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Original Study

Osteosarcopenic Obesity: Prevalence and Relation With Frailty and Physical Performance in Middle-Aged and Older Women

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A B S T R A C T

Objectives: The aims of this study were to determine the prevalence of osteosarcopenic obesity (OSO) and to investigate its association with frailty and physical performance in Mexican community-dwelling middle-aged and older women.
Design: Cross-sectional analysis of a prospective cohort.
Setting: The FraDySMex study, a 2-round evaluation of community-dwelling adults from 2 municipalities in Mexico City.
Participants: Participants were 434 women aged 50 years or older, living in the designated area in Mexico City.
Measurements: Body composition was measured with dual-energy X-ray absorptiometry and OSO was defined by the coexistence of sarcopenia, osteopenia, or osteoporosis and obesity. Information regarding demographic characteristics; comorbidities; mental status; nutritional status; and history of falls, fractures, and hospitalization was obtained from questionnaires. Objective measurements of muscle strength and function were grip strength using a hand dynamometer, 6-meter gait speed using a GAIT Rite instrumented walkway, and lower extremity functioning measured by the Short Physical Performance Battery (SPPB). Frailty was assessed using the Frailty Phenotype (Fried criteria), the Gerontopole Frailty Screening Tool (GFST), and the FRAIL scale, to build 3 logistic regression models.
Results: The prevalence of OSO was 19% (n = 81). Frailty (according to the Frailty Phenotype and the GFST) and poor physical performance measured by the SPPB were independently associated with OSO, controlled by age. In the logistic regression model assessing frailty with the Frailty Phenotype, the odds ratio (95% confidence interval) for frailty was 4.86 (2.47–9.55), and for poor physical performance it was 2.11 (1.15–3.89). In the model assessing frailty with the GFST, it was 2.12 (1.10–4.11), and for poor physical performance it was 2.15 (1.18–3.92). Finally, in the model with the FRAIL scale, it was 1.69 (0.85–3.36) for frailty and 2.29 (1.27–4.15) for poor physical performance.
Conclusion: OSO is a frequent condition in middle-aged and older women, and it is independently associated with frailty and poor physical performance.

Recently, the concept of osteosarcopenic obesity (OSO) emerged in the scientific literature to better establish the relationship between alterations in body composition and adverse events. It is characterized by the triad of osteopenia/osteoporosis (low bone mineral density), sarcopenia/dynapenia (decreased muscle mass and strength), and increased adiposity.[1,2] Each one of these conditions is related to common complications in older people, such as falls, fractures, poor quality of life, and disability.[3–9] When combined, it is hypothesized that osteoporosis, sarcopenia, and obesity are associated with worse outcomes than when considered individually.[1,2] In a study of obese postmenopausal women, the women with OSO had lower grip strength, slower walking speed, and lower leg stance time in comparison with sarcopenic obesity, sarcopenia, and obesity alone.[10] However, there is still no consensus in the criteria used to define OSO.[1,2,11]

Studies have already showed the association of low bone mineral density with sarcopenia and fat mass.[12,13] Moreover, osteoporosis and sarcopenia share common physiopathology, risk factors, and outcomes.[14] It is hypothesized that in OSO, the excess of adiposity increases proinflammatory cytokines and hormonal disturbances, leading to loss of muscle and bone tissues, and ultimately raising the risk of falls, fractures, and disability.[2,15] These pathologic processes

The authors declare no conflicts of interest.

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start at an early age and targeted interventions could stop their progression and consequences. It was demonstrated that young healthy overweight/obese individuals had lower bone and muscle mass, higher C-reactive protein levels, and higher evening salivary cortisol concentration than lean controls.[16] The increased low-grade chronic inflammation and the decline in physical activity are conditions also related to frailty, although to the extent of our knowledge, the association of OSO and frailty has not been investigated yet.

