ORIGINAL ARTICLE

Prevalence and Risk Factors of Sarcopenia Among Community Dwelling Older Adults in Klang Valley

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ABSTRACT

Introduction: Sarcopenia is one of the geriatric syndromes affecting the ability of older adults to lead an independent living. However, its risk factors among Malaysian older adults are yet to be determined. This study investigated the prevalence and risk factors of sarcopenia among community-dwelling older adults in Klang Valley. **Methods:** This cross-sectional study involved 393 Malaysians aged 60 and above, residing in urban areas of Klang Valley recruited through convenience sampling. Socio-demographic and food intake information were obtained using validated questionnaires. Cut-off points for sarcopenia screening were obtained from the Asian Working Group of Sarcopenia(AWGS) while body impedance analysis(BIA) was employed to determine skeletal muscle index. A handgrip dynamometer was used to assess dominant handgrip strength and a 6-meter gait speed test was used to determine walking speed. Binary logistic regression analysis was used to determine the risk factors of sarcopenia. **Results:** Prevalence of sarcopenia was 33.6% and women(35.9%) were more affected compared to men(30.1%). The mean age of women assessed to have sarcopenia(69.1±6.5 years old) was higher compared to men(68.3±5.8 years old) ($p<0.05$). After adjusting for confounding factors, older adults with one year increased in age and one mg decreased in habitual dietary iron intake were estimated to be 1.08 times and 0.93 times the chances to have sarcopenia respectively. **Conclusion:** Approximately one-third of community-dwelling older adults in Klang Valley were assessed to have sarcopenia. Older adults aged 60 years and above and those with low dietary iron intake were at an increased risk of developing sarcopenia.

Keywords: Community-dwelling, Iron intake, Older adults, Risk factors, Sarcopenia

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INTRODUCTION

Ageing is associated with structural and functional changes leading to a gradual decrease in physical and mental capacity, increasing risk of chronic diseases, multiple admissions to hospitals and ultimately death (1, 2). The world's population is ageing and it is predicted by 2050, the world's population aged 60 years old and above is expected to stand at 2 billion (2). It is also predicted that in 2040, Malaysia will become an ageing nation with approximately 15% of the population being at 60 years old and above (3). The ultimate aim is to achieve healthy ageing and as per World Health Organization definition, "the process of developing and maintaining the functional ability that enables wellbeing in older age" (4).

One of the most prominent issues that inhibit healthy ageing is sarcopenia or decrease in physical strength and loss of skeletal muscle mass as a result of ageing. It is hypothesized that individuals lose 15% of muscle mass per decade after the age of 50 years old and 30% per decade after the age of 70 years old (5). In a meta-analysis conducted by Mayhew et al. (2019), the prevalence of sarcopenia among community-dwelling older adults worldwide lies between 9.9 to 40.4% depending on the definition used (6). As per Asian Working Group of Sarcopenia (AWGS) cut-off points, the prevalence of sarcopenia among Asians was reported to be about 4.1 to 11.5% (7).

Some of the issues raised in epidemiological studies of sarcopenia includes a no consensus on clinical definition of sarcopenia as there are many different cut-offs points available globally. There is also a difficulty in assessing

quantity and function of skeletal muscle mass (8). In many earlier studies, clinicians and researchers used functional parameters related to strength for example handgrip strength measured using a dynamometer and/or a measurement related to performance such as gait speed (8). On the other hand, there are many different instruments such as body impedance analysis (BIA), dual-energy X-ray absorptiometry (DXA), magnetic resonance imaging (MRI), computerized tomography scan (CT scan) and ultrasonic devices that can be used to determine quantity of skeletal muscle mass.

The mechanisms behind the cause of sarcopenia is unclear but is generally thought to be multifactorial. Environmental causes such as poor dietary intake, sedentary lifestyle, smoking and alcohol intake, intrinsic factors such as age and genetics, co-morbidities and polypharmacy are some of the contributing factors (9). In community-dwelling population, those who are still mobile and capable of carrying out their activities of daily living, the most notable environmental cause was decline in food intake due to loss of appetite (10). The three main nutrients that played an important role in muscle maintenance are protein, leucine and vitamin D (10). Decline in food intake is usually attributed to changes in the digestive system, medication intake which alters the sense of taste and smell, pain, disease burden, changes in vision, loss of teeth that causes chewing difficulties and a decreased need for energy (9). In the local context, prevalence of sarcopenia among Malaysian older adults in Klang Valley was 59.8% as assessed using Skeletal Muscle Index (SMI), with no risk factors detected (11). Later, Rosli et al (2017) reported prevalence of sarcopenia of 50.5% using SMI and 32.2% using a more comprehensive algorithm, the European Working Group of Sarcopenia (EWGSOP), with age ≥75 years old and arthritis noted as risk factors (12). It is noteworthy that, dietary factors have not been adequately assessed in the previous studies. Thus, in this study, we aimed to determine the prevalence of sarcopenia using a more recent criterion, the Asian Working Group of Sarcopenia (AWGS) and to identify a wider range of risk factors including diet intake in Malaysian community-dwelling older adults in Klang Valley.

MATERIALS AND METHODS

Study design & subjects selection

This cross-sectional study is a part of a larger randomized controlled trial study which provides high protein oral nutrition supplement (ONS) to older adults suffering from sarcopenia. It was carried out over a period of 5 weeks from September 2019 to October 2019 among multi-ethnic older adults aged 60 years old and above. Subjects were recruited using convenience sampling from the lower income households (< RM 4850 or USD 1158) [Projek Perumahan Rakyat (PPR) and Perumahan Awam (PA)], middle income households (< RM 10960 or USD 2616) (flats and mosques) and upper income households (≥ RM 10960 or USD 2616) (Rukun Tetangga). Ethical approval was obtained at the institutional level from UKM Research Ethics Committee (NN-2019-098) and consent was also obtained from Kuala Lumpur City Hall (DBKL) and the respective committees in the communities' (Rukun Tetangga) for the use of the community centres as data collection grounds. Other tools used to recruit subjects were posters, banners, flyers and WhatsApp messages. The inclusion criteria included individuals aged 60 years and above, community-dwelling subjects residing for at least a year in Klang Valley, those with no disabilities that affected standing balance, walking and dominant handgrip strength and also those with no mental issues. Written informed consent was obtained from all subjects.

Demography, health profile & dietary intake

Subjects were interviewed to obtain data on sociodemographic, lifestyle and also health behaviors (smoking, alcohol intake and frequency of exercising, presence of diseases and number of medication intake). All the demography and health profiles were self-reported by the subjects. Assessment of food intake was carried out using a validated Diet History Questionnaire (DHQ) (13). The information gathered from DHQ was analyzed using the Nutritionist Pro (Axxya Systems Stafford, USA) software.

