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Determinants of dementia risk among older adults with probable sarcopenia and sarcopenia

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Abstract

Background Probable sarcopenia is a condition related to low muscle strength which increases the risk of sarcopenia. Both probable sarcopenia and sarcopenia increases the risk of dementia. The aim of this study is to investigate the factors associated with dementia among probable sarcopenia and sarcopenia older adults. It was hypothesized that comorbidities among probable sarcopenia and sarcopenia subjects may elevate the risk of dementia.

Methodology This study involved 194 older adults with probable sarcopenia and sarcopenia aged 60 years and above. Sarcopenia was assessed using the Asian Working Group of Sarcopenia (AWGS) 2019. Among the parameters investigated in this study were sociodemographic, medical history, anthropometry, body composition, physical fitness, subjective cognitive decline, depressive symptoms, cognitive function and functional status. Dementia risk was assessed using the Montreal Cognitive Assessment (MoCA) tool. Adjusted binary logistic regression was employed to identify the factors associated with dementia among probable sarcopenia and sarcopenia older adults.

Results Probable sarcopenia subjects with dementia were older (68.5(7.8) years old) as compared to those without dementia (66.0(6.0) years old). Among the probable sarcopenia, 66.1% of the subjects with dementia had hypertension, while 64.3% of the sarcopenia subjects had hypertension. Fat mass was significantly higher among dementia subjects with probable sarcopenia (33.0(6.5) %) as compared to non-dementia subjects (30.4(6.8) %). Multivariate analysis revealed that hypertension (OR: 4.049; 95% CI: 1.510; 10.855, $p=0.005$) was the only factor associated with dementia risk among older adults with probable sarcopenia and sarcopenia.

Conclusion Hypertension is the only factors associated with risk of dementia after adjusting for potential confounders among older adults with probable sarcopenia and sarcopenia. Good control of blood pressure is essential among sarcopenia patients for lowering risk of dementia. Well-designed clinical trials are essential to investigate optimizing blood pressure level to reduce risk of dementia among patients with sarcopenia and probable sarcopenia.

Keywords Probable sarcopenia, Sarcopenia, Dementia risk, Hypertension, Factors, Older adults

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Introduction

Sarcopenia is currently regarded as a muscle disease characterized by loss of muscle mass, muscle strength and decline in physical performance. It increases the risk of cardiovascular disease, diabetes mellitus, and cognitive impairment [1]. Sarcopenia can be managed with proper diet and physical activity. The diagnostic criteria for sarcopenia are the European Working Group on Sarcopenia in Older People (EWGSOP), International Working Group on Sarcopenia (IWGS), the Asian Working Group for Sarcopenia (AWGS), and the Foundation for the National Institutes of Health Sarcopenia Project (FNIH) [2]. In 2019, the EWGSOP and AWGS have been updated to EWGSOP2 and AWGS 2019 which provides specific updated cut-off values that assesses sarcopenia. AWGS 2019 defined sarcopenia as low muscle mass added with low muscle strength or low muscle performance [3]. In AWGS 2019, the grip strength threshold has been increased from 26 to 28 kg for men while for women the cut-off remains the same. Meanwhile, the walking speed value has increased from 0.8 m/s to less than 1 m/s [4]. Besides sarcopenia, it is vital to assess the population at-risk of sarcopenia. The AWGS 2019 has proposed the concept of `possible sarcopenia` which indicated the presence of low muscle mass. The prevalence of possible sarcopenia in the Asian countries ranged from 2.9 to 38.5% using the AWGS 2019 criteria [5].

As the global population continues to age, the implications of sarcopenia have become increasingly apparent, extending far beyond musculoskeletal health [6]. Concurrently, dementia, a syndrome characterized by a decline in cognitive function, remains a formidable public health challenge. While these two conditions have traditionally been considered separate entities, mounting evidence suggests a profound interplay between sarcopenia and dementia, unveiling an intricate relationship that demands exploration and understanding [7]. Pathogenesis of sarcopenia is contributed by several factors such as neuromuscular degeneration, cognitive decline, hormonal imbalance, inflammation, and oxidative stress [8]. Older adults with dementia have altered body composition especially having slowed gait speed and weak grip strength [9]. Findings from several cross-sectional studies involving older adults with mean age of 69.9 to 82.3 years have demonstrated significant association between sarcopenia and cognitive impairment [9–11]. The ELSA-Brazil study by Szlejf et al. (2019) reported that poor muscle strength was associated with lowest scores in all cognitive tests [12]. A longitudinal study among 496 older people in Mexico demonstrated that sarcopenia increases the risk of cognitive impairment by 1.74 [13]. Another cross-sectional study conducted in Turkey showed that probable sarcopenia patients with Alzheimer`s disease (AD were frail and lower activities of daily living score [14]. Similarly, the same author reported that AD was closely related to probable sarcopenia and sarcopenia, while dementia with Lewy body was associated with probable sarcopenia and slow gait speed [15].

