Accepted Article

Journal of Frailty, Sarcopenia and Falls

Original Article

The Impact of Sarcopenic Obesity on Frailty, Cognition, and Function in Community-Dwelling Older Adults

Le Alicia How[#1], Xin Xiang Lee[#1], Sarah Ann Lee Hui-En[2], Yao Hao Teo[2], Kar Cheng Goh[3], Li Feng Tan[3]

[1]Yong Loo Lin School of Medicine, National University of Singapore, Singapore;
[2]Department of Medicine, National University Hospital, National University Health System, Singapore;
[3]Healthy Ageing Programme, Alexandra Hospital, National University Health System, Singapore
[#] Equal contribution

Abstract

Objectives: The impact of sarcopenic obesity (SO) on frailty, cognition, and function compared to sarcopenia and obesity alone remains unclear. This study examined SO's effects on these domains in community-dwelling older adults. **Methods**: We assessed 202 older adults (mean age 80.4 ±7.3 years) attending a community frailty screening clinic. Obesity was defined as BMI≥25, and sarcopenia was assessed using Asian Working Group for Sarcopenia guidelines. SO was defined as the presence of both conditions. Assessments included the Clinical Frailty Scale, Modified Barthel Index, Singapore-modified Mini-Mental State Examination, and mobility aid use. **Results**: Multivariate regression showed SO was significantly associated with frailty (OR 4.71), impaired function (ß: -16.53), and mobility limitations (OR 5.73). SO was also linked to cognitive impairment (OR 3.56). Sarcopenia alone was associated with frailty (OR 3.39), impaired function (ß -11.46), and mobility limitations (OR 3.32), but not cognition. Obesity alone showed no associations. SO posed higher risks for frailty, cognitive impairment, functional decline, and mobility limitations compared to sarcopenia or obesity alone. **Conclusions**: SO is associated with greater risks of frailty, cognitive impairment, functional decline, and mobility limitations than sarcopenia or obesity alone.

Keywords: Frailty, Obesity, Sarcopenia, Sarcopenic obesity

Introduction

With populations ageing globally, there is an increased prevalence of age-related conditions, such as frailty and sarcopenia. Older adults with sarcopenia experience disability, reduced quality of life, increased mortality and healthcare utilisation[1]. Concurrently, rates of obesity are increasing and has become a major public health concern[2], affecting approximately 13% or nearly 1 billion individuals[2]. Older adults have higher rates of obesity, estimated at 35% globally with >70% overweight3. Individually, sarcopenia[1] and obesity[3] have been shown to be associated with increased morbidity or mortality. In older adults, however, the impact of obesity is not clear. Some studies have demonstrated that increased adiposity may have a protective effect in older adults, termed the 'obesity paradox'[4]. A systematic review by Flegal et al[4] found that compared to normal BMI, being overweight was associated with significantly lower all-cause mortality, especially in older adults.

The coexistence of both sarcopenia and obesity - termed sarcopenic obesity (SO) - has been found to act synergistically to exacerbate metabolic impairment, disability, cardiovascular disease and mortality more so than either condition alone[5], making SO an emerging critical public health issue globally[6].

However, few studies have compared the associations of sarcopenia, obesity and SO, or investigated associations of

The authors have no conflict of interest.

Corresponding author: *Dr Tan Li Feng, Healthy Ageing Programme, Alexandra Hospital, National University Health System, Blk 20A, 378 Alexandra Road, Singapore 159964*

E-mail: *li_feng_tan@nuhs.edu.sg*

Edited by: *Yannis Dionyssiotis*

Accepted *22 June 2025*

SO in a multi-ethnic, Asian context. This is important given the ethnic variation in body composition, risk factor profile and disease outcomes in Asians compared to Caucasians[7].

Our study aims to fill the examine of associations of SO with frailty, cognition and function in community-dwelling older adults.

Methods

Community-dwelling older adults who were seen at three community frailty clinic sites[8] in the Western region of Singapore were consented for use of their data. Details of the community frailty clinic programme including referral criteria and collected data have been published previously[8]. Data were collected through questionnaires and bedside tests conducted by trained clinic nurses.

Frailty was assessed using the Clinical Frailty Scale (CFS)[9] and the 5-item FRAIL scale (Fatigue, Resistance, Ambulation, Illness, and Loss of Weight)[10,11]. A cut-off of CFS≥5 was used to stratify participants into frail vs non-frail[9] while on FRAIL, participants were categorised into frail (3-5), pre-frail (1-2), and not frail (0).