Conducting epidemiological studies is critical for a deeper comprehension of OSO, permitting better establishment of the diagnostic criteria, the frequencies in different populations, and the association with outcomes related to frailty and disability. Therefore, the aims of this study were (1) to determine the prevalence of OSO, and (2) to investigate its association with frailty and physical performance in Mexican community-dwelling middle-aged and older women.

Methods

Study Population and Design

The present study is a cross-sectional analysis of data from women aged 50 years and older, participating in the FraDySMex (Frailty, Dynapenia and Sarcopenia in Mexican Adults) Study. It is a cohort of community-dwelling adults from Mexico City, all of them able to mobilize with or without assisting devices, and able to answer the study questionnaire for themselves (or with the help of a caregiver if the Mini-Mental State Examination [MMSE] score was $\leq$10).[17] The study consisted of 2 rounds of objectives evaluations by the medical staff at the Functional Evaluation Research Laboratory at Instituto Nacional de Geariatría in Mexico City: the first round assessed individuals from October 2014 to December 2014. The second round, from October 2015 to December 2015, added new individuals to the cohort, and reevaluated some participants from the first round. Further details of the FraDySMex Study design, recruitment, and selection of participants can be found elsewhere.[18] The study was approved by the Angeles Mocel General Hospital Ethics Committee and registered by the Instituto Nacional de Geriatría under the number DI-PI-002/2014. Written informed consent was obtained from all individuals before the study.

Physical Measurements

Body composition was measured by dual-energy X-ray absorptiometry (DXA) (Hologic Discovery-WI; Hologic Inc, Bedford-MA). Total fat (in kg and %), total lean mass (kg), appendicular (arms and legs) lean mass (kg), body mass index (kg/m^2), and whole-body bone mineral density (g/cm^2) were obtained through the total body scan. Bone mineral density was also measured at the lumbar spine (L1–L4) and femur. The appendicular lean mass–to–body mass index ratio (ALM_{BMI}) was calculated dividing the appendicular skeletal muscle mass by the body mass index. A hand dynamometer (JAMAR Hydraulic Hand Dynamometer, Lafayette, IN) was used to measure grip strength. Three measurements were taken from each side and the highest of all was considered. Gait speed was recorded from a 6-meter usual pace walk in the GAIT Rite (platinum 20) instrumented walkway (204 $\times$ 35.5 $\times$ 0.25 inches, sample rate 100 Hz).

Definition of Osteosarcopenic Obesity

OSO is a recent concept whose diagnostic criteria are still not well defined in the literature. Ilich et al[15] recommended criteria for postmenopausal women, but considering the high prevalence of obesity and osteopenia in Mexico, we propose a definition that would be sensitive for middle-aged and older Mexican women. In our study, sarcopenia was defined in accordance with the Foundation for the National Institutes of Health (FNIH) criteria: ALM_{BMI} lower than 0.512 and grip strength lower than 16 kg in women.[19] We decided to use the FNIH definition of sarcopenia because the weight-adjusted muscle index is adequate to show the effects of older age in the prevalence of sarcopenia, and facilitates the identification of sarcopenic obesity.[20] As the definition of obesity based on body fat percentage is not well established and has arbitrary cutoff points,[21] we chose to use the World Health Organization (WHO) recommendation of $\geq$35% body fat for women younger than 60 years,[22] and the definition proposed by Dufour et al[23] of >40% body fat for women aged 60 years and older. Osteoporosis and osteopenia were defined according to WHO as low bone mineral density T-score at the lumbar spine or hip lower than −2.5, and between −2.5 and −1.0 SD below that of the reference population of young adults, respectively.[24] The whole-body T-score was used as a substitute for the lumbar spine or hip T-scores in 92 participants for the following reasons: (1) presence of hip and vertebral prosthesis or instrumentation; (2) severe arthropathy or curvature disorders of the lumbar spine, preventing adequate positioning of the localized scans; and (3) inability to endure the whole scan because of vertigo. In these cases, osteoporosis was considered when the T-score was lower than −2.5 SDs below that of the reference population of young adults, and osteopenia when the T-score was between −2.5 and −1.0 SDs of the reference population of young adults. OSO was considered when sarcopenia, obesity, and osteopenia/osteoporosis were encountered in the same individual.