This article aims to determine the prevalence of dementia risk among probable sarcopenia and sarcopenia older adults and further determine the factors associated with dementia risk among this group of patients.

Methodology

This was a cross-sectional study with convenience sampling strategy was conducted among older adults aged 60 years and above residing in one of the poorest states in Malaysia located in the East Coast, Kelantan. This study was conducted in five districts in Kelantan which included, Tumpat, Bachok, Pasir Mas, Kota Bharu and Machang. Villages chosen were based on a previous study by Nazri (2022) that found the prevalence of sarcopenia among older adults in these regions to be almost 40% [16]. Ethical approval has been obtained from the Universiti Sains Malaysia Human Research Ethics Committee (JEPeM-USM) with the protocol code USM/JEPeM/22080543. A total of 287 older adults were recruited for this study, however after screening 194 older adults with risk of probable sarcopenia (169 people) and sarcopenia risk (25 people) were selected for analysis.

The inclusion criteria for this study were older adults aged 60 years and above, able to walk and move independently without crutches, presence of artificial limbs or limb prothesis. On the other hand, the exclusion criteria of the study were older adults with severe hearing or vision problem, having mobility problems that may limit their ability to perform physical tests such as amputation, stroke, or arthritis for the past 6 months, having severe health problems such as infectious diseases, current stroke, cancer on active treatment or recurrent cancer, end stage renal failure on hemodialysis, amputee, underwent any major surgery recently and severe depressive symptoms indicated by geriatric depression scale (GDS) score of 12 and above.

The data collection was done by administering structured questionnaires via interview approach. The research team was responsible in conducting the interviews and the necessary measurements. The questionnaires that were used in this research had been validated among the study population as reported by previous studies.

The parameters included in this study were sociodemographic profile, comorbidities, polypharmacy, anthropometric measurements, body composition, physical fitness, cognitive function, functional status, and depressive symptoms. Comorbidities was self-reported

by subjects, however this information was confirmed by checking the subject`s hospital medical card which had detailed information of the medications taken by them. In addition, this information was used to determine polypharmacy defined as the use of at least five medications [17].

Cognitive function

The English version of MoCA was developed by (Nasreddine et al., 2005) [18] and translated into the Malay language by Din et al. (2016) [19]. The Cronbach alpha for the MoCA-BM was 0.691 [19]. The MoCA-BM aids in quickly determining a subject's impaired thinking ability, thus in this study it will be used to identify global cognitive impairment among Malaysian older adults. There were eight key cognitive domains in this test namely attention and concentration, executive function, memory, language, visual constructional skills, conceptual thinking, calculations, and orientation. The scoring for MOCA ranged from 0 to 30 whereby a higher score indicated better cognition. Score below 22 indicated risk of dementia [20].

Anthropometry

Weight was measured using the Karada Scan Omron Body Composition Monitor HBF-214 by Omron Healthcare, Kyoto, Japan. Height was taken using stadiometer by Seca North America, Chino, USA. For older adults with scoliosis and kyphosis, height was measured using arm span which was the distance between one finger's middle tip to another finger's middle tip. The height estimation using arm span were calculated using formula by Shahar and Pooy (2003) [21] as shown below:

$$Men : Height = [0.681 \times armspan(cm) + 47.56]$$

$$Women : Height = [0.851 \times armspan(cm) + 18.78]$$

BMI was calculated as weight in kilograms divided by the square of the height in meters (kg/m^2) and was categorized according to cut-off point specific for older adults into three categories, namely underweight (less than 24 kg/m^2), normal (24 kg/m^2 to 27 kg/m^2), and overweight (greater than 27 $kg/m^{2)}$ [22].

Waist circumference was measured at a level midway between the lower rib margin and iliac crest with Lufkin tape all around the body in a horizontal position. Reading of ≥ 90 cm (men) or ≥ 80 cm showed a high risk of cardiovascular diseases [23]. Hip circumference was the measurement of the widest part of the pelvis. Lufkin tape was used to take the measurements.

MUAC was a useful tool for a fast assessment of nutritional status [24]. It was defined as the measurement of distance of mid-point between the acromion point and the olecranon process. Subjects were required to stand upright with their arms bent at the elbow, positioned at 90° with the palms facing upwards. The distance between the acromion and olecranon bones were marked. Measurement of < 23 cm in men and < 22 cm in women indicated muscle wasting [25].