Determination of sarcopenia

In this study, sarcopenia was classified based on the cut-off points in The Asian Working Group for Sarcopenia (AWGS) (7). Three different parameters were measured including skeletal muscle index (SMI), dominant handgrip strength and gait speed tests. SMI is the sum of the lean mass of the four limbs (appendicular lean mass) normalized for height. The cut-off points of each of the parameters are defined as below (7):

(i) Poor SMI was determined using Body Impedance Analysis (BIA), InBody 270 (In Body Co. Ltd., Korea) and the cutoff points are < 7.0 kg/m2 for male and < 5.7 kg/m2 for female. Other anthropometry measurements such as weight, body mass index (BMI), skeletal muscle mass, body fat mass and percentage body fat was also determined using the same instrument.

(ii) Poor gait speed was determined using 6m gait speed test and the cut-off point defined as ≤ 0.8 m/s for both males and females.

(iii) Poor hand grip strength was determined using Takei 5401 Hand Grip Dynamometer (Takei Co., Ltd., Japan) and cut-off points are defined as < 26 kg for males and < 18 kg for females.

Muscle wasting or sarcopenia was classified as three different categories based on the cumulative readings of the three different parameters (14). These three categories are pre-sarcopenia, sarcopenia and severe sarcopenia. Low muscle mass without an influence on muscle strength or athletic performance defines the 'pre-

sarcopenia' stage. This stage can only be identified by techniques that measure muscle mass accurately and in reference to standard populations. The 'sarcopenia' stage is characterized by low muscle mass, plus low muscle strength or low physical performance. When all three conditions of the criterion are met (low muscle mass, low muscle strength and low physical performance), the stage is called 'severe sarcopenia' (14). There is also sarcopenic obesity where there is a loss in muscle mass which is associated with increased body fat so that despite normal weight there is marked weakness (15).

Statistical analysis

All statistical analysis was conducted using Statistical Package for Social Sciences (SPSS) version 23. All parameters were presented in mean and standard deviation for continuous variables whereas frequencies and percentages were presented for categorical variables. Normality test was employed prior to all statistical tests. Chi-square test was employed for categorical variables while independent t-test was employed for continuous variables. The relationship between potential risk factors and sarcopenia was determined by deriving odds ratios (ORs) and 95% confidence intervals (CIs) using chi-square test. Subsequently, variables with $p < 0.05$ were included into a binary logistic regression analysis by considering weight, years of education, polypharmacy, kidney disease and calcium intake, sarcopenia (as per AWGS criteria) as confounding factors. The model was constructed with Forward LR algorithm used to identify the independently associated factors of sarcopenia. Goodness-of-fit for binary logistic regression models was assessed using the Hosmer-Lemeshow test (H-L test). Multicollinearity among variables using the variance inflation factor and significant differences were defined by $p < 0.05$.

RESULTS

Prevalence of sarcopenia

As shown in Table I, a total of 393 older adults volunteered to participate, with the mean age of the subjects ranging from 60 to 86 years old at 67.4 ± 5.5 years old. The subjects with sarcopenia (68.9 ± 6.3) were significantly older in age ($p<0.001$) than those without sarcopenia (66.6 ± 5.0 years old). The prevalence of sarcopenia was 30.1% in men and 35.9% in women with an overall prevalence of 33.6%. (Figure 1). Most of the subjects were categorized as sarcopenia with a total prevalence of 14.5% and a subsequent breakdown of prevalence in men being 14.7% and prevalence in women being 14.3%. On the other hand, total prevalence of pre-sarcopenia was 11.2% with a breakdown of 9.6% in men and 12.3% prevalence in women. Besides that, total prevalence of severe sarcopenia was 7.1% with a breakdown of 5.8% in men and 8.0% in women. Total prevalence of sarcopenic obesity was 0.8% and it was only seen in 1.3% of the women. The results from χ^2 analyses which is to investigate the association between various independent variables and incidence of sarcopenia between genders are shown in Table I.

Anthropometry and functional measurements between sarcopenia and non-sarcopenia subjects

The results in Table II showed that subjects with sarcopenia had lower weight (men: 57.5 ± 7.2kg; women: 50.4 ± 8.0kg), BMI (men: 22.7 ± 3.2 kg/m^2 ; women: 22.7 ± 3.5 kg/m^2), skeletal muscle mass (men: 21.4 ± 3.2kg; women:16.2 ± 2.3kg), skeletal muscle index (men: 7.7 ± 0.5 kg/m^2); women: 5.0 ± 0.6 kg/m^2) and body fat mass (men:17.5 ± 5.6 kg; women: 18.9 ± 6.1kg) compared to subjects without sarcopenia in both men and women ($p<0.05$ for all parameters). As for percentage body fat, a significant difference ($p<0.001$) was noted in the percentage body fat of non-sarcopenic women (42.7 ± 5.8%) as compared to women with sarcopenia (36.6 ± 7.1%). As for functional measurements, there was a significant difference ($p<0.001$) in handgrip strength among men (23.1 ± 7.8 kg) and women (16.5 ± 4.6 kg).

Nutrient and food intake between genders

The results in Table III showed that there was a lower net intake of energy, carbohydrate, protein, fat and sodium in subjects with sarcopenia as compared to non-sarcopenic subjects but no significant differences were noted. A significant difference was noted in iron intake (non-sarcopenic: 13 ± 11 mg/day; sarcopenia: 6 ± 5 mg/day) and calcium intake (non-sarcopenic: 419 ± 231 mg/day; sarcopenia: 348 ± 165 mg/day) between sarcopenic status in men ($p<0.05$ for both parameters). Dietary fiber, vitamin D and leucine showed about similar values between non sarcopenic and sarcopenic men and women. When this intake was compared to the Recommended Nutrient Intake (RNI) 2017 (24); energy, protein, calcium, dietary fiber, leucine and vitamin D intake did not meet the RNI but the carbohydrate, fat and iron intake (except sarcopenic men) met the daily RNI. Only sodium intake over exceeded the RNI.

Factors associated with sarcopenia incidence between genders

The variables with significant associations ($p<0.05$) were selected from Table I and Table II and inserted into the hierarchical binary logistic regression model (Table IV). After grouping the "unsure" and "no" variables together and adjusting for weight, years of education, polypharmacy, kidney disease and calcium intake, sarcopenia (as per AWGS criteria) was found to be older adults with one year increased in age and one mg decreased in habitual dietary iron intake were estimated to be 1.08 times and 0.93 times the chances to have sarcopenia respectively ($p<0.001$).