The Singapore-modified Mini-mental state examination (SM-MMSE)[12] was used to determine cognitive function. Cut-offs were based on education level, with 17/18 for those with no formal education, 20/21 for primary school level education, and 24/25 for secondary school level education and above.

The 16-item Falls efficacy scale international (FESI)[13] was used to assess fear of falling. Participants were categorised into low concern (16-19), moderate concern (20-27) and high concern (28-64)[13]. Function was measured by the Modified Barthel Index (MBI)[14].

Sarcopenia was evaluated based on SARC-F scores[15]. Handgrip strength was assessed using a Jamar dynamometer, using the best of 3 readings using the dominant hand. Participants who scored SARC-F≥4 and handgrip strength <28kg for males or <18kg for females were determined to have possible sarcopenia based on accordance with the Asian Working Group for Sarcopenia 2019[16] diagnostic algorithm for sarcopenia. Body composition analysis was not performed due to the logistical limitations of a community setting. Obesity was determined using body mass index (BMI). Based on Asian cut-offs, participants with BMI≥25 were classified as obese[17,18]. SO was defined as the presence of both obesity and sarcopenia, as defined above, in the same individual.

Statistical Analysis

Statistical analysis was performed using R, with logistic regression used to determine odds ratios and linear regression to determine coefficient for MBI. Multivariate regression was performed adjusting for a priori determined co-variates age, gender, hypertension, DM and hyperlipidemia. Descriptive tests utilised include chi-square test and ANOVA, performed across categories obesity only, sarcopenia only and SO. P-values of $p<0.05$ were considered statistically significant.

Results

Data of 202 participants were analysed – 41 (20.3%) were obese, 65 (32.2%) were sarcopenic only and 20 (9.9%) had SO. The breakdown of characteristics of participants is outlined in Table 1.

Obese and SO had higher BMI than the cohort and those with sarcopenia ($p <0.001$). A significantly greater proportion of SO and sarcopenic patients were frail compared with those who are obese on both CFS ($p <0.001$) and FRAIL ($p = 0.001$). The prevalence of frailty was highest in SO (85.0% on CFS and 55.0% on FRAIL) compared with the overall cohort (59.4% on CFS and 26.7% on FRAIL). SO participants also had the highest fear of falls at 93.8% vs 80.0% in sarcopenia, while those who were obese had to lowest proportion of fear of falls (62.5%, $p = 0.020$). SO had the lowest MBI score (81.9 ± 24.3 vs 92.8 ± 15.8, $p = 0.004$) and the highest prevalence of cognitive impairment based on SM-MMSE cut-off (52.9% vs 29.6%, $p = 0.004$). Those with SO also had the highest use of mobility aids (85.0%), followed by sarcopenic participants (73.8%) while obese participants had the lowest use (45.0%) ($p = 0.002$). The prevalence of diabetes mellitus was highest in SO (65.0%) compared with obese (36.6%) and lowest in those with sarcopenia alone (27.7%) ($p = 0.010$). Prevalence of hypertension was highest in obese participants (92.7% vs 76.7% total cohort, $p = 0.005$), followed by SO (90.0%) and lowest in those with sarcopenia alone (68.3%). Obese participants were younger than those with sarcopenias or SO (77.9 ± 6.6 vs 82.0 ± 7.8 vs 80.9 ± 5.4, $p = 0.020$).

On multiple logistic regression (Table 2), adjusting for age, gender, and other significant comorbidities, participants with sarcopenia only showed increased odds of having frailty on CFS (OR = 3.39; 95% CI 1.58 – 7.57). Participants with SO showed a stronger association with frailty (OR = 4.71; 95% CI 1.35 – 22.23). Obese participants had lower odds of frailty although this did not reach statistical significance.

Participants with SO had significantly higher odds of being cognitively impaired, when adjusted for age only (OR = 3.50; 95% CI 1.17 – 10.76), age and gender (OR = 3.56; 95% CI 1.18 – 10.98), but not when adjusted for age, gender and other comorbidities (OR = 2.95, p-value = 0.05).

Sarcopenic participants and those with SO had higher odds of requiring assistance on MBI and mobility limitations even after adjusting for age, gender and comorbidities, with SO having higher odds than those with sarcopenia alone (Figure 1).