Calf circumference was used for determining presence of sarcopenia. The widest part of the calf was measured to determine calf circumference. This measurement was taken when subject was in a sitting position with their feet touching the ground. According to Chen et al., 2020, the calf circumference with measurement of < 34 cm (men) and < 33 cm in women was the cut-off point to assess for muscle mass and one of the criteria for sarcopenia [3].

Blood pressure was measured using the Omron Blood Pressure Monitor. Two readings were taken. During the measurements, subjects was seated in a relaxed position. Reading was taken to the nearest mmHg.

Body composition

Body composition included fat mass and skeletal muscle mass which were measured using the Karada Scan Omron Body Composition Monitor HBF-214 by Omron Healthcare, Kyoto, Japan. This machine uses single-frequency Bioelectrical Impedance Analysis (BIA) technology which provides useful data on body composition, however, may not accurately diagnose sarcopenia. Body composition was necessary to calculate the skeletal muscle index (SMI). SMI formula was muscle mass divided by square of height. This was also a criterion to determine the risk of sarcopenia. Low muscle mass was indicated by < 7 kg/m^2 for men and < 5.7 kg/m^2 for women [3].

Physical fitness

Physical fitness comprises of eight items namely Short Physical Performance Battery (SPPB), hand grip test, back scratch test, timed-up and go test, two-minute step test and chair sit and reach test.

Short Physical Performance Battery (SPPB)

Lower extremity functioning and muscle performance in older persons were evaluated using the SPPB which was an objective assessment tool [26, 27]. The SPPB had three sets of tests namely balance test, sit-to-stand test, and gait speed. Each test was explained below.

a) Balance test

The balance test had three components namely the side-by-side stand, semi-tandem stand, and tandem stand. The side-by-side stand required the subject

to stand with their feet together for 10 seconds. The semi- tandem stand required the subject to stand with the heel of one foot placed by the big toe of the other foot for 10 seconds. As for tandem stand, subjects were required to put either one foot directly in front of the other foot touching the toes for 10 seconds.

b) Sit-to-stand test
Sit-to-stand test was the second test in SPPB. It required subject to rise from a seated position for five times with arms crossed across shoulders without stopping in between. They would be timed with a stopwatch.

c) Gait speed
The last test in SPPB was gait speed test. This will require subject to walk at their usual pace for 4 meters. This were repeated twice.
The scoring for SPPB was the sum of the three tests components with the maximum score of 12 and a minimum score of 0. The higher the score, the better the muscle function typically at the lower extremities [28]. Subjects who scored ≤ 9 points were considered as having a poor physical performance [3].

Risk of sarcopenia assessment

Risk of sarcopenia were diagnosed based on the revised Asian Work Group for Sarcopenia (AWGS 2019) guidelines [3]. The criteria for sarcopenia used in this study was low muscle mass AND low muscle strength OR low physical performance. Severe sarcopenia was diagnosed when a subject has lower score in all the three components: muscle strength, skeletal muscle mass/quality, muscle performance. Possible sarcopenia was when a subject had either one of the diagnostic criteria (low muscle mass/low muscle strength/ low physical performance) or even a combination of just two criteria (low muscle strength/ low physical performance) excluding low muscle mass.

Muscle strength was measured using hand grip strength using a hand dynamometer (Fabrication Enterprises Inc, New York, USA). Subjects were required to be seated on a chair with no arm rests. They were asked to press the dynamometer as hard as they could with their elbow flexed at 90° and forearm kept at a neutral position. Two readings were taken for both hands with rest of 30 s in between each reading. The highest value of the dominant hand was recorded for analysis to the nearest kg [29]. A poor hand grip strength was categorized according to values of < 28.0 kg (men) and < 18.0 kg (women) [3].

Besides, muscle performance was assessed using the Short Physical Performance Battery (SPPB). Subjects with ≤ 9 points were considered having poor physical performance [3]. Body composition included fat mass and skeletal muscle mass which were measured using the Karada Scan Omron Body Composition Monitor HBF-214 by Omron Healthcare, Kyoto, Japan. Body composition was necessary to calculate the skeletal muscle index (SMI). Low muscle mass was indicated by < 7 kg/m^2 for males and < 5.7 kg/m^2 for females. A subject was categorised as having sarcopenia when they had 'low muscle mass/quality and low muscle strength or low muscle performance'. Severe sarcopenia was characterized by 'a low muscle strength and low skeletal muscle mass/quality and low muscle performance' [3].