DISCUSSION

Malaysia has the highest rate of obesity in South East Asia, eventually contributing to being the most populous diabetic country in South East Asia (16). Excess energy

Table I: Demography, lifestyle and health behaviours of community dwelling older adults

	Men (n= 156)						Women (n= 237)						Total (n= 393)					
Factor	n	Non-sarcopenia	Sarcopenia	Crude OR	95% CI	p*	n	Non-sarcopenia	Sarcopenia	Crude OR	95% CI	p*	n	Non-sarcopenia	Sarcopenia	Crude OR	95% CI	p*
Ethnicity																		
Malay	76	54 (71.1)	22 (28.9)	NA	NA	0.917	110	71 (64.5)	39(35.5)	NA	NA	0.543	186	125 (67.2)	61 (32.8)	NA	NA	0.747
Chinese	37	26 (70.3)	11 (29.7)				55	32 (58.2)	23(41.8)				92	58 (63.0)	34 (37.0)			
Indian	43	29 (67.4)	14 (32.6)				71	49 (69.0)	22(31.0)				114	78 (68.4)	36 (31.6)			
Bumiputra	0	0 (0)	0 (0)				1	1 (100.0)	0 (0)				1	1(100.0)	0 (0)			
Marital status																		
Single	28	16 (57.1)	12 (42.9)	NA	NA	0.694	144	88 (61.1)	56 (38.9)	NA	NA	0.653	172	104 (60.5)	68 (39.5)	NA	NA	0.274
Married	128	93 (72.7)	35 (27.3)				93	65 (69.9)	28 (30.1)				221	158 (71.5)	63 (28.5)			
Residing with																		
Alone	10	6 (60.0)	4 (40.0)	0.626	0.168-	0.482	38	20 (52.6)	18 (47.4)	0.551	0.273-	0.094	48	26 (54.2)	22 (45.8)	0.546	0.296-	0.050
Family	146	103 (70.5)	43 (29.5)		2.331		199	133 (66.8)	66 (33.2)		1.112		345	236 (68.4)	109 (31.6)		1.006	
Education level																		
Informal	2	1 (50.0)	1 (50.0)				32	22 (68.8)	10 (31.3)				34	23 (67.6)	11 (32.4)			
Primary	44	26 (59.1)	18 (40.9)	NA	NA	0.165	105	64 (61.0)	41 (39.0)	NA	NA	0.876	149	90 (60.4)	59 (39.6)	NA	NA	0.152
Secondary	83	61 (73.5)	22 (26.5)				80	54 (67.5)	26 (32.5)				163	115 (70.6)	48 (29.4)			
STPM/Diploma	3	1 (33.3)	2 (66.7)				2	1 (50.0)	1 (50.0)				5	2 (40.0)	3 (60.0)			
Certificate	13	10 (76.9)	3 (23.1)				10	6 (60.0)	4 (40.0)				23	16 (69.6)	7 (30.4)			
Tertiary	11	10 (90.9)	1(9.1)				8	6 (75.0)	2 (25.0)				19	16 (84.2)	3 (15.8)			
Current Working status																		
Not working	109	74 (67.9)	35(32.1)	0.725	0.336 –	0.411	187	117 (62.6)	70 (37.4)	0.650	0.328 –	0.215	296	191 (64.5)	105 (35.5)	0.666	0.401 –	0.116
Still Working	47	35 (74.5)	12 (25.5)		1.564		50	36 (72.0)	14 (28.0)		1.289		97	71 (73.2)	26 (26.8)		1.108	
Household income, (RM)																		
<1000	62	44 (71.0)	18 (29.0)	NA	NA	0.779	116	70 (60.3)	46 (39.7)	NA	NA	0.188	178	114 (64.0)	64 (36.0)	NA	NA	0.583
1000 to 2999	60	39 (65.0)	21 (35.0)				79	56 (70.9)	23 (29.1)				139	95 (68.3)	44 (31.7)			
3000 to 4999	18	14 (77.8)	4 (22.2)				23	13 (56.5)	10 (43.5)				41	27 (65.9)	14 (34.1)			
≥5000																		
Unknown	15	11 (73.3)	4 (26.7)				16	13 (81.3)	3 (18.8)				31	24 (77.4)	7 (22.6)			
	1	1 (100.0)	0 (0)				3	1 (33.3)	2 (66.7)				4	2 (50.0)	2 (50.0)			
Read																		
Yes	147	105 (71.4)	42 (28.6)	3.125	0.8-	0.087	195	127 (65.1)	68 (34.9)	1.149	0.577-	0.692	342	232 (67.8)	110 (32.2)	1.476	0.809-	0.203
No	9	4 (44.4)	5 (55.6)		12.207		42	26 (61.9)	16 (38.1)		2.289		51	30 (58.8)	21 (41.2)		2.696	
Write	145																	
Yes	11	103 (71.0)	42 (29.0)	2.044	0.591-	0.250	185	121 (65.4)	64 (34.6)	1.182	0.626-	0.607	330	224 (67.9)	106 (32.1)	1.390	0.798-	0.243
No		6 (54.5)	5 (45.5)		7.061		52	32 (61.5)	20 (38.5)		2.231		63	38 (60.3)	25 (39.7)		2.422	
Count																		
Yes	153	107 (69.9)	46 (30.1)	1.163	0.103-	0.903	206	134 (65.0)	72 (35.0)	1.175	0.540-	0.683	359	241 (67.1)	118 (32.9)	1.264	0.612-	0.526
No	3	2 (66.7)	1 (33.3)		13.148		31	19 (61.3)	12 (38.7)		2.557		34	21 (61.8)	13 (38.2)		2.613	
Exercise Intensity																		
Light	50	33 (66.0)	17 (34.0)	NA	NA	0.447	68	42 (61.8)	26 (38.2)				118	75 (63.6)	43 (36.4)	NA	NA	0.092
Moderate	15	13 (86.7)	2 (13.3)				8	7 (87.5)	1 (12.5)				23	20 (87.0)	3 (13.0)			
Light-Moderate	4	3 (75.0)	1 (25.0)				4	4 (100.0)	0 (0)	NA	NA	0.119	8	7 (87.5)	1 (12.5)			
Heavy	5	3 (60.0)	2 (40.0)				0	0 (0)	0 (0)				5	3 (60.0)	2 (40.0)			
Smoking																		
Yes	48	30 (62.5)	18 (37.5)				2	2 (100.0)	0(0)				50	32 (64.0)	18 (36.0)			
No	69	53 (76.8)	16 (23.2)	NA	NA	0.222	232	150 (64.7)	82 (35.3)	NA	NA	0.305	301	203 (67.4)	98 (32.6)	NA	NA	0.840
Ex-smoker	39	26 (66.7)	13 (33.3)				3	1 (33.3)	2 (66.7)				42	27 (64.3)	15 (35.7)			

Table I: Demography, lifestyle and health behaviours of community dwelling older adults (continued)