Characteristics	All	Obesity	Sarcopenia	Sarcopenic Obesity	P value
Number of participants	202	41 (20.3)	65 (32.2)	20 (9.9)	
Age	80.40 ± 7.27	77.93 ± 6.59	82.02 ± 7.84	80.90 ± 5.41	0.020*
Female gender	127 (62.9)	30 (73.2)	38 (58.6)	15 (75.0)	0.190
Ethnicity					
Chinese	153 (75.7)	25 (61.0)	53 (81.5)	13 (65.0)	0.150
Indian	16 (7.9)	4 (9.8)	3 (4.6)	4 (20.0)	
Malay	30 (14.9)	11 (26.8)	8 (12.3)	3 (15.0)	
Others	3 (1.5)	1 (2.4)	1 (1.5)	0 (0.0)	
BMI[a]	23.0 ± 5.3	29.2 ± 4.1	19.9 ± 3.0	29.2 ± 4.1	<0.001*
Smoking	40 (21.7)	3 (8.8)	12 (19.7)	5 (26.3)	0.220
Alcohol	29 (15.8)	3 (8.8)	9 (14.8)	5 (26.3)	0.230
Clinical Frailty Score (CFS ≥ 5)	120 (59.4)	15 (36.6)	50 (76.9)	17 (85.0)	<0.001*
FRAIL status					
Frail	54 (26.7)	4 (9.8)	26 (40.0)	11 (55.0)	0.001*
Pre-frail	71 (35.1)	14 (34.1)	19 (29.2)	6 (30.0)	
None	77 (38.1)	23 (56.1)	20 (30.8)	3 (15.0)	
Falls Efficacy Scale International (FESI)					
16 - 19 (low concern)	27 (16.6)	8 (25.0)	3 (5.5)	0 (0.0)	0.020*
20 - 27 (moderate concern)	31 (19.0)	4 (12.5)	8 (14.5)	1 (6.2)	
28 - 64 (high concern)	105 (64.4)	20 (62.5)	44 (80.0)	15 (93.8)	
Diabetes Mellitus	71 (35.1)	15 (36.6)	18 (27.7)	13 (65.0)	0.010*
Hypertension	155 (76.7)	38 (92.7)	41 (68.3)	18 (90.0)	0.005*
Hyperlipidaemia	130 (64.4)	32 (78.0)	36 (55.4)	14 (70.0)	0.050
Modified Barthel's Index (MBI)	92.78 ± 15.79	98.41 ± 4.05	86.91 ± 20.54	81.94 ± 24.31	0.004*
SM-MMSE[b]					
Cognitive Impairment	55 (29.6)	5 (13.2)	24 (39.3)	9 (52.9)	0.004*
No Cognitive Impairment	131 (70.4)	33 (86.8)	37 (60.7)	8 (47.1)	
Primary Caregiver					
None	94 (46.8)	25 (61.0)	29 (44.6)	9 (45.0)	0.010*
Family	42 (20.9)	4 (9.8)	22(33.8)	7 (35.0)	
Helper	56 (27.9)	12 (29.3)	13 (20.0)	2 (10.0)	
Others	9 (4.5)	0 (0.0)	1 (1.5)	2 (10.0)	
Requires Mobility Aids	118 (59.0)	18 (45.0)	48 (73.8)	17 (85.0)	0.002*

[a]BMI, body mass index; [b]SM-MMSE, Singapore modified Mini-Mental State Examination; Data presented as mean ± SD, median (IQR), or n (%).

Table 1. Characteristics of study participants by sarcopenia and obesity status.