Depressive symptoms

Depressive symptoms among subjects was identified using the GDS-15. GDS was first created by Yesavage et al. (1982) which was a 30-item questionnaire which was later simplified into a 15-questions questionnaire [30]. The GDS-15 version had been used extensively in community setting and has a Cronbach alpha value of 0.84 [31]. The scores 0–4 were considered normal, depending on age, education, and complaints; 5–8 indicated mild depression; 9–11 indicated moderate depression; and 12–15 indicated severe depression [32]. Subjective cognitive decline was assessed using item 10 in GDS asking patients about their perception of current cognitive status. Presence of subjective cognitive decline is indicted by answer of `yes` for the question [33].

Functional status

Functional status was asssesed using the Malay version of Instrumental Activities of Daily Living with Cronbach alpha value of 0.838 [34]. There were eight components in this test namely ability to use phone, shopping, food preparation, housekeeping, laundry, mode of transportation, responsibility for own medications and ability to handle finances. The scoring for this test ranges from 0 (indicating low function and is dependent) to 8 (indicating high function and independent) for women and 0 to 5 for men excluding areas of food preparation, housekeeping and laundering to eliminate gender bias [35]. Functional limitation was indicated by score of four and below for men and score of seven and below for women.

Statistical analysis

The data collected were entered and analyzed using IBM SPSS Statistics 26 software. Descriptive statistics was used to summarize the socio-demographic characteristics of subjects, medical problems and falls history, supplement intake, anthropometry, blood pressure, body composition, sarcopenia and cognitive assessment. The numerical data were presented as mean (SD) and median (IQR) based on their normality distribution. The categorical data were presented as frequency (percentage). Based

on normality test using histogram, baseline univariate analysis was done. For normal distribution, independent-t test was used. For non-normal distribution, the median differences between categorical variable with two groups and numerical variable was tested using Mann–Whitney test. On the other hand, Chi-Square analysis was used to test the association between categorical variables. Multivariate analysis using binary logistic regression was employed for identifying the factors associated with dementia among older adults with probable sarcopenia and sarcopenia. Independent variables chosen for the model were those variables significant during the univariate analysis and those with strong association with dementia from previous literature. The significance level was set at p-value less than 0.05. Missing data was handled using the multiple imputation method.

Results

Both the subjects with probable sarcopenia and sarcopenia were mostly of Malay ethnicity with household income of less than MYR1500 ($p < 0.05$). Probable sarcopenia subjects with dementia were older (68.5(7.8) years) as compared to those without dementia (66.0(6.0) years). Those without dementia had better education level as compared to their counterparts in both the probable sarcopenia (12.4(3.8) vs 5.6(3.8) years) and sarcopenia group (7.7(2.6) vs 4.9(4.2) years). Fifty percent of sarcopenic subjects with dementia were reported to either live alone or with their partner with no differences between both probable sarcopenia and sarcopenia groups ($p > 0.05$) (Table 1).

Among the chronic diseases, only hypertension was reported to be significant in both the probable sarcopenia and sarcopenia group. In the probable sarcopenia group, subjects with dementia had reported to have higher percentage of hypertension cases (66.1%) ($p < 0.008$), and for the sarcopenia group 64.3% of the subjects had dementia ($p < 0.021$). Other diseases reported to have no significant difference between the two groups. The probable sarcopenia group with dementia were reported to have higher percentage of functional limitation (48.6%) as compared to the non-demented group (16.7%) ($p < 0.001$) (Table 2).

Findings from Table 3 demonstrated that older adults without dementia with probable sarcopenia had greater weight (66.4(12.3) kg) and lower fat mass (30.4 (6.8) %) as compared to sarcopenia group. Calf circumference was reported to be lowest among non-demented subjects (33.5(4.1) cm) with probable sarcopenia as compared to those with normal cognition with probable sarcopenia (34.1(3.4) cm) ($p < 0.010$). SMI was significantly higher among subjects with probable sarcopenia without dementia (7.0(2.0) %) as compared to dementia subjects (6.7(1.3) %) ($p < 0.001$).

The goodness-of-fit of this logistic regression model was assessed using Hosmer–Lemeshow test which resulted in a Chi-Square value of 5.005 ($p = 0.757$). The non-significant p-value indicated that the model fits the data well. The Nagelkerke R Square value was 0.503, indicated a strong model fit, suggesting that the model predictors explained substantial portion of the variation in the dependent variable. This model had high sensitivity value of 86.2% indicating that the model correctly identified the actual positive dementia risk cases. Multivariate analysis revealed that the factor associated with dementia among probable sarcopenia and sarcopenia older adults is having high blood pressure. Older adults with probable sarcopenia and sarcopenia who had high blood pressure had 4.049 times higher risk of developing dementia (95%CI: 1.510, 10.855; p: 0.005) (Table 4).