	Men (n= 156)						Women (n= 237)						Total (n= 393)					
Factor	n	Non-sarcopenia	Sarcopenia	Crude OR	95% CI	p*	n	Non-sarcopenia	Sarcopenia	Crude OR	95% CI	p*	n	Non-sarcopenia	Sarcopenia	Crude OR	95% CI	p*
Alcohol intake																		
Yes	28	20 (71.4)	8 (28.6)	NA	NA	0.866	13	11 (84.6)	2 (15.4)	NA	NA	0.296	326	214 (65.6)	112 (34.4)	NA	NA	0.439
No	105	74 (70.5)	31 (29.5)				221	140 (63.3)	81 (36.7)				26	17 (65.4)	9 (34.6)			
Ex-drinker	23	15 (65.2)	8 (34.8)				3	2 (66.7)	1 (33.3)				0	0(0)	0(0)			
Uses walking aid																		
Yes	5	3 (60.0)	2 (40.0)	0.637	0.103-	0.625	10	6 (60.0)	4 (40.0)	0.816	0.224-	0.758	15	9 (60.0)	6 (40.0)	0.741	0.258-	0.577
No	151	106 (70.2)	45 (29.8)		3.941		227	147 (64.8)	80 (35.2)		2.978		378	253 (66.9)	125 (33.1)		2.128	
Poor appetite																		
Yes																		
No	22	13 (59.1)	9 (40.9)	NA	NA	0.407	37	22 (59.5)	15 (40.5)	0.773	0.377-	0.480	59	35 (59.3)	24 (40.7)	NA	NA	0.342
Unsure	133	95 (71.4)	38 (28.6)				200	131 (65.5)	69 (34.5)		1.584		333	226 (67.9)	107 (32.1)			
	1	1 (100.0)	0 (0)				0	0 (0)	0 (0)				1	1 (100.0)	0 (0)			
Difficulty in chewing food																		
Yes	21	14 (66.7)	7 (33.3)	NA	NA	0.617	38	24 (63.2)	14 (36.8)	NA	NA	0.568	59	38 (64.4)	21 (35.6)	NA	NA	0.343
No	133	40 (30.1)	93 (69.9)				196	127 (64.8)	69 (35.2)				329	220 (66.9)	109 (33.1)			
Unsure	2	2 (100.0)	0 (0)				2	2 (100.0)	0 (0)				4	4 (100.0)	0 (0)			
Type 2 Diabetes																		
Yes	59	39 (66.1)	20 (33.9)	NA	NA	0.603	97	58 (59.8)	39 (40.2)	NA	NA	0.360	156	97 (62.2)	56 (37.8)	NA	NA	0.306
No	92	67 (72.8)	25 (27.2)				131	88 (67.2)	43 (32.8)				223	155 (69.5)	68 (30.5)			
Unsure	5	3(60.0)	2 (40.0)				9	7 (77.8)	2 (22.2)				14	10 (71.4)	4 (28.6)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			
Hypertension																		
Yes	79	60 (75.9)	19 (24.1)	NA	NA	0.175	130	86 (66.2)	44 (33.8)	NA	NA	0.356	209	146 (69.9)	63 (30.1)	NA	NA	0.110
No	72	45 (62.5)	27 (37.5)				100	61 (61.0)	39 (39.0)				172	106 (61.6)	66 (38.4)			
Unsure	5	4 (80.0)	1 (20.0)				7	6 (85.7)	1 (14.3)				12	10 (83.3)	2 (16.7)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			
Hypercholesterolemia																		
Yes	87	66 (75.9)	21 (24.1)	NA	NA	0.085	153	105 (68.6)	48 (31.4)	NA	NA	***0.026**	240	171 (71.3)	60 (28.7)	NA	NA	***0.034**
No	60	39 (65.0)	21 (35.0)				73	42 (57.5)	31 (42.5)				133	81 (60.9)	52 (39.1)			
Unsure	9	4 (44.4)	5 (55.6)				11	6 (54.5)	5 (45.5)				20	10 (50.0)	10 (50.0)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			
Kidney																		
Yes	1	1 (100.0)	0 (0)				6	1 (16.7)	5 (83.3)				7	5 (71.4)	2 (28.6)	NA	NA	0.069
No	147	104 (70.7)	43 (29.3)				212	140 (66.0)	72 (34.0)				359	244 (68.0)	115 (32.0)			
Unsure	6	3 (50.0)	3 (50.0)	NA	NA	0.446	19	12 (63.2)	7 (36.8)	NA	NA	***0.044**	25	15 (60.0)	10 (40.0)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			
Liver																		
Yes	0	0 (0)	0 (0)	NA	NA	0.175	1	0 (0)	1 (100.0)	NA	NA	0.356	1	0 (0)	1 (100.0)			
No	150	105 (70.0)	45 (30.0)				225	147 (65.3)	78 (34.7)				375	252 (67.2)	123 (32.8)	NA	NA	0.110
Unsure	6	4 (66.7)	2 (33.3)				11	6 (54.5)	5 (45.5)				17	10 (58.8)	7 (41.2)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			
Thyroid																		
Yes	0	0 (0)	0 (0)	0.768	0.930-	0.821	13	10 (76.9)	3 (23.1)	NA	NA	0.446	13	10 (76.9)	3 (23.1)	NA	NA	0.609
No	152	106 (69.7)	46 (30.3)		1.211		216	139 (64.4)	77 (35.6)				368	245 (66.6)	123 (33.4)			
Unsure	4	3 (75.0)	1 (25.0)				8	4 (50.0)	4 (50.0)				12	7 (58.3)	5 (41.7)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			
Heart																		
Yes	32	24 (75.0)	8 (25.0)	NA	NA	0.175	15	9 (60.0)	6 (40.0)	NA	NA	0.356	47	33 (70.2)	14 (29.8)	NA	NA	0.110
No	118	81 (68.6)	37 (31.4)				216	140 (64.8)	76 (35.2)				334	221 (66.2)	113 (33.8)			
Unsure	6	4 (66.7)	2 (33.3)				6	4 (66.7)	2 (33.3)				12	8 (66.7)	4 (33.3)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			

Table I: Demography, lifestyle and health behaviours of community dwelling older adults (continued)