Characteristics	Obesity	Sarcopenia	Sarcopenic Obesity
Frailty (CFS ≥ 5)			
Model 1[1]	0.67 (0.29 - 1.48)	3.18 (1.51 - 6.93)*	5.69 (1.69 - 26.22)*
Model 2[2]	0.70 (0.30 - 1.56)	3.20 (1.52 - 6.99)*	5.91 (1.76 - 27.27)*
Model 3[3]	0.69 (0.29 - 1.60)	3.39 (1.58 - 7.57)*	4.71(1.35 - 22.23)*
Cognitive Impairment (by education-adjusted SM-MMSE[a] score)			
Model 1[1]	0.48 (0.15 - 1.35)	2.00 (0.95 - 4.31)	3.50 (1.17 - 10.76)*
Model 2[2]	0.49 (0.15 - 1.39)	2.01 (0.95 - 4.33)	3.56 (1.18 - 10.98)*
Model 3[3]	0.45 (0.13 - 1.31)	2.10 (0.98 - 4.60)	2.95 (0.95 - 9.36)
Modified Barthel's Index (MBI)[b]			
Model 1[1]	-0.08 (-6.44 - 6.28)	-11.65 (-17.03 - -6.26)*	-16.59 (-24.51 - -8.67)*
Model 2[2]	-0.57 (-6.90 - 5.77)	-11.36 (-16.72 - -6.00)*	-16.92 (-24.79 - -9.04)*
Model 3[3]	-0.69 (-7.13 - 5.76)	-11.46 (-16.88 - -6.03)*	-16.53 (-24.55 - -8.52)*
Requires Use of Mobility Aids			
Model 1[1]	1.13 (0.50 - 2.55)	3.05 (1.46 - 6.56)*	6.55 (1.94 - 30.37)*
Model 2[2]	1.20 (0.53 - 2.74)	3.09 (1.47 - 6.67)*	6.93 (2.04 - 32.13)*
Model 3[3]	1.15 (0.49 - 2.69)	3.32 (1.56 - 7.35)*	5.73 (1.65 - 27.02)*

**Indicates statistical significance (p < 0.05); [a]SM-MMSE, Singapore modified Mini-Mental State Examination; [b]Presented as regression coefficients (β) [95% confidence interval (CI)]; [1] Model 1: adjusted for age. [2] Model 2: adjusted for Model 1, gender. [3] Model 3: adjusted for Model 2, hypertension, hyperlipidemia, diabetes mellitus.*

Table 2. Association of obesity, sarcopenia and sarcopenic obesity with cognition, frailty measures, function and mobility. Presented as odds ratios (OR) and regression coefficients (β) [95% confidence interval (CI)].

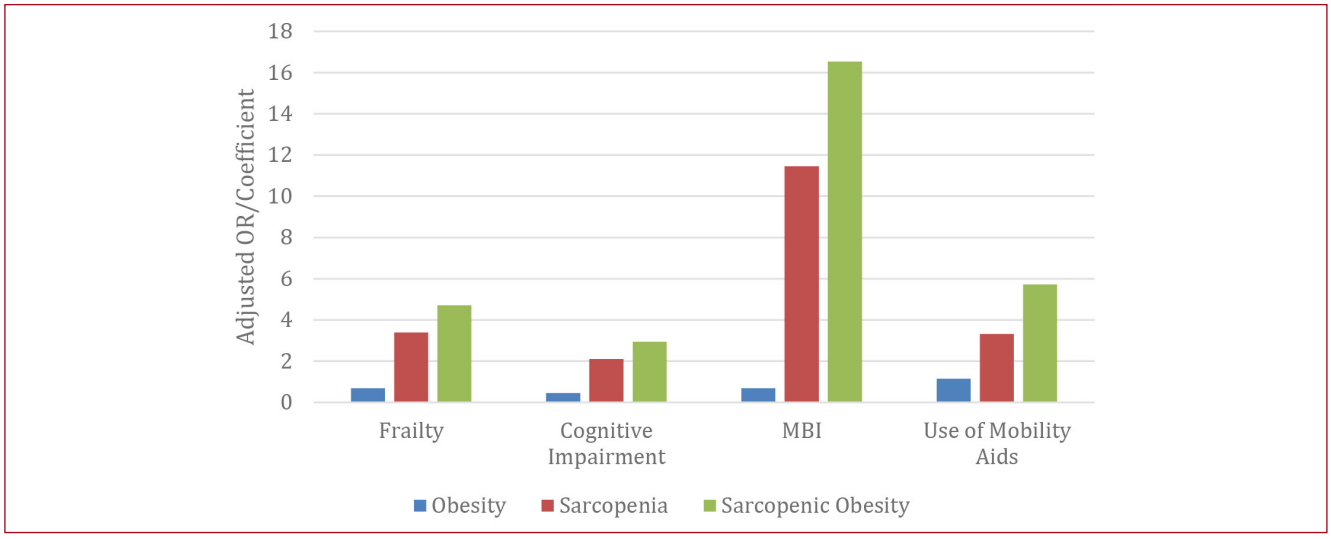

Figure 1. Associations of Obesity, Sarcopenia, and Sarcopenic Obesity with Cognition, Frailty, Function, and Mobility: Adjusted Odds Ratios and Regression Coefficients (Model 3). **MBI – Modified Barthel's Index. Note: MBI scores have been reverse-coded for graphical consistency—higher values indicate worse functional status.*

Discussion

Our study highlights the disproportionate burden of frailty, cognitive impairment, functional dependence, and mobility limitations in individuals with SO compared to those with sarcopenia or obesity alone. Our findings underscore that SO is not merely an additive condition but represents a distinct phenotype with compounded adverse health outcomes.