Discussion

The prevalence of probable sarcopenia in this study was 87.1%, while sarcopenia was 12.9%. In the Singapore Strengthening Health in Elderly through nutrition (SHIELD) study, which was conducted among 694 community dwelling older adults at risk of malnutrition found almost similar prevalence of possible sarcopenia with the current study, 85%, however sarcopenia was 76% among the SHIELD study participants [36]. In the SHIELD study, men (78.9%) reported to have significantly higher prevalence of sarcopenia as compared to women (74.9%). Probable sarcopenia in the current study is higher compared to other studies. Probable sarcopenia among 201 older people in Klang Valley, Malaysia was 20.4% [37]. However, this study used SARC-F to determine probable sarcopenia. Wong et al. (2022) used the AWGS 2019 to classify probable sarcopenia among stroke patients and found a prevalence of 42.3% [38]. A study conducted among 729 community dwelling older adults in China reported much lower prevalence of probable sarcopenia, 11.11%, assessed using AWGS 2019 with no significant gender differences [39].

This was in agreement with another study conducted among 230 middle-aged and older adults which found sarcopenia prevalence of 12.6% [40]. However, this study by Foo et al. was only conducted among Chinese people residing in one particular area in Kelantan. Another cross-sectional study conducted among 393 community dwelling older people in Klang Valley reported a higher prevalence of sarcopenia 33.6%, however this study focused among urban older adults [41]. A study in China involving 4500 multiethnic older adults identified 19.31% of sarcopenia [42]. Rapid decline in testosterone and insulin-like growth factor-1 levels leads to poorer muscle strength and mass in men. Meanwhile in women, decreasing muscle mass and function was

Table 1 Sociodemographic characteristic according to sarcopenia status

Variables	Probable sarcopenia (*n* = 169)			Sarcopenia (*n* = 25)		
	Dementia (*n* = 109)	No dementia (*n* = 60)	*p-value*	Dementia (*n* = 14)	No dementia (*n* = 11)	*p-value*
Age[+a]	68.5 (7.8)	66.0 (6.0)	0.005*	70.0 (9.5)	73.0 (16.0)	1.000
Gender[+++b]			0.134			1.000
Men	56 (51.4)	38 (63.3)		11 (78.6)	8 (72.7)	
Women	53 (48.6)	22 (36.7)		3 (21.4)	3 (27.3)	
Race[+++b]			< 0.001*			0.033*
Malay	63 (57.8)	56 (93.3)		7 (50.0)	8 (72.7)	
Chinese	11 (10.1)	4 (6.7)		1 (7.1)	3 (27.3)	
Siamese	35 (32.1)	0 (0.0)		6 (42.9)	0 (0.0)	
Income[+++b]			< 0.001*			0.195
< MYR1500	80 (89.9)	26 (57.8)		14 (100.0)	7 (63.6)	
> MYR1500	9 (10.1)	19 (42.2)		0 (0.0)	4 (36.4)	
Marital Status[+++b]			0.278			0.661
Married	75 (68.8)	46 (76.7)		10 (71.4)	9 (81.8)	
Unmarried	34 (31.2)	14 (23.3)		4 (28.6)	2 (18.2)	
Divorced/Widow						
Occupation (Current) [+++b]			0.168			0.116
Private/ Self-work	35 (32.1)	13 (22.0)		8 (57.1)	2 (18.2)	
Unemployed	74 (67.9)	46 (78.0)		6 (42.9)	9 (81.8)	
Occupation (Previous) [+++b]			< 0.001			0.410
Government	15 (13.8)	31 (51.7)		4 (28.6)	4 (36.4)	
Private	13 (11.9)	8 (13.3)		3 (21.4)	2 (18.2)	
Own	66 (60.6)	15 (25.0)		6 (42.9)	2 (18.2)	
Unemployed	15 (13.8)	6 (10.0)		1 (7.1)	3 (27.3)	
Education Years[++c]	5.6 (3.8)	12.4 (3.8)	< 0.001*	4.9 (4.2)	7.7 (2.6)	0.010*
Living Arrangement[+++b]			0.096			0.156
-Alone/with Partner Only	30 (27.5)	24 (40.0)		7 (50.0)	1 (9.1)	
-With Partner& Children/ Children only	79 (72.5)	36 (60.0)		7 (50.0)	10 (90.9)	

[+] Median (IQR)

[++] Mean (SD)

[+++] n (%)

[a] Mann-Whitney test

[b] Pearson Chi Square

[c] Independent t-test

[*] Significant at *p*-value less than 0.05

significant during the early phase of menopause due to rapid decrease in estrogen level [43].