Other Measurements

Other measurements obtained were as follows: (1) the 7-item Center for Epidemiologic Studies Depression Scale Short Form (CES D-7) to evaluate depression (depression was considered if score $\geq$5)[25]; (2) the MMSE to assess cognition (cognitive impairment was considered when score $\leq$23 if schooling $\geq$5 years, $\leq$19 if schooling between 1 and 4 years, $\leq$16 if schooling $\leq$1 year)[17]; (3) the Charlson comorbidity index to evaluate comorbidities[26,27]; (4) the Mini Nutritional Assessment (MNA) was applied to determine nutritional status (risk of undernutrition if score $\leq$23.5)[28]; (5) and the Short Physical Performance Battery (SPPB) to measure lower extremity functioning (poor physical performance was considered if score $\leq$9).[29,30] Three scales were used to assess frailty: the Frailty Phenotype (Fried criteria), based on objective questions and physical measurements (a score $\geq$3 defines frailty)[31]; the Gerontopole Frailty Screening Tool (GFST), based on the examiner's clinical judgment about the individual's vulnerability, after considering 6 points: living alone, weight loss, fatigue, mobility, memory problems, slow gait speed[32]; and the FRAIL scale, a 5-point questionnaire that does not require physical examination techniques (frailty defined by score $\geq$3).[18] Data regarding current or previous smoking status, schooling years (<10 years vs $\geq$10 years, based on Mexican law that ensures at least 9 years of schooling), and history of falls, fractures related to falls, and hospitalization in the past year also were obtained.

Statistical Analysis

Data were analyzed using PASW Statistics version 18 (SPSS Inc, Chicago, IL). A sample size of 81 participants with OSO and 162 participants without OSO would give us 80% power to detect a difference of 15% in the frequency of frailty between individuals with and without OSO, with the ratio of participants with and without OSO of 1:2, and the significance level of 5%, using a 2-sided 2-sample test of proportions with the Yates correction for continuity. However, we included 427 individuals, with a ratio of participants with and without OSO of approximately 1:5.

Descriptive statistics are reported as means $\pm$ SDs for continuous variables and as number and frequencies for binary and categorical variables. Some continuous variables were dichotomized for analytic purposes, according to cutoff points previously established in the

literature. Age was dichotomized using the sample mean as the cutoff point. Logistic regression was used to compare all the variables between individuals with and without OSO, and results are shown as crude odds ratio (OR) with the respective 95% confidence intervals (CIs). Three multiple-logistic regression models were built to determine the factors independently related to OSO. The variables included in the models were those significantly related to OSO in the crude analysis, but each model had a different frailty measurement: The Frailty Phenotype, the GFST, and the FRAIL scale. The other variables were the same in all models. As grip strength is used to define both frailty, according to the Frailty Phenotype, and sarcopenia, according to the FNIH criteria, this redundancy could lead to a biased association between frailty and OSO. Therefore, we also examined this association with the GFST and the FRAIL scale, instruments that do not require physical measurements. To assess the goodness of fit of the models, we used the Hosmer-Lemeshow Goodness of Fit test and the area under the receiver operating characteristic curve (AUROC). The AUROC of the models with adequate goodness of fit were compared with the DeLong test.

Results

The FraDySMex cohort included 606 individuals, of which 434 were women aged 50 years and older (236 were evaluated in the first round and 198 were added in the second round). A total of 7 participants were excluded from the analysis (6 because they were not submitted to the DXA scan and 1 because she did not perform the handgrip test); therefore, the present study evaluated 427 women (Figure 1). The prevalence of sarcopenia, obesity, and osteopenia/osteoporosis were 144 (33.7%), 310 (72.6%), and 332 (77.8%), respectively. OSO was found in 19% (n = 81) of the study sample (Figure 2). The characteristics of all participants regarding demographics, health conditions, and physical performance can be seen in Table 1.