	Men (n= 156)						Women (n= 237)						Total (n= 393)					
Factor	n	Non-sarcopenia	Sarcopenia	Crude OR	95% CI	p*	n	Non-sarcopenia	Sarcopenia	Crude OR	95% CI	p*	n	Non-sarcopenia	Sarcopenia	Crude OR	95% CI	p*
Gastric/ Ulcer							39	25 (64.1)	14 (35.9)	NA	NA	0.819	61	39 (63.9)	22 (36.1)	NA	NA	0.414
Yes	22	14 (63.6)	8 (36.4)	NA	NA	0.243	193	125 (64.8)	68 (35.2)				322	218 (67.7)	104 (32.3)			
No	129	93 (72.1)	36 (27.9)				4	2 (50.0)	2 (50.0)				9	5 (55.6)	4 (44.4)			
Unsure	5	2 (40.0)	3 (60.0)				1	1 (100.0)	0 (0)				1	1 (100.0)	0 (0)			
Recovered	0	0 (0)	0 (0)															
Gastrointestinal																		
Yes	2	1 (50.0)	1 (50.0)	NA	NA	0.736	5	5 (100.0)	0 (0)	NA	NA	0.224	7	6 (85.7)	1 (14.3)	NA	NA	0.559
No	146	103 (70.5)	43 (29.5)				225	143 (63.6)	82 (36.4)				371	246 (66.3)	125 (33.7)			
Unsure	8	5 (62.5)	3 (37.5)				7	5 (71.4)	2 (28.6)				15	10 (66.7)	5 (33.3)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			
Previous bone fracture																		
Yes	24	18 (75.0)	6 (25.0)	NA	NA	0.834	28	19 (67.9)	9 (32.1)				52	37 (71.2)	15 (28.8)	NA	NA	0.408
No	129	89 (69.0)	40 (31.0)				205	130 (63.4)	75 (36.6)	NA	NA	0.294	334	219 (65.6)	115 (34.4)			
Unsure	3	2 (66.7)	1 (33.3)				4	4 (100.0)	0 (0)				7	6 (85.7)	1 (14.3)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			
Osteoarthritis/ osteoporosis													45	32 (71.1)	13 (28.9)	NA	NA	0.797
Yes	9	7 (77.8)	2 (22.2)	NA	NA	0.868	36	25 (69.4)	11 (30.6)	NA	NA	0.801	313	207 (66.1)	106 (33.9)			
No	134	93 (69.4)	41 (30.6)				179	114 (63.7)	65 (36.3)				35	23 (65.7)	12 (34.3)			
Unsure	13	9 (69.2)	4 (30.8)				22	14 (63.6)	8 (36.4)				0	0 (0)	0 (0)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)									
Stroke																		
Yes	3	3 (100.0)	0 (0)	NA	NA	0.519	5	2 (40.0)	3(60.0)	NA	NA	0.996	8	6 (75.0)	2 (25.0)	NA	NA	0.777
No	143	98 (68.5)	45 (31.5)				223	144 (64.6)	79(35.4)				366	242 (66.1)	124 (33.9)			
Unsure	3	2 (66.7)	1 (33.3)				6	4 (66.7)	2(33.3)				9	6 (66.7)	3 (33.3)			
Recovered	7	6 (85.7)	1 (14.3)				3	2 (66.7)	1(33.3)				10	8 (80.0)	2 (20.0)			
Cancer																		
Yes	0	0 (0)	0 (0)	NA	NA	0.552	1	1 (100.0)	0 (0)	NA	NA	0.597	1	1 (100.0)	0 (0)	NA	NA	0.677
No	151	106 (70.2)	45 (29.8)				228	148 (64.9)	80 (35.1)				379	254 (67.0)	125 (33.0)			
Unsure	4	2 (50.0)	2 (50.0)				5	3 (60.0)	2 (40.0)				9	5 (55.6)	4 (44.4)			
Cancer survivor	1	1 (100.0)	0 (0)				3	1 (33.3)	2 (66.7)				4	2 (50.0)	2 (50.0)			
Gout																		
Yes	5	4 (80.0)	1 (20.0)	1.752	0.191-16.111	0.616	2	1 (50.0)	1 (50.0)	NA	NA	0.693	7	5 (71.4)	2 (28.6)	NA	NA	0.750
No	151	105 (69.5)	46 (30.5)				234	151 (64.5)	83 (35.5)				385	256 (66.5)	129 (33.5)			
Unsure	0	0 (0)	0 (0)				1	1 (100.0)	0 (0)				1	1 (100.0)	0 (0)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			
Benign Prostate Hyperplasia																		
Yes	13	11 (84.6)	2 (15.4)	2.526	0.537-11.868	0.226	0	0 (0)	0 (0)	NA	NA	0.228	13	11 (84.6)	2 (15.4)	2.827	0.617-12.944	0.163
No	143	98 (68.5)	45 (31.5)				237	153 (64.6)	84 (35.4)				380	251 (66.1)	129 (33.9)			
Unsure	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			
Recovered	0	0 (0)	0 (0)				0	0 (0)	0 (0)				0	0 (0)	0 (0)			
Co-morbidities																		
0	27	19 (70.4)	8 (29.6)	NA	NA	0.305	36	24 (66.7)	12 (33.3)	NA	NA	0.197	63	43 (68.3)	20 (31.7)	NA	NA	0.723
1	32	23 (71.9)	9 (28.1)				47	26 (55.3)	21 (44.7)				79	49 (62.0)	30 (38.0)			
2	33	17 (51.5)	16 (48.5)				54	39 (72.2)	15 (27.8)				87	56 (64.4)	31 (35.6)			
3	39	30 (76.9)	9 (23.1)				54	33 (61.1)	21 (38.9)				93	63 (67.7)	30 (32.3)			
4	19	15 (78.9)	4 (21.1)				32	23 (71.9)	9 (28.1)				51	38 (74.5)	13 (25.5)			
5	3	2 (66.7)	1 (33.3)				9	7 (77.8)	2 (22.2)				12	9 (75.0)	3 (25.0)			
6	2	2 (100.0)	0 (0)				3	1 (33.3)	2 (66.7)				5	3 (60.0)	2 (40.0)			
7	1	1 (100.0)	0 (0)				2	0 (0)	2 (100.0)				3	1 (33.3)	2 (66.7)			
Polypharmacy (>4 drugs)																		
Yes	32	23 (71.9)	9 (28.1)	1.129	0.478-2.688	0.782	48	25 (52.1)	23 (47.9)	0.518	0.272-0.985	***0.043**	80	48 (60.0)	32 (40.0)	0.694	0.418-1.152	0.156
No	124	86 (69.4)	38 (30.6)				189	128 (67.7)	61 (32.3)				314	262 (66.7)	131 (33.3)			

