preserved in similar containers, sealed, and coded numerically. Subjects were allowed to smell the odors twice for 5 s

before being asked to identify each of the odors. They were given a 30-s break before identifying the next odor. A score below 7 was considered abnormal olfactory function [14]. All cardiovascular parameters were analyzed at rest. The procedures for measuring blood pressure were adapted from the VIII Joint National Committee of High Blood Pressure [19]. Smoking status was categorized into "never," "former," and "current smoker."

Statistical analysis

The characteristics between groups were compared using binary logistic analysis. Associations of sarcopenia with other independent variables were assessed using multivariate logistic regression (including age, sex, and other variables) using backward analysis for the adjusted odds ratio (AOR). Stepwise regression was used because it can reduce the number of predictors in the model, improving sample accuracy (generalizability), compared to the enter method. Backward use was important in the case of collinearity because variables may be forced to be kept in the model, unlike forward selection, where none of them might be entered. The analyzed data were presented with a P value ($P < 0.05$ was considered significant) and 95% confidence interval (CI). The analyses were carried out using IBM SPSS Software Version 22 (IBM, New York, USA).

Ethical approval

This study is approved by the Faculty of Medicine and Health Science, Atma Jaya Catholic University of Indonesia Ethical Committee, with referral number 04/03/KEP-FKIKUAJ/2021.

Data availability statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Results

Characteristics of respondents

From a total of 398 participants in this study, the mean age was 68.1 ± 8.7 years. Two-thirds (69.6%) of the total population were female. Most had middle-high education background (≥9 years; 71.6%) and 16.8% were diagnosed as sarcopenia [Table 1]. Low muscle mass, low muscle strength, and low physical performance were found in 20.4%, 28.9%, and 71.2%, respectively. Over 91.2% of the participants did not smoke on a daily basis, did exercise (61.8%), were categorized as obese (76.4%), and had no history of diabetes, hypertension, and heart diseases (83.4%, 52.3%, and 96%, respectively). There was 64.1% of the total population who had dyslipidemia. For the neurocognitive test, the majority of the participants were categorized as impaired in several tests, including MMSE (75.6%), visuoconstruction (71.4%), word list recall (71.1%), word list memory (65.4%), word list recognition (55.5%), and verbal fluency (52.8%). BNT results were normal in 39.7% of the participants, while the normal olfactory test was 56.4%.

Associations with sarcopenia

Bivariate analysis showed that sarcopenia has significant associations with older age, males, smoking, cognitive impairment (measured by MMSE), and impairment of word list memory, word list recall, word list recognition, and olfactory test [Table 1].

Sarcopenia was significantly associated with older age (AOR: 2.91, 95% CI: 1.22–3.95) and smoking (AOR: 6.53, 95% CI: 2.89–14.73) [Table 2]. Global cognitive impairment, word list recall impairment, and olfactory dysfunction have 191% (95% CI: 1.28–6.66), 141% (95% CI: 1.12–5.2), and 100% (95% CI: 1.11–3.61) increase of odds of having sarcopenia, respectively. The interaction between smoking and the olfactory test was evaluated; we did not find any significant interaction between both variables.

A separate analysis of each sarcopenia parameter was done, including muscle mass, muscle strength, and physical performance toward independent variables. Low muscle mass was associated significantly with older age (AOR: 3.38, 95% CI: 1.23–9.32), low education (AOR: 6.26, 95% CI: 2.15–18.25), being male (AOR: 3342.74, 95% CI: 278.25–42,198.74), lack of exercise (AOR: 6.38, 95% CI: 1.64–24.74), impaired in olfactory test (AOR: 3.62, 95% CI: 1.35–9.67), and cognitive impairment (AOR: 7.44, 95% CI: 2.06–27.87) [Table 3].

Low muscle strength was significantly associated with low education, word list recall, and olfactory test, with an AOR of 3.16 (95% CI: 1.91–5.23), 2.51 (95% CI: 1.36–4.65), and 1.91 (95% CI: 1.17–3.11), respectively [Table 4]. Low physical performance was significantly associated with one variable, which is hypertension (AOR: 1.92, 95% CI: 1.09–3.38) [Table 5]. No significant collinearity was found among the variables (correlation coefficient [r] ranged from − 0.242 to 0.295); collinearity was considered significant if r is more than or equal to 0.8.