SO was the strongest predictor of frailty measured on both CFS and FRAIL, whilst obesity had the least association with frailty. Obesity alone on multivariate regression was not associated with frailty, but its combination with sarcopenia markedly exacerbated the odds, likely due to a synergistic interaction between muscle weakness, chronic inflammation, and metabolic dysregulation[19]. These findings align with prior literature indicating that SO contributes to a more profound loss of physical resilience than either condition in isolation[6,20].

The evidence of the impact of SO on frailty is mixed. Some studies suggests that obesity has differential effects on muscle mass[21] depending on factors influencing the anabolic resistance of patients, such as age and level of activity, with older, inactive individuals being more disproportionately affected by obesity in the impairment of muscle quality. However, Ozkok et al.[22] found that while both sarcopenia and SO were associated with frailty and worse physical performance, SO was more weakly associated than sarcopenia when compared to robust individuals (OR = 5.90 for frailty and 3.90 for physical performance, for SO vs OR = 6.05 and 4.40 for sarcopenia alone). This suggests that obesity might protect against frailty and poor physical performance in sarcopenic patients. It is postulated that this could be due to obese individuals having higher overall and protein intake, and the increased body weight exerting an overload stimulus, leading to increases in muscle mass and bone mineral density, protecting against osteoporotic fractures which is associated with further muscle loss. However, they note that a head-to-head comparison between SO and sarcopenia only showed no significant difference in performance, suggesting that overall, the supposed beneficial and negative impact of obesity in patients with sarcopenia only might balance out. Another study by Heng et al[23] demonstrated that while concomitant sarcopenia and obesity increase odds of frailty than sarcopenia or obesity alone, interestingly, the increased odds of frailty were lower than expected from the combined effect of obesity and sarcopenia, demonstrating a negative synergism or antagonism between both conditions that moderates the effect of frailty. The available literature finds that SO is more strongly associated with frailty than sarcopenia alone although the evidence is mixed and could be due to differing measures of frailty, obesity and sarcopenia. Nevertheless, further research is required to establish if SO has a greater impact on frailty than sarcopenia alone, and to elucidate the underlying mechanisms. Standardised definitions of obesity, sarcopenia and SO[24] should be used in future studies.

We found that sarcopenic obesity (SO) was significantly associated with poorer functional outcomes and higher frailty burden compared to sarcopenia or obesity alone. Specifically, individuals with SO were nearly twice as likely to require mobility aids compared to those with sarcopenia and also had significantly lower MBI scores, reflecting greater limitations in activities of daily living. These findings underscore the compounded functional disadvantage conferred by the coexistence of low muscle mass and excess adiposity.

This relationship may be explained by the synergistic pathophysiology of sarcopenia and obesity. Sarcopenia contributes to reduced strength, balance, and mobility, while obesity imposes additional biomechanical load and promotes systemic inflammation through adipokines and pro-inflammatory cytokines[5,30]. Fat infiltration into skeletal muscle, a hallmark of SO, impairs muscle quality and mitochondrial function, further accelerating physical decline[31,25]. As physical activity diminishes with age, this creates a self-perpetuating cycle of reduced mobility, muscle atrophy, and fat accumulation—culminating in frailty and functional dependence.

Participants with SO also reported greater fear of falling, as reflected in significantly higher Fall Efficacy Scale-International (FES-I) scores. This is consistent with prior literature linking sarcopenia to fall risk[26,27], and obesity to postural instability and impaired balance[28,29]. The InCHIANTI study[30] similarly found that obese individuals with poor muscle strength were more likely to experience decline in gait speed and develop new mobility impairments over time. These functional vulnerabilities likely contribute to the higher frailty burden observed in participants with SO.

However, it is important to note that evidence in this area remains mixed. While several studies[31,32] have reported lower functional scores in individuals with SO compared to sarcopenia alone, others[33] have not observed significant differences. These inconsistencies may reflect variations in the definitions and cutoffs used to classify sarcopenia, obesity, and functional impairment. In our cohort, the use of population-specific criteria for sarcopenia and obesity in an Asian context may have allowed for more accurate phenotyping, and thus clearer associations with frailty and function.