* Significant at p<0.05, using Chi-square test

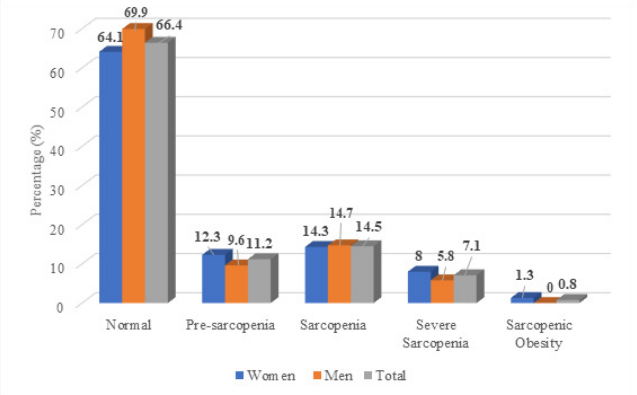

Figure 1: Percentage of subjects according to stage of sarcopenia

intake, physical inactivity, low-grade inflammation, insulin resistance and changes in hormonal milieu will eventually lead to an increased risk of sarcopenia (17). Hence, it is not surprising that the prevalence of sarcopenia in this study at 33.6%, is relatively higher than our neighbouring counterparts Singapore (20.6%), Vietnam (26.2%) and Thailand (30.1%) (18-20). It should be noted that the study carried out in Singapore and Thailand used instruments and cut-off points similar to this study which is BIA and AWGS, whilst the study in Vietnam used cut-off points by the National Institutes of Health (NIH) and Dual X-Ray absorptiometry (DXA).

Our present study found that women were more likely to be sarcopenic; in line with findings from Singapore

Table II: Anthropometry and functional measurements of community-dwelling older adults

	Men (n= 156)			Women (n= 237)		
	Non-sarcopenia	**Sarcopenia**	**p****	**Non-sarcopenia**	**Sarcopenia**	**p****
Number	109	47		153	84	
Weight (kg)	72.8 ±8.3	57.5 ± 7.2	**<0.001**	67.5 ± 9.6	50.4 ± 8.0	**<0.001**
Body mass index (kg/m²)	26.8 ± 3.0	22.7 ± 3.2	**<0.001**	29.3 ± 4.7	22.7 ± 3.5	**<0.001**
Skeletal muscle mass (kg)	28.0 ± 2.9	21.4 ± 3.2	**<0.001**	20.6 ±2.4	16.2 ± 2.3	**<0.001**
Skeletal muscle index (kg/m²)	7.7 ± 0.5	6.2 ± 0.6	**<0.001**	6.4 ± 0.7	5.0 ± 0.6	**<0.001**
Body Fat Mass (kg)	22.2 ± 6.1	17.5 ± 5.6	**<0.001**	30.6 ± 17.2	18.9 ± 6.1	**<0.001**
Percentage Body Fat (%)	30.2 ± 5.8	29.8 ± 6.8	0.745	42.7 ± 5.8	36.6 ± 7.1	**<0.001**
Dominant Handgrip strength (kg)	29.9 ± 5.8	23.1 ± 7.8	**<0.001**	19.1 ± 5.1	16.5 ± 4.6	**<0.001**
Gait speed (m/s)	1.06 ± 0.24	0.98 ± 0.26	0.056	0.95 ± 0.25	0.94 ± 0.31	0.821

***independent sample t-test; p < 0.001

Table III: Nutrient and food intake of community dwelling older adults

	Men (n= 156)			Women (n= 237)		
	Non-sarcopenia	**Sarcopenia**	**p[a]**	**Non-sarcopenia**	**Sarcopenia**	**p[a]**
Number	109	47		153	84	
Energy (kcal/day) % RNI	1424 ± 389 80.0	1294 ± 451 72.7	0.072	1167 ± 433 75.3	1112 ± 443 71.7	0.351
Carbohydrate (g/day) % Kcal % RNI[1]	193.2 ± 52.7 54.3 108.6	179.8 ± 66.6 55.6 111.2	0.182	163.6 ± 64.9 56.1 112.2	151.5 ± 57.7 54.5 109.0	0.157
Protein (g/day) % Kcal % RNI[1]	51.9 ± 18.6 14.6 73.0	46.1 ± 18.8 14.3 71.5	0.077	42.0 ± 15.9 14.4 72.0	41.2 ± 20.6 14.8 74.0	0.750
Fat (g/day) % Kcal % RNI[1]	48.3 ± 16.9 30.5 101.7	43.2 ± 18.2 30.0 100.0	0.093	38.0 ± 17.1 29.3 97.7	37.6 ± 18.5 30.4 101.3	0.852
Sodium (mg/day) % RNI	2247 ± 851 187.3	2124 ± 1274 177.0	0.479	1803 ± 797 150.3	1798 ± 1005 149.8	0.965
Calcium (mg/day) % RNI	419 ± 231 34.9	348 ± 165 29.0	***0.032**	341 ± 166 28.4	328 ± 199 27.3	0.579
Dietary Fiber (g/day) % RNI[1]	5.2 ± 3.5 26.0	5.3 ± 4.3 26.5	0.861	5.1 ± 3.4 25.5	4.9 ± 3.2 24.5	0.674
10% Iron (mg/day) % RNI	13 ± 11 92.9	6 ± 5 42.9	***0.045**	12 ± 6 109.1	10 ± 5 90.9	0.057
15% Iron (mg/day) % RNI	13 ± 11 144.4	6 ± 5 66.7		12 ± 6 150.0	10 ± 5 125.0	
Vitamin D (µg/day) % RNI	0.09 ± 0.5 0.45	0.04 ± 0.2 0.20	0.422	0.04 ± 0.2 0.20	0.09 ± 0.4 0.45	0.188
^Leucine (mg/day) % RNI	82 ± 240 1.00	85 ± 178 1.06	0.946	64 ± 158 0.80	61 ± 200 0.77	0.908

*Significant at p<0.05 using independent sample t-test
Note: RNI: Recommended Nutrient Intake ^ Leucine is not available in RNI Malaysia 2017, cut-off values are obtained from USDA
[1]RNI intake is set at 50% CHO, 20% protein, 30% fat & 20g fiber [29]

Table IV: Hierarchical binary logistic regression for the associated risk factors of sarcopenia

Variable	Cox & Snell R^2	Nagelkerke R^2	Chi-Square	β	S.E.	Wald	p***	OR	95% CI
Step 1	0.038	0.053	5.074						
Age (years)				0.075	0.020	14.780	**<0.001**	1.078	1.038-1.120
Step 2	0.066	0.092	7.798						
Age (years)				0.08	0.020	16.230	**<0.001**	1.084	1.042 – 1.127
Iron intake (mg)				-0.068	0.021	10.181	**<0.001**	0.934	0.895 – 0.974

***Significant at p<0.001 using Hierarchical binary logistic regression adjusted for confounding variables
Note: CI: Confidence interval; OR: Odd ratio; S.E.: Standard error

(18). This can be attributed to higher mean age of women as compared to men, particularly within the sarcopenic group. Also, the prevalence of sarcopenia among older adults from the Southeast Asian region is higher as compared to studies in other countries (19, 20). For example, in a systematic review of 86 studies by Mata Diz et al. accumulating 6 countries (United Kingdom, Taiwan, USA, South Korea, Brazil and Japan) and targeting older adults aged 60 years old and above, the highest prevalence of sarcopenia was in Japan (22.0%) and lowest in Taiwan (4.0%) (21). In 5 out of the 6 countries, the prevalence of sarcopenia was higher in males as compared to females (21).