Discussion

The prevalence of sarcopenia varies from 9.9% to 40.4%, depending on the definition used. A systematic review and meta-analyses by Mayhew *et al*. showed that with the AWGS, the estimated prevalence was 12.9%, while in this study, it was 16.8% [7]. The prevalence in this study was slightly higher than in studies conducted by Therakomen *et al*. (10%) and Wu *et al*. (12.7%), who had participants from community-dwelling and rural communities in Japan and Taiwan, respectively [20,21]. Compared to a cross-sectional study by Yamada *et al*., the prevalence was lower (21.8%–22.1%) [22].

Sarcopenia has always been related to older age, especially primary sarcopenia. Physiological and morphological changes in the skeletal muscle with older age, including declines in the number of neuromuscular junctions, are thought to be one of the important roles. In skeletal muscle of older adults, cell content is reduced, especially in type-2 skeletal muscle fibers [23]. In this study, older adults over 70 years old were at significant risk of sarcopenia ($P = 0.01$). This result was in accordance with several other studies [20,23,24]. Therakomen *et al*. divided the age group into three categories: 60–69, 70–79 (middle-old), and 80 (very-old) years. The middle-old and very-old groups had a significantly higher risk than the younger groups.

Table 1: Variable characteristics and bivariate analysis of factors associated with sarcopenia among 398 participants

Variables	Frequency (%)[#]	Sarcopenia status (%)[+]		Unadjusted OR (95% CI)
		Normal	Sarcopenia	
Age of ≥70 years old	150 (37.7)	115 (34.7)	35 (52.2)	2.05 (1.21-3.49)**
Male	121 (30.4)	55 (16.6)	66 (98.5)	335.18 (45.48-2470.34)**
Low education (<9 years)	113 (28.4)	99 (29.9)	14 (20.9)	1.62 (0.86-3.05)
Low muscle mass	82 (20.4)			
Low muscle strength	155 (28.9)			
Low physical performance	283 (71.2)			
Current smoker	35 (8.8)	18 (5.4)	17 (25.4)	5.91 (2.86-12.23)**
Not doing exercise	152 (38.2)	134 (40.5)	18 (26.9)	0.54 (0.3-0.97)*
Underweight	20 (5)	15 (4.5)	5 (7.5)	1.21 (0.38-3.83)
Overweight/obese	304 (76.4)	258 (77.9)	46 (68.7)	0.65 (0.34-1.22)
Diabetes	66 (16.6)	56 (16.9)	10 (14.9)	0.86 (0.42-1.79)
Hypertension	190 (47.7)	152 (45.9)	38 (56.7)	1.54 (0.91-2.62)
Heart diseases	16 (4)	13 (3.9)	3 (4.5)	1.15 (0.32-4.14)
Dyslipidemia	255 (64.1)	204 (61.6)	52 (76.1)	0.69 (0.38-1.27)
Impaired verbal fluency	210 (52.8)	180 (54.4)	30 (44.8)	0.68 (0.4-1.15)
Impaired BNT	158 (39.7)	135 (40.8)	23 (34.3)	0.76 (0.44-1.32)
Impaired MMSE	301 (75.6)	243 (73.4)	58 (86.6)	2.33 (1.11-4.91)*
Impaired word list memory	261 (65.4)	207 (62.3)	54 (80.6)	2.51 (1.32-4.78)**
Impaired visuoconstruction	284 (71.4)	242 (73.1)	42 (62.7)	0.62 (0.36-1.07)
Impaired word list recall	283 (71.1)	226 (68.3)	57 (85.1)	2.65 (1.3-5.39)**
Impaired word list recognition	221 (55.5)	176 (53.2)	45 (67.2)	1.8 (1.04-3.13)*
Impaired olfactory test	174 (43.6)	134 (40.4)	40 (59.7)	2.19 (1.28-3.74)**

*P<0.05, **P<0.01, [#]Proportion of the cohort (among all populations), [+]Proportion among each subgroups (normal and sarcopenia). OR: Odds ratio, CI: Confidence interval, BNT: Boston Naming Test, MMSE: Mini-Mental State Examination