The current study findings demonstrated that subjects with probable sarcopenia (64.5%) and sarcopenia (56.0%) had the highest prevalence of dementia. Similarly, a study conducted by Cipolli et al. (2021) also reported higher prevalence of cognitive impairment with lower scores in MMSE, visual reproduction and clock drawing test among older adults with probable sarcopenia [44]. Skeletal muscle releases several components such as myokines, cytokines and chemokines which are able to mediate muscle-brain signaling for coordinating complex functions such as learning, memory, and motor coordination as well as strengthening global cognitive function [45]. The risk of mild cognitive impairment (MCI) was 1.72 times higher among older adults with sarcopenia. MCI individuals are usually sedentary and have poor dietary habits which increases their risk of several chronic diseases such as diabetes mellitus, hypertension, hyperlipidemia and metabolic syndrome [46].

Table 2 Medical history and health conditions according to sarcopenia categories

Variables	Probable sarcopenia (*n* = 169)			Sarcopenia (*n* = 25)		
	Dementia (*n* = 109)	No dementia (*n* = 60)	*p-value*	Dementia (*n* = 14)	No dementia (*n* = 11)	*p-value*
Chronic Diseases[++a]						
HBP	72 (66.1)	27 (45.0)	0.008*	9 (64.3)	2 (18.2)	0.021*
High Cholesterol	68 (62.4)	33 (55.0)	0.349	8 (57.1)	7 (63.6)	0.742
Diabetes	38 (34.9)	19 (31.7)	0.674	2 (14.3)	0 (0.0)	0.191
Heart Diseases	17 (15.6)	8 (13.3)	0.692	2 (14.3)	1 (9.1)	1.000
Arthritis	34 (31.2)	14 (23.3)	0.278	1 (7.1)	4 (36.4)	0.133
Stroke	6 (5.5)	1 (1.7)	0.423	1 (7.1)	1 (9.1)	0.859
GIT	31 (28.7)	12 (20.3)	0.237	0 (0.0)	3 (27.3)	0.072
Hearing problems	12 (20.1)	2 (3.4)	0.222	0 (100)	0 (100)	-
Vision problem	10 (9.2)	8 (13.6)	0.380	3 (21.4)	3 (27.3)	0.734
Chewing problem	24 (22.0)	12 (20.0)	0.759	6 (42.9)	2 (18.2)	0.189
Swallowing problem	3 (2.8)	3 (5.0)	0.450	0 (100.0)	0 (100.0)	-
Covid-19	34 (31.2)	18 (30.0)	0.872	1 (7.1)	4 (36.4)	0.070
Smoking[a]	31 (28.4)	22 (36.7)	0.270	7 (50.0)	4 (36.4)	0.495
	78 (71.6)	38 (63.3)		7 (50.0)	7 (63.6)	
Polypharmacy[a]						
Yes	13 (11.9)	7 (11.7)	1.000	2 (14.3)	1 (9.1)	0.692
No	96 (88.1)	53 (88.3)		12 (85.7)	10 (90.9)	
Sleeping problems[a]						
Yes	29 (26.6)	13 (22.0)	0.578	4 (28.6)	3 (27.3)	0.943
No	80 (73.4)	47 (78.0)		10 (71.4)	8 (72.7)	
Blood Pressure[a]						
Systolic[+]	137.5 (21.5)	135.8 (20.3)	0.883	140.4 (25.6)	130.0 (21.8)	0.293
Diastolic[+]	73.3 (9.3)	77.0 (16.0)	0.978	68.1 (14.3)	71.5 (14.7)	0.568
GDS[a]			0.343			
Normal	84 (76.9)	46 (76.7)		11 (78.6)	10 (90.9)	0.404
Mild Depression	24 (22.2)	11 (18.3)		3 (21.4)	1 (9.1)	
Moderate Depression	1 (0.9)	2 (3.3)				
Severe Depression	0 (0.0)	1 (1.7)				
Subjective Cognitive Decline[a]			0.144			
Yes	47 (43.1)	19 (31.7)		7 (50.0)	3 (27.3)	0.250
No	62 (56.9)	41 (68.3)		7 (50.0)	8 (72.7)	
IADL[a]						
Functional Limitation	53 (48.6)	10 (16.7)	< 0.001*	1 (7.1)	2 (18.2)	0.399
Normal functioning	56 (51.4)	50 (83.3)		13 (92.9)	9 (81.8)	