The observation that older adult men showed a lower prevalence of sarcopenia than women, could be due to the fact that men have a proportionately higher skeletal muscle mass (17). Moreover, with an increase in age, myostatin acts as a negative regulator of muscle mass growth which causes rapid degeneration of muscles (17). On the other hand, for older women, percentage body fat increases and this is due to the dampened levels of type I insulin growth factor (IGF1) in the body which contributes to the deterioration of muscle and an increase in body fat (17). Although the subjects of the mentioned studies were community-dwelling older adults, it can be difficult to compare the prevalence rates among these studies due to the differences in inclusion criteria for the subjects, definitions, instruments used to measure muscle mass and cut-off values considered.

Our study results also demonstrated that older adults with sarcopenia had a higher mean age than those who were non sarcopenic. This is in tandem with many studies that found the prevalence and risk of sarcopenia increases with age (8). In the present study, an increase in one year of age, increases the odds of having sarcopenia by 1.084 times. A significant difference in weight, BMI, skeletal muscle mass, skeletal muscle index, body fat mass and percentage body fat with lower measurements in subjects with sarcopenia as compared to non-sarcopenic was also shown in the present study. Thus, supporting the fact that a decrease in muscle mass and muscle strength with ageing is inevitable.

As expected the energy, macronutrient and micronutrient intake of subjects who were categorised as having sarcopenia were lesser than the non-sarcopenic; however, significant differences were only noted for calcium and iron intake. Poor appetite which worsens with aging may be the reason for the poor intake of energy, macronutrients and micronutrients (except sodium which meets the RNI). Protein, leucine and vitamin D which were the nutrients of interest while exhibiting a strong correlation with predisposition of sarcopenia in many studies were not shown to have a significant association in our study (22-24). Intake of leucine and vitamin D was to the bare minimal and not all foods that were analyzed using the existing database (Nutritionist Pro) in this study provided values for leucine and vitamin D.

Moreover, the Nutritionist Pro software has not been recently updated hence the nutrients in the software did not take into account the current trend of food fortification and food enrichment done to meet the populations daily needs. In this study, intake of supplements was also not taken into account considering some older adults might be consuming vitamin D and leucine supplements but did not share this information with the researchers hence resulting in an underestimation of intake. Duration of exposure to the sun was also not taken into account and so was the serum 25(OH)D level. Serum 25(OH)D level is the best indicator of vitamin D supply to the body from cutaneous synthesis and nutritional intake (24).

In our study, 1 mg increase in dietary iron intake reduced the risk of sarcopenia by 6.6%. This result was supported by Beaudart et al. (2019) reported that sarcopenic subjects were more prevalent to non sarcopenic subjects due to insufficient of dietary iron intake (23). In addition, Moon et al. (2015) also indicated that sarcopenia subjects were more prevalent to anemia and low dietary iron intake (25). We reasoned that dietary iron might play an essential role in muscle mass retention. Iron is an essential micronutrient and is known to play a critical role in oxidative energy metabolism as well as numerous cellular processes in the skeletal muscles (26). Muscle tissue contains 10-15% of iron stores and a depletion of this iron stores reduces aerobic metabolism in mitochondria leading to changes in the mitochondria morphology and a reduction in mitochondrial numbers (26). Changes from aerobic to anaerobic oxidation occurs in the muscles and this will reduce aerobic and endurance capacity resulting in reduced physical performance and subsequently muscle wasting (27).

With the many different factors contributing to sarcopenia and varying prevalence rates reported in other studies, it can only be concluded that confounding factors are one of the main causes. Confounding factors can potentially be identified and adjusted correctly in many studies and if not managed well they can create difficulties in studies of sarcopenia, particularly in terms of planning and implementing an adequate study design. Our findings were supported by Kurose et al. (2020) indicated that sarcopenia were associated with age, lower rates of obesity, hypertension and malnutrition such as dietary iron intake (28). These are the confounding factors that have been proven from previous literature.

As this study is a cross-sectional study it cannot be used to infer a cause-effect relationship. Convenience sampling also limit the study to generalise the target population in Malaysia. While attaining the diet recall of subjects, underreporting and inability to recall diet intake could be some of the limitations. In addition, the Nutritionist Pro software which was not updated and some food items borrowed from the Singapore database could have affected the results. Also, creation of a standardised recipe and estimation of portion sizes may not be similar to the actual food which the subject ate. Lastly, this study used convenience sampling and this data can only be used to represent older adults living in the urban areas of Klang Valley and not those living in rural areas, other towns or states, in different settings or in East Malaysia.

CONCLUSION

In conclusion, approximately one-third (33.6%) of the community-dwelling older adults in Klang Valley has been categorized as having sarcopenia. Those aged 60 years old and above and those with low dietary iron intake were at an increased risk of having sarcopenia. Hence, these findings could be used to devise early and effective interventions for those who are at risk of sarcopenia.

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REFERENCES

1. Zoico E, Di Francesco V, Guralnik JM, Mazzali G, Bortolani A, Guariento S, et al. Physical disability and muscular strength in relation to obesity and different body composition indexes in a sample of healthy elderly women. International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity. 2004;28(2):234-41. Epub 2004/01/07. doi: 10.1038/sj.ijo.0802552. PubMed PMID: 14708033.
2. He W, Goodkind D, Kowal P. An Aging World: 2015 International Population Reports Washington D.C. United States 2016.
3. Department of Statistics Malaysia. Current population estimates Malaysia 2018-2019. Putrajaya: Department of Statistics 2019.
4. Organisation WH. World Report on Ageing and Health. Geneva: United Nations Economic and Social Council (SZ): 2015.
5. Yamauchi T, Islam MM, Koizumi D, Rogers ME, Rogers NL, Takeshima N. Effect of home-based well-rounded exercise in community-dwelling older adults. Journal of Sports Science and Medicine. 2005;4(4):563-71. PubMed PMID: 24501569.
6. Mayhew AJ, Amog K, Phillips S, Parise G, McNicholas PD, de Souza RJ, et al. The prevalence of sarcopenia in community-dwelling older adults, an exploration of differences between studies and within definitions: a systematic review and meta-analyses. Age Ageing. 2019;48(1):48-56. Epub 2018/07/28. doi: 10.1093/ageing/afy106. PubMed PMID: 30052707.
7. Chen LK, Lee WJ, Peng LN, Liu LK, Arai H, Akishita M. Recent Advances in Sarcopenia Research in Asia: 2016 Update From the Asian Working Group for Sarcopenia. Journal of the American Medical Directors Association. 2016;17(8):767.e1-7. Epub 2016/07/04. doi: 10.1016/j.jamda.2016.05.016. PubMed PMID: 27372539.
8. Bijlsma AY, Meskers CG, Ling CH, Narici M, Kurrle SE, Cameron ID, et al. Defining sarcopenia: the impact of different diagnostic criteria on the prevalence of sarcopenia in a large middle aged cohort. Age (Dordr). 2013;35(3):871-81. Epub 2012/02/09. doi: 10.1007/s11357-012-9384-z. PubMed PMID: 22314402.
9. Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, et al. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. Journal of the American Medical Directors Association. 2013;14(8):542-59. Epub 2013/07/23. doi: 10.1016/j.jamda.2013.05.021. PubMed PMID: 23867520.
10. Anton SD, Hida A, Mankowski R, Layne A, Solberg LM, Mainous AG, et al. Nutrition and Exercise in Sarcopenia. Current protein & peptide science. 2018;19(7):649-67. Epub 2016/12/29. doi: 10.2174/1389203717666161227144349. PubMed PMID: 28029078.
11. Shari N, Mohamed Sakian N, Suzana S, Hasnan M, Zahara M, Zaitun Y. Sarcopenia and Its Impact on Health: Do They Have Significant Associations?

