

Original Article

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

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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 $BMI \geq 25$, 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 (β : -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 (β : -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 utilisation¹. Concurrently, rates of obesity are increasing and has become a major public health concern², affecting approximately 13% or nearly 1 billion individuals². Older adults have higher rates of obesity, estimated at 35% globally with >70% overweight³. Individually, sarcopenia¹ and obesity³ 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 al⁴ 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 alone⁵, making SO an emerging critical public health issue globally⁶.

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

The authors have no conflict of interest.

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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 Caucasians⁷.

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 sites⁸ 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 previously⁸. 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 $\geq$ 5 was used to stratify participants into frail vs non-frail⁹ 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 scores¹⁵. Handgrip strength was assessed using a Jamar dynamometer, using the best of 3 readings using the dominant hand. Participants who scored SARC-F $\geq$ 4 and handgrip strength <28 kg for males or <18 kg for females were determined to have possible sarcopenia based on accordance with the Asian Working Group for Sarcopenia 2019¹⁶ 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 $\geq$ 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-variables 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*

^aBMI, body mass index; ^bSM-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 ($p < 0.05$); ^aSM-MMSE, Singapore modified Mini-Mental State Examination; ^bPresented 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)].

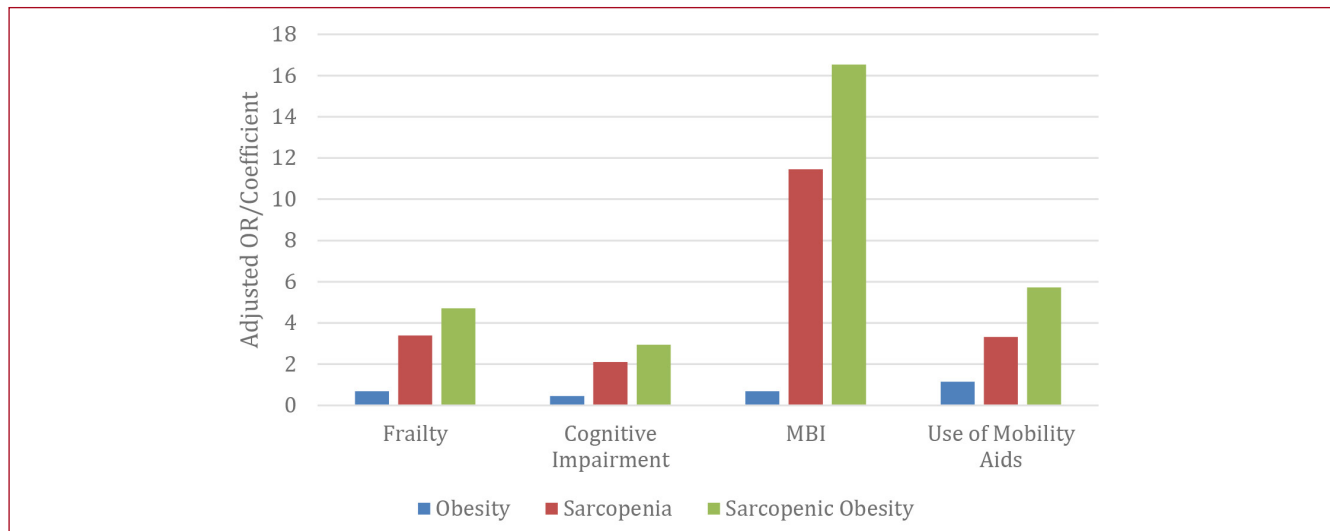


Figure 1. Associations of Obesity, Sarcopenia, and Sarcopenic Obesity with Cognition, Frailty, Function, and Mobility: Adjusted Odds Ratios and Regression Coefficients (Model 3). *MBI – Modified Barthel's Index. Note: MBI scores have been reverse-coded for graphical consistency—higher values indicate 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 dysregulation¹⁹. 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 suggest that obesity has differential effects on muscle mass²¹ 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 SO²⁴ 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 study³⁰ 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, others³³ 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 cognition³⁴⁻³⁶. 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 obesity²⁴ or adjustment of various body composition indices³⁸. 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 SO³⁹. 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-O4. The funder has played no role in the study design or preparation of the manuscript.

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