In terms of cognition, individuals with SO had significantly higher odds of cognitive impairment in unadjusted and partially adjusted models. However, this association attenuated and lost statistical significance when adjusted for age, gender and chronic cardiovascular risk factors which suggest that cardiovascular risk factors may play a role in mediating the effects of SO on cognition.

Our findings corroborate with other studies that show that SO is associated with the highest odds of having

cognitive impairment compared with sarcopenia, obesity or control[34,35]. Possible mechanistic pathways linking obesity and sarcopenia to cognitive impairment include chronic inflammation, insulin resistance, and reduced production of neuroprotective myokines. Also in line with existing literature is the less consistent effect of sarcopenia and obesity alone on cognition[34-36]. Whilst SO has consistently been found to be associated with cognitive impairment, the differential effects of SO, obesity and sarcopenia on cognition can be attributed to differences in assessment of muscle mass and obesity as well as population differences in cardiovascular risk factors. The underlying mediating mechanisms and impact on different populations warrants further study.

The ethnic composition of our study participants (Chinese 75.5%, Indian 7.9%, Malay 14.9%, Others 1.5%) is representative of that of Singapore residents (Chinese 75.9%, Indian 7.5%, Malay 15.0%, Others 1.6%)[37], suggesting that our results are generalisable to the wider local population. The study results could help inform public policy for better prediction of needs. Investigating community-dwelling older adults in a multiethnic population also provides a unique perspective into a population generally underrepresented in research.

Our study has several limitations. Firstly, as a cross-sectional study we cannot determine the causal relationship between SO and its impact on function and cognition. Further research is needed to assess the role of SO in the development and exacerbation of these conditions. Secondly, we used BMI to measure obesity and did not have body composition as this was not feasible in the community setting. There is currently no agreement on the definition of sarcopenic obesity[24] or adjustment of various body composition indices[38]. The 2022 Sarcopenic Obesity Global Leadership Initiative, recommends screening using BMI or waist circumference using ethnicity-specific cut-offs, followed by muscle strength and body composition assessment for the diagnosis of SO[39]. The consensus statement recognises the limitations of BMI but states that BMI is acceptable in the screening phase of SO due to ease and accessibility and further work on different assessments of SO and their associations is needed.

Conclusion

This study illustrates the associations of SO with negative physical and cognitive effects. After adjusting for relevant covariates, SO remains significantly associated with frailty, cognitive impairment, reduced mobility and independence in performing ADLs. SO was found to be a greater risk factor than sarcopenia or obesity alone.

Ethics approval

This study received ethics approval from the NHG Domain Specific Review Board (DSRB Ref: 2021/00839)

Authors' contributions

Le Alicia How – analysis and interpretation of data; drafting of manuscript; Lee Xin Xiang – analysis and interpretation of data; drafting of manuscript; Sarah Ann Lee Hui-En – drafting of manuscript; Teo Yao Hao - analysis and interpretation of data; drafting of manuscript; Goh Kar Cheng – acquisition of data, supervision; Li Feng Tan – acquisition of data; supervision. All authors read and approved the final version of the manuscript.

Funding

This work was supported by the Ministry of Health (MOH) Singapore Health Service Development Programme (HSDP) Fund No: 19NU-04. The funder has played no role in the study design or preparation of the manuscript.