Sains Malaysiana. 2013;42:1345-55.
12. Rosli H, Shahar S, Badrasawi M, Singh DKA, Mohamed Sakian N. Identification of Older Adults with Sarcopenia: Comparison of Two Methods. Jurnal Sains Kesihatan Malaysia. 2017;15:103-8. doi: 10.17576/jskm-2017-1502-04.
13. Shahar S, Earland J, Abdulrahman S. Validation of a Dietary History Questionnaire against a 7-D Weighed Record for Estimating Nutrient Intake among Rural Elderly Malays. Malaysian journal of nutrition. 2000;6(1):33-44. Epub 2000/03/01. PubMed PMID: 22692390.
14. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing. 2010;39(4):412-23. Epub 2010/04/16. doi: 10.1093/ageing/afq034. PubMed PMID: 20392703.
15. Santilli V, Bernetti A, Mangone M, Paoloni M. Clinical definition of sarcopenia. Clin Cases Miner Bone Metab. 2014;11(3):177-80. PubMed PMID: 25568649.
16. Institute for Public Health. National Health and Morbidity Survey 2019. 2019.
17. Stewart CE, Pell JM. Point:Counterpoint: IGF is/is not the major physiological regulator of muscle mass. Point: IGF is the major physiological regulator of muscle mass. Journal of applied physiology (Bethesda, Md : 1985). 2010;108(6):1820-1; discussion 3-4; author reply 32. Epub 2009/11/07. doi: 10.1152/japplphysiol.01246.2009. PubMed PMID: 19892924.
18. Tey SL, Chew STH, How CH, Yalawar M, Baggs G, Chow WL, et al. Factors associated with muscle mass in community-dwelling older people in Singapore: Findings from the SHIELD study. PLoS One. 2019;14(10):e0223222. Epub 2019/10/10. doi: 10.1371/journal.pone.0223222. PubMed PMID: 31596873.
19. Khongsri N, Tongsuntud S, Limampai P, Kuptniratsaikul V. The prevalence of sarcopenia and related factors in a community-dwelling elders Thai population. Osteoporosis and Sarcopenia. 2016;2(2):110-5. doi: https://doi.org/10.1016/j.afos.2016.05.001.
20. Nguyen T, Nguyen T, Nguyen T, Nguyen H, Nguyen T, Vu H. Older people with sarcopenia in Vietnam: Who are at higher risk of having frailty? Innovation in Aging. 2018;2(Suppl 1):985-. doi: 10.1093/geroni/igy031.3643. PubMed PMID: PMC6239788.
21. Diz JBM, Queiroz BZd, Tavares LB, Pereira LSM. Prevalкncia de sarcopenia em idosos: resultados de estudos transversais amplos em diferentes paнses. Revista Brasileira de Geriatria e Gerontologia. 2015;18:665-78.
22. Malafarina V, Uriz-Otano F, Malafarina C, Martinez JA, Zulet MA. Effectiveness of nutritional supplementation on sarcopenia and recovery in hip fracture patients. A multi-centre randomized trial. Maturitas. 2017;101:42-50. Epub 2017/05/26. doi: 10.1016/j.maturitas.2017.04.010. PubMed PMID: 28539168.
23. Beaudart C, Locquet M, Touvier M, Reginster J-Y, Bruyиre O. Association between dietary nutrient intake and sarcopenia in the SarcoPhAge study. Aging clinical and experimental research. 2019;31(6):815-24. doi: 10.1007/s40520-019-01186-7.
24. Tieland M, Brouwer-Brolsma EM, Nienaber-Rousseau C, van Loon LJ, De Groot LC. Low vitamin D status is associated with reduced muscle mass and impaired physical performance in frail elderly people. European journal of clinical nutrition. 2013;67(10):1050-5. Epub 2013/08/15. doi: 10.1038/ejcn.2013.144. PubMed PMID: 23942175.
25. Moon J-H, Kong M-H, Kim H-J. Relationship between low muscle mass and anemia in Korean elderly men: Using the Korea National Health and Nutrition Examination Survey (KNHANES IV–V). Journal of Clinical Gerontology and Geriatrics. 2015;6(4):115-9. doi: https://doi.org/10.1016/j.jcgg.2015.03.007.
26. Polonifi A, Politou M, Kalotychou V, Xiromeritis K, Tsironi M, Berdoukas V, et al. Iron metabolism gene expression in human skeletal muscle. Blood Cells, Molecules, and Diseases. 2010;45(3):233-7. doi: https://doi.org/10.1016/j.bcmd.2010.07.002.
27. Anderson CP, Shen M, Eisenstein RS, Leibold EA. Mammalian iron metabolism and its control by iron regulatory proteins. Biochimica et biophysica acta. 2012;1823(9):1468-83. Epub 2012/05/23. doi: 10.1016/j.bbamcr.2012.05.010. PubMed PMID: 22610083.
28. Kurose S, Nishikawa S, Nagaoka T, Kusaka M, Kawamura J, Nishioka Y, et al. Prevalence and risk factors of sarcopenia in community-dwelling older adults visiting regional medical institutions from the Kadoma Sarcopenia Study. Scientific Reports. 2020;10(1):19129. doi: 10.1038/s41598-020-76185-0.
29. National Coordinating Committee on Food and Nutrition. Malaysia Recommended Nutrient Intake: Ministry of Health Malaysia; 2017. Available from: http://nutrition.moh.gov.my.