[+] Mean (SD)

[++] n (%)

Abbreviations: *HBP* High blood pressure, *GDS* Geriatric depression scale, *GIT* Gastrointestinal tract, *IADL* Instrumental activities of daily living

[a] Pearson Chi Square

[b] Independent t-test

[*] Significant at *p*-value less than 0.05

In addition, fat mass was reported to be significantly higher among probable sarcopenia older adults with dementia (33.0(6.5)%). Intramuscular fat infiltration increases the risk of obesity. Obese individuals are exposed to increased levels of cytokine which produces paracrine signals that promotes differentiation of muscle progenitor cells to adipocycte-like phenotype. Adequate amount of muscle tissue lowers the likelihood of

Table 3 Anthropometry and body composition of participants according to sarcopenia categories

Variables	Probable sarcopenia (*n* = 169)			Sarcopenia (*n* = 25)		
	Dementia (*n* = 109)	No dementia (*n* = 60)	*p-value*	Dementia (*n* = 14)	No dementia (*n* = 11)	*p-value*
Weight[+a], kg	63.4 (10.1)	66.4 (12.3)	0.029*	52.7 (7.3)	54.7 (6.5)	0.622
Height[+a], cm	158.4 (7.3)	162.4 (7.5)	0.009*	158.6 (6.8)	161.5 (6.8)	0.298
BMI[b], n (%)			0.219			0.596
Underweight	23 (21.1)	17 (28.3)		11 (78.6)	10 (90.9)	
Normal	37 (33.9)	13 (21.7)		2 (14.3)	1 (9.1)	
Overweight	49 (45.0)	30 (50.0)		1 (7.1)	0 (0.0)	
BMI	25.8 (4.3)	26.2 (4.5)	0.567	20.9 (3.9)	21.3 (2.6)	0.834
Waist Circumference[+a], cm	90.6 (9.2)	93.4 (9.8)	0.223	77.1 (11.9)	79.5 (78.1)	0.683
Hip Circumference[+a], cm	97.7 (10.8)	97.8 (7.5)	0.958	87.1 (5.4)	89.5 (5.0)	0.437
MUAC[+a], cm	29.0 (4.4)	29.0 (4.5)	0.089	25.7 (2.8)	26.5 (1.59)	0.503
Calf Circumference[+a], cm	34.1 (3.4)	35.5 (4.1)	0.010*	31.7 (1.59)	32.3 (2.7)	0.338
Body Composition						
Muscle Mass[+a], (%)	26.6 (3.9)	28.1 (4.1)	0.094	30.5 (3.7)	28.8 (3.3)	0.884
Fat Mass[+a], (%)	33.0 (6.5)	30.4 (6.8)	0.010*	27.2 (6.0)	28.1 (6.4)	0.754
SMI[++c]	6.7 (1.3)	7.0 (2.0)	< 0.001*	6.6 (1.1)	6.2 (1.4)	0.584

[+] Mean (SD)

[++] Median (IQR)

[+++] n (%)

[a] Independent t-test

[b] Pearson Chi Square

[c] Mann-Whitney test

[*] Significant at *p*-value less than 0.05

Alzheimer`s disease (AD). In diet-induced animal model, increasing fat mass is associated with low grade inflammation which will lead to neuroinflammation in the hypothalamus, hippocampus, amygdala, cerebral cortex and cerebellum [47]. As a result, loss of neural integrity or density will be observed leading to cognitive decline. Gonzales et al. (2012) assessed neuroinflammation via the elevated ratio of myoinositol (mIns) to creatine (Cr) in the occipitoparietal cortex [48]. On the other hand, Coplan et al. (2014) reported that increasing BMI or fat mass was associated with lower levels of N-acetylaspartate (NAA) in the hippocampus [49]. A longitudinal study discovered that accumulation of fat in liver, muscle fat infiltration and weight-to-muscle ratio were associated with brain ageing [50].