References

1. Woo J, Leung J, Morley JE. Defining sarcopenia in terms of incident adverse outcomes. J Am Med Dir Assoc. Mar 2015;16(3):247-52.
2. Jaacks LM, Vandevijvere S, Pan A, McGowan CJ, Wallace C, Imamura F, et al. The obesity transition: stages of the global epidemic. Lancet Diabetes Endocrinol. Mar 2019;7(3):231-240.
3. Malenfant JH, Batsis JA. Obesity in the geriatric population - a global health perspective. J Glob Health Rep. 2019;3
4. Flegal KM, Kit BK, Orpana H, Graubard BI. Association of all-cause mortality with overweight and obesity using standard body mass index categories: a systematic review and meta-analysis. JAMA. Jan 2 2013;309(1):71-82.
5. Kalinkovich A, Livshits G. Sarcopenic obesity or obese sarcopenia: A cross talk between age-associated adipose tissue and skeletal muscle inflammation as a main mechanism of the pathogenesis. Ageing Res Rev. May 2017;35:200-221.
6. Ji T, Li Y, Ma L. Sarcopenic Obesity: An Emerging Public Health Problem. Aging Dis. Apr 2022;13(2):379-388.
7. Tan KHX, Tan LWL, Sim X, Tai ES, Lee JJ, Chia KS, et al. Cohort Profile: The Singapore Multi-Ethnic Cohort (MEC) study. Int J Epidemiol. Jun 1 2018;47(3):699-699j.
8. Tan LF TJ, Chew ZJ, Choong A, Hong L, Aroos R, Menon PV, Sumner J, Goh KC, Seetharaman SK. Geriatric Services Hub — A Collaborative Frailty Management Model between The Hospital and Community Providers. J Frailty Aging. 2023;(Apr 11:1–6)
9. Rockwood K, Theou O. Using the Clinical Frailty Scale in Allocating Scarce Health Care Resources. Can Geriatr J. Sep 2020;23(3):210-215.
10. Woo J, Yu R, Wong M, Yeung F, Wong M, Lum C. Frailty Screening in the Community Using the FRAIL Scale. J Am Med Dir Assoc. May 1 2015;16(5):412-9.
11. Tan LF, Lim ZY, Choe R, Seetharaman S, Merchant R. Screening for Frailty and Sarcopenia Among Older Persons in Medical Outpatient Clinics and its Associations With Healthcare Burden. J Am Med Dir Assoc. Jul 1 2017;18(7):583-587.
12. Feng L, Chong MS, Lim WS, Ng TP. The Modified Mini-Mental State Examination test: normative data for Singapore Chinese older adults and its performance in detecting early cognitive impairment. Singapore Med J. Jul 2012;53(7):458-62.
13. Delbaere K, Close JC, Mikolaizak AS, Sachdev PS, Brodaty H, Lord