Table 2: Backward logistic regression analysis of factors associated with sarcopenia

Variables	AOR (95% CI)	*P*
Age of ≥70 years old	2.91 (1.22-3.95)	0.009
Current smoker	6.53 (2.89-14.73)	<0.001
Impaired MMSE	2.91 (1.28-6.66)	0.011
Impaired word list recall	2.41 (1.12-5.2)	0.024
Impaired olfactory test	2 (1.11-3.61)	0.022

MMSE: Mini-Mental State Examination, CI: Confidence interval, AOR: Adjusted odds ratio

Table 3: Backward logistic regression analysis of factors associated with muscle mass

Variables	AOR (95% CI)	*P*
Age of ≥70 years old	3.38 (1.23-9.32)	0.019
Low education (<9 years)	6.26 (2.15-18.25)	0.001
Male	3342.74 (271.25-41193.743)	<0.001
Not doing exercise	6.38 (1.64-24.74)	0.007
Impaired olfactory test	3.62 (1.35-9.67)	0.010
Impaired MMSE	7.44 (2.06-26.87)	0.002

MMSE: Mini-Mental State Examination, CI: Confidence interval, AOR: Adjusted odds ratio

There was a significant association between sarcopenia and the habit of smoking, which was consistent with other studies. In this study, smoking has a big magnitude with an odds ratio (OR) of 6.53, compared to a cohort study by Locquet *et al*. (OR: 2.37) and a meta-analysis by Steffl *et al*. (OR: 1.12) [25,26]. Lower results in the meta-analysis were caused by a small number of studies included and high heterogeneity. The investigation by Locquet *et al.* involved following older adults with a normal baseline for 5 years by separating them into nonsmoker and smoker groups and evaluating the dose–response relationship, in which one cigarette consumption confers a 5% higher risk for developing sarcopenia. From a biological perspective, smoking creates a higher concentration of radical oxygen species and promotes capillary regression, which results in the deterioration of skeletal muscle structure and function [26,27]. These results might suggest a causal relationship, but it is too early to conclude a definite correlation between both variables. Definition of 'doing exercise' in this study was not as detailed compared to other assessment tools. This might be the cause of high significant result in smoking variable, but not in 'doing exercise' variable among the older adults [28,29]. Regular exercise three sessions a week, each lasting a minimal 30 min, should be done for at least 6 months. Intensity, type of exercise, and protein intake also affect sarcopenia [30]. Exercise that includes resistance and endurance training was shown to have a major positive impact on sarcopenia. Adequate protein intake or protein supplementation, especially within 60 min after exercise, improves sarcopenia, although taking protein at any time also benefits sarcopenia [31]. We did not found a significant association between BMI status and sarcopenia; however, another study showed that being underweight is a considerable risk factor for sarcopenia [32].

Sarcopenia and cognitive impairment association have mixed results in many studies. In ours, sarcopenia was significantly associated with cognitive impairment, but many studies did not find a significant result [33-37]. These findings might not reflect the complicated association between cognitive function and

Table 4: Backward logistic regression analysis of factors associated with muscle strength

Variables	AOR (95% CI)	*P*
Low education (<9 years)	3.16 (1.91-5.23)	<0.001
Impaired word list recall	2.51 (1.36-4.65)	0.003
Impaired olfactory test	1.91 (1.17-3.11)	0.009

CI: Confidence interval, AOR: Adjusted odds ratio

Table 5: Backward logistic regression analysis of factors associated with physical performance

Variables	AOR (95% CI)	*P*
Hypertension	1.92 (1.09-3.38)	0.025

CI: Confidence interval, AOR: Adjusted odds ratio

sarcopenia. Still, the subsequent analysis was done by Ogawa *et al.* to evaluate each of the sarcopenia domains in Alzheimer's patients, which were handgrip strength and muscle mass [36]. They found that cognitive deterioration was more associated with muscle strength than muscle mass. Coelho-Júnior *et al.* found an association between MMSE score and lower body function (measured by Short Physical Performance Battery), however there was no association between MMSE and muscle mass [34]. In addition, lower limb muscle strength or performance might be more important than upper limb muscle. Due to these findings, the word dynapenia, which means an age-associated loss of muscle strength, was often used when evaluating cognitive function based on some studies [35,36]. However, in this study, we found that muscle mass was associated with MMSE score in our subanalysis of each sarcopenia parameter. A significant association was found between muscle mass and MMSE (AOR: 7.44) and olfactory test (AOR: 3.62), while muscle strength was significantly associated with the olfactory test with lower AOR of 1.91 and word list recall with AOR of 2.51. Hence, the importance between muscle mass and muscle strength remains unclear. Either decrease of muscle mass or sarcopenia or dynapenia, all of them was found to be associated with cognitive impairment in this study.