Findings from multivariate analysis revealed that hypertension was the only significant risk factor of dementia risk among older adults with probable sarcopenia and definitive sarcopenia. Baseline hypertension among men was associated with cognitive impairment four to six years later, but not in women in the Framingham Heart Study. The optimal target for systolic blood pressure was below 130 mmHg for the prevention of cerebrovascular accident according to the 2018 European Hypertension Guidelines [51]. The mechanism underlying the hypertension and dementia is the interference with cerebral blood flow and poor cellular stress resilience which contributed to molecular damage, oxidative stress, endothelial dysfunction, inflammation and blood–brain barrier damage. Uncontrolled hypertension increases the risk of plaque formation in the cerebral arteries which affected cerebral blood flow thus leading to ischemic stroke and cognitive impairment [52]. Hypertension is closely related to sarcopenia via endothelial insulin resistance. Insulin resistance interferes with the mTOR pathway which may accelerate muscle loss [53]. In addition, sarcopenic obesity is associated with arterial stiffness. Higher visceral fat among sarcopenic obese patients is related to elevated levels of pro-inflammatory cytokines which may contribute to hypertension [54].

This study has several strengths and limitations. The strength of this study is it focuses on possible sarcopenia which is a condition which may lead to sarcopenia if no lifestyle interventions were taken. This study is not without its limitations. The limitation of this study is its cross-sectional nature which limits identification of causal relationship. The results of this study may not be generalized to other part of the country as it involves patients

Table 4 Factors associated with risk of dementia among older adults with probable sarcopenia and sarcopenia

Variables	B	S.E	Exp (B)	95% C.I for EXP(B)		*p-value*
				Lower	Upper	
HBP	1.398	0.503	4.049	1.510	10.855	0.005*
High cholesterol	−0.848	0.498	0.428	0.161	1.137	0.089
Diabetes	−0.277	0.477	0.758	0.298	1.931	0.562
Heart diseases	0.167	0.609	1.182	0.358	3.900	0.784
Arthritis	0.096	0.509	1.100	0.406	2.982	0.851
Stroke	−0.176	1.175	0.839	0.084	8.400	0.881
Smoking	0.153	0.538	1.165	0.406	3.344	0.777
Systolic BP	−0.007	0.013	0.994	0.968	1.019	0.620
Diastolic BP	−0.003	0.024	0.902	0.952	1.045	0.997
Waist circumference	0.018	0.033	1.018	0.955	1.085	0.587
Hip circumference	0.016	0.040	1.016	0.939	1.100	0.687
MUAC	−0.139	0.103	0.870	0.711	1.065	0.176
Calf circumference	−0.119	0.087	0.888	0.749	1.054	0.173
IADL	−0.177	0.141	0.837	0.635	1.105	0.209
Polypharmacy	−0.093	0.663	0.911	0.248	3.341	0.888
Muscle mass	−0.022	0.217	0.979	0.640	1.497	0.921
Fat mass	0.143	0.120	1.154	0.912	1.460	0.233

Adjusted for age, gender, education years, GDS

Abbreviation: *HBP* High blood pressure, *GIT* Gastrointestinal, *BP* Blood pressure, *GDS* Geriatric Depression Scale, *MUAC* Mid-upper arm circumference, *IADL* Instrumental activities of daily living, *SE* Standard error, *CI* Confidence interval

Dependent variable: Dementia (0 = No dementia, 1 = Dementia)

* Significant at *p*-value less than 0.05

from only one state in Malaysia. Besides that, this study used single-frequency BIA for assessing low muscle mass which may not be accurate. Future studies should use reliable method such as Dual-Energy X-ray Absorptiometry (DXA).

Conclusion

Probable sarcopenia prevalence in the current study is 87% which is higher than other similar studies. Univariate analysis revealed that among older adults with probable sarcopenia, 48.6% of functional limitation and 66.1% of hypertension cases were reported by those with higher risk of dementia. Lower fat mass and higher skeletal muscle index was reported among probable sarcopenia older adults without dementia. The multivariate findings of this study found that high blood pressure was the only factor associated with dementia among probable sarcopenia and sarcopenia older adults. Ageing itself is a significant risk factor of sarcopenia. Presence of other aggravating factors such as dementia, sarcopenia, underlying comorbidities, unhealthy eating habits, physical inactivity may further increase the risk of hypertension. Future studies may focus on other parameters such as inflammation, oxidative stress and dietary habits of patients with probable sarcopenia and sarcopenia.

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Authors' contributions
NIL and DV wrote the main manuscript. DV, NIL, DD, WRWI, and RM were involved in study design, conception, data analysis, review results and final approval of the manuscript.

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Data availability
The dataset used to analyse these data will be available from the corresponding author on a reasonable request.

Declarations

Ethics approval and consent to participate
This study has obtained ethical approval from the Human Research Ethics Committee Universiti Sains Malaysia (USM) with the approval number of USM/JEPeM/22080543. All the participants of this study provided informed consent to participate in this study.

Consent for publication
All participants involved in this research agreed for their data to be published anonymously. No individual patient name will be revealed.

Competing interests
The authors declare no competing interests.

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