SR. The Falls Efficacy Scale International (FES-I). A comprehensive longitudinal validation study. Age Ageing. Mar 2010;39(2):210-6.
14. Shah S, Vanclay F, Cooper B. Improving the sensitivity of the Barthel Index for stroke rehabilitation. J Clin Epidemiol. 1989; 42(8):703-9.
15. Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. J Am Med Dir Assoc. Aug 2013; 14(8):531-2.
16. Chen LK, Woo J, Assantachai P, Auyeung TW, Chou MY, Iijima K, et al. Asian Working Group for Sarcopenia: 2019 Consensus Update on Sarcopenia Diagnosis and Treatment. J Am Med Dir Assoc. Mar 2020;21(3):300-307 e2.
17. World Health Organization. The Asia-Pacific perspective: redefining obesity and its treatment. 2000;
18. Pang BWJ, Wee SL, Lau LK, Jabbar KA, Seah WT, Ng DHM, et al. Obesity Measures and Definitions of Sarcopenic Obesity in Singaporean Adults - the Yishun Study. J Frailty Aging. 2021;10(3):202-210.
19. Bahat G, Kilic C, Ozkok S, Ozturk S, Karan MA. Associations of sarcopenic obesity versus sarcopenia alone with functionality. Clin Nutr. May 2021;40(5):2851-2859.
20. Wei S, Nguyen TT, Zhang Y, Ryu D, Gariani K. Sarcopenic obesity: epidemiology, pathophysiology, cardiovascular disease, mortality, and management. Front Endocrinol (Lausanne). 2023;14:1185221.
21. Morgan PT, Smeuninx B, Breen L. Exploring the Impact of Obesity on Skeletal Muscle Function in Older Age. Front Nutr. 2020;7:569904.
22. Ozkok S, Aydin CO, Sacar DE, Catikkas NM, Erdogan T, Bozkurt ME, et al. Sarcopenic obesity versus sarcopenia alone with the use of probable sarcopenia definition for sarcopenia: Associations with frailty and physical performance. Clin Nutr. Nov 2022;41(11):2509-2516.
23. Heng MWY, Chan AWD, Man REK, Fenwick EK, Chew STH, Tay L, et al. Individual and combined associations of sarcopenia, osteoporosis and obesity with frailty in a multi-ethnic asian older adult population. BMC Geriatr. Dec 5 2023;23(1):802.
24. Donini LM, Busetto L, Bischoff SC, Cederholm T, Ballesteros-Pomar MD, Batsis JA, et al. Definition and diagnostic criteria for sarcopenic obesity: ESPEN and EASO consensus statement. Clin Nutr. Apr 2022;41(4):990-1000.
25. Merchant RA, Seetharaman S, Au L, Wong MWK, Wong BLL, Tan LF, et al. Relationship of Fat Mass Index and Fat Free Mass Index With Body Mass Index and Association With Function, Cognition and Sarcopenia in Pre-Frail Older Adults. Front Endocrinol (Lausanne). 2021;12:765415.
26. Alzar-Teruel M, Hita-Contreras F, Martinez-Amat A, Lavilla-Lerma ML, Fabrega-Cuadros R, Jimenez-Garcia JD, et al. SARC-F and the Risk of Falling in Middle-Aged and Older Community-Dwelling Postmenopausal Women. Int J Environ Res Public Health. Nov 4 2021;18(21)
27. Zhang X, Huang P, Dou Q, Wang C, Zhang W, Yang Y, et al. Falls among older adults with sarcopenia dwelling in nursing home or community: A meta-analysis. Clin Nutr. Jan 2020;39(1):33-39.
28. Jeon BJ. The effects of obesity on fall efficacy in elderly people. J Phys Ther Sci. Nov 2013;25(11):1485-9.
29. Neri SGR, Gadelha AB, de David AC, Ferreira AP, Safons MP, Tiedemann A, et al. The Association Between Body Adiposity Measures, Postural Balance, Fear of Falling, and Fall Risk in Older Community-Dwelling Women. J Geriatr Phys Ther. Jul/Sep 2019;42(3):E94-E100.
30. Bianchi L, Ferrucci L, Cherubini A, Maggio M, Bandinelli S, Savino E, et al. The Predictive Value of the EWGSOP Definition of Sarcopenia: Results From the InCHIANTI Study. J Gerontol A Biol Sci Med Sci. Feb 2016;71(2):259-64.
31. Fonfria-Vivas R, Perez-Ros P, Barrachina-Igual J, Pablos-Monzo A, Martinez-Arnau FM. Assessing quality of life with SarQol is useful in screening for sarcopenia and sarcopenic obesity in older women. Aging Clin Exp Res. Oct 2023;35(10):2069-2079.
32. Kim YP, Kim S, Joh JY, Hwang HS. Effect of interaction between dynapenic component of the European working group on sarcopenia in older people sarcopenia criteria and obesity on activities of daily living in the elderly. J Am Med Dir Assoc. May 2014;15(5):371 e1-5.
33. Davison KK, Ford ES, Cogswell ME, Dietz WH. Percentage of body fat and body mass index are associated with mobility limitations in people aged 70 and older from NHANES III. J Am Geriatr Soc. Nov 2002;50(11):1802-9.
34. Tolea MI, Chrisphonte S, Galvin JE. Sarcopenic obesity and cognitive performance. Clin Interv Aging. 2018;13:1111-1119.
35. Someya Y, Tamura Y, Kaga H, Sugimoto D, Kadowaki S, Suzuki R, et al. Sarcopenic obesity is associated with cognitive impairment in community-dwelling older adults: The Bunkyo Health Study. Clin Nutr. May 2022;41(5):1046-1051.
36. Booranasuksakul U, Macdonald IA, Stephan BCM, Siervo M. Body Composition, Sarcopenic Obesity, and Cognitive Function in Older Adults: Findings From the National Health and Nutrition Examination Survey (NHANES) 1999-2002 and 2011-2014. J Am Nutr Assoc. Aug 2024;43(6):539-552.
37. Singapore Department of Statistics, Ministry of Trade and Industry, Republic of Singapore. Singapore Census of Population 2020, Statistical Release 1: Demographic Characteristics, Education, Language and Religion. Accessed 1 April 2025, https://www.singstat.gov.sg/-/media/files/publications/cop2020/sr1/findings.pdf
38. Tan LF, Chan YH, Denishkrshna A, Merchant RA. Association between different skeletal muscle mass indices, physical function, and inflammation in obese pre-frail older adults. Arch Gerontol Geriatr. Mar 2024;118:105289.
39. Donini LM, Busetto L, Bischoff SC, Cederholm T, Ballesteros-Pomar MD, Batsis JA, et al. Definition and Diagnostic Criteria for Sarcopenic Obesity: ESPEN and EASO Consensus Statement. Obes Facts. 2022;15(3):321-335.