Table 2 shows the comparison of characteristics between participants with and without OSO, with the respective ORs and 95% CIs. OSO was associated with older age, poor physical performance, and frailty. Table 3 shows the logistic regression models, including age, frailty (measured by the Frailty Phenotype, the GFST, and the FRAIL scale in each model), and physical performance, with the respective Hosmer-Lemeshow Goodness of Fit test and AUROC. Frailty and poor physical performance were independently associated with OSO in the models with the Frailty Phenotype and the GFST, controlled by age. There was no difference between the AUROCs of these models according to the DeLong test ($P = .125$) (Figure 3).

Fig.1. Flowchart of the FraDySMex study.

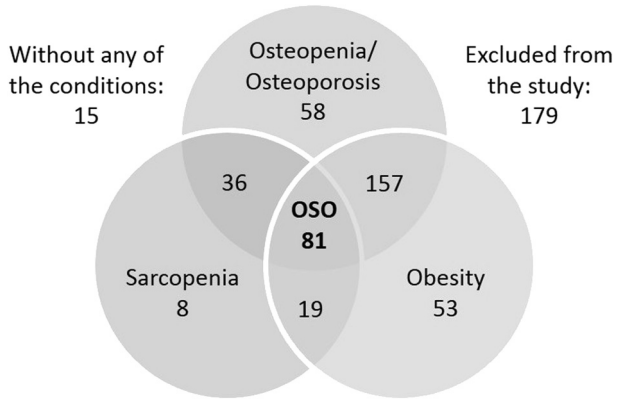

Fig.2. Venn daigram of overlap of sarcopenia, osteopenia/osteoporosis and obesity.

Table 1
Characteristics of All Participants (n = 427)

Characteristic	Mean ± SD or n (%)
Age, y	71.3 ± 9.5
Schooling <10 y*	234 (54.9)
Cognitive impairment (MMSE adjusted for schooling)*	26.7 ± 3.2
CES-D7	5.4 ± 5.1
Charlson Comorbidity Index	
3 comorbidities or more	109 (25.5)
Smoking status (current or previous)	185 (43.3)
MNA	25.1 ± 3.0
Gait speed, cm/s*	93.5 ± 25.2
Grip strength, kg	17.6 ± 5.1
Physical performance of lower extremity (SPPB)	8.8 ± 2.2
Frailty	
Frailty Phenotype (score ≥3)	46 (10.8)
GFST	211 (49.4)
FRAIL scale (score ≥3)	49 (11.5)
Sarcopenia (FNIH criteria)	144 (33.7)
Osteopenia/osteoporosis	332 (77.8)
Obesity	310 (72.6)
Falls in the past year*	186 (43.8)
Fractures related to falls in the past year	23 (5.4)
Hospitalization in the past year*	40 (9.4)

*There was 1 missing datum for schooling, MMSE, and hospitalization in the past year; 2 missing data for falls in the past year; and 3 missing data for gait speed.