This study showed a significant relationship between sarcopenia and word list recall after adjustment. Similarly, Kim and Won reported that there was a relationship between verbal episodic memory impairment and slow gait speed [6]. The possible mechanism was physical inactivity could decrease the expression of molecules (brain-derived neurotrophic factor and insulin-like growth factor -1) that are related to the learning process [38]. However, the specific mechanism related to this has not been elucidated yet and thus needs further study. Nishiguchi *et al*. also reported an association between cognitive decline and memory decline with frailty in a group of women over 65 years in Japan. However, the cognitive decline was not associated with sarcopenia. Sarcopenia is only associated with frailty; thus, the mechanism related to this result needs to be explained further [39]. Sarcopenia and cognitive impairment could share the same pathophysiology pathway, such as inflammations, oxidative stress, and hormonal changes. Alteration in muscle strength could affect sarcopenia and cognitive function as the muscle strength is reflected in the change in the brain-aging process [40].

The results of this study are also similar to the study on 141 older adults with a mean age of 73 years by Harita *et al*., which also stated that there was a relationship between olfactory disorders and sarcopenia index even after adjustment for several other factors. This study also showed that the relationship between olfactory disorders and sarcopenia index was also related to the total protein content in the body [41].

In a study by Iritani *et al*. using the index between olfactory and cognitive values, it was found that the higher the index value, the stronger the relationship between frontal lobe shrinkage and a decrease in muscle mass or muscle strength, and this also affects the development of Alzheimer's disease [42]. Olfactory dysfunction may have a clinical correlation with incidental Lewy body disease, Parkinson's disease, dementia with Lewy bodies, idiopathic rapid eye movement sleep behavior, mild cognitive impairment, and Alzheimer's disease. Several mechanisms have been linked to the association between olfactory disorders and neurodegenerative diseases, but the biological relationship is remained unclear [43].

The smoking habit might affect olfactory function. Few potential mechanisms are increased squamous metaplasia, reversible sinonasal inflammation, and effects on central neural pathways. However, in this study, we did not find a significant interaction between both variables and the majority of the participants (91.2%) never smoked [44].

Olfactory impairment reflects decrease in brain plasticity, which accompanied by frailty, which is defined by the increased vurnerability and inability for quick recovery of physiological systems [45]. Decreased ability to smell and taste reduces appetite and food intake, which can be connected to frailty [46].

There were limitations to this study. Although sarcopenia was measured using objective standard measurements, our cross-sectional models only provided associations between factors. Therefore, interpretation of risk factors should be made with caution. Due to lack of resources, chronic conditions status, exercise, and smoking variable were assessed based on the self-reported data. More objective measurements might achieve accurate results. Research involving a larger sample of data in a prospective cohort model might help identify causality and map sarcopenia trajectories in participants with risk factors.

Conclusions

There is a significant association between sarcopenia and older age and smoking habit. Global cognitive impairment, word list recall impairment, and olfactory dysfunction could be predictors of sarcopenia. Referring to each component of sarcopenia, low muscle strength was associated with older age, low education, male, lack of exercise, olfactory impairment, and low MMSE score, while low muscle strength with low education, word list recall, and olfactory impairment. Low physical performance was significantly associated with hypertension, with no collinearity among all variables. Strategies and implementations directed more toward the improvement of cognitive impairment might improve or

prevent sarcopenia. However, the exact causality between both variables still needs to be explored further.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Supplementary Material

Supplementary Material 1: Word List Memory/Recall/Recognition Verbatim List

The words are in Bahasa Indonesia.

1. Mentega
2. Tangan
3. Pantai
4. Surat
5. Ratu
6. Ruangan
7. Kolam
8. Tiket
9. Rumput
10. Mesin.