Table 2
Comparison of Individuals With and Without OSO

Characteristic	With OSO, n = 81	Without OSO, n = 346	OR (95% CI)	P*
Age >70 y	62 (76.5)	176 (50.9)	3.15 (1.81–5.49)	<.001
Schooling <10 y†	50 (61.7)	184 (53.3)	1.41 (0.86–2.32)	.173
Cognitive impairment (MMSE adjusted for schooling)†	13 (16.0)	32 (9.3)	1.87 (0.93–3.75)	.078
Depression (CES-D7score ≥5)	37 (45.7)	158 (45.7)	1.00 (0.62–1.63)	.998
Charlson Comorbidity Index				
3 comorbidities or more	26 (32.1)	83 (24.0)	1.50 (0.88–2.54)	.133
Smoking status (current or previous)	36 (44.4)	149 (43.1)	1.06 (0.65–1.72)	.821
Risk of undernutrition (MNA score ≤23.5)	23 (28.4)	97 (28.0)	1.02 (0.60–1.74)	.948
Poor physical performance of lower extremity (SPPB score ≤9)	62 (76.5)	174 (50.3)	3.23 (1.85–5.62)	<.001
Frailty				
Frailty Phenotype (score ≥3)	25 (30.9)	21 (6.1)	6.91 (3.62–13.18)	<.001
GFST	55 (67.9)	156 (45.1)	2.58 (1.54–4.30)	<.001
FRAIL scale (score ≥3)	15 (18.5)	34 (9.8)	2.09 (1.07–4.05)	.030
Falls in the past year†	36 (44.4)	150 (43.5)	1.00 (0.99–1.00)	.303
Fractures related to falls in the past year	4 (4.9)	19 (5.5)	0.89 (0.30–2.70)	.843
Hospitalization in the past year†	12 (14.8)	28 (8.1)	1.97 (0.95–4.06)	.067

*P values from the crude logistic regression.
†There was 1 missing datum for schooling, MMSE, and hospitalization in the past year; 2 missing data for falls in the past year.

Discussion

This is the first study to establish an independent association of OSO with frailty (according to either the Frailty Phenotype or the GFST) and poor physical performance (according to the SPPB). It also determines the prevalence of OSO in Mexican middle-aged and older women, proposing suitable criteria to identify the condition in this population.

The prevalence of OSO found in the present study (19%) is higher than other studies. In a Korean survey of individuals aged 50 years and older, 13.5% had OSO,[33] and in a cohort of postmenopausal overweight and obese women, 12.4% presented the condition.[10] The higher frequency is probably due to (1) the high prevalence of obesity and osteopenia in Mexico,[34,35] and (2) the different criteria used to define OSO in the present study. The FNIH definition of sarcopenia, based on the weight-adjusted muscle index and low grip strength, seems to be adequate for the study population: older women with high prevalence of obesity.[20] It also agrees with the recent sarcopenia consensus criteria that add muscle weakness to low lean mass.[36–38] In addition, our study used different cutoff points to define obesity, adjusted by gender and age.

The association between OSO and frailty strengthens the hypothesis that individuals with the 3 conditions (sarcopenia, osteopenia/osteoporosis, and obesity) also are vulnerable to adverse outcomes like the frail individuals. According to our results, participants with frailty defined by the Frailty Phenotype had 5 times increased risk of having OSO, and 2 times increased risk if frailty was determined by the GFST. The association of frailty and OSO remains significant if the Frailty Phenotype is replaced by the GFST, a subjective instrument that relies on the examiner's clinical perception, indicating that the redundancy on the definition of OSO and frailty by grip strength may be irrelevant. We believe that frailty defined by the FRAIL scale was not independently associated with OSO due to the low frequency of comorbidities in the sample. To the extent of our knowledge, the relation of OSO and frailty has not been demonstrated yet, although a previous study in older Australian men showed that sarcopenic obesity was longitudinally associated with frailty.[39] As the processes leading to OSO start in young individuals,[16] the condition should be considered as an early marker of frailty and an indication for preventive interventions.

OSO was also related to poor physical performance, with 2 times increased risk. The SPPB is a widely used instrument to measure physical performance[29] that covers several domains: balance, strength, and gait speed. In a cross-sectional study of postmenopausal overweight/obese women, OSO was associated with the lowest handgrip scores, slowest walking speed, and shortest time to each leg stance when compared with sarcopenic obesity, sarcopenia, and obesity alone.[10] Individuals with OSO and poor physical performance probably engage less in physical activity, increasing the loss of muscle and bone, and thus creating a vicious cycle.

The present study has some limitations. The cross-sectional analysis prevents establishing a causal relationship between OSO and the other variables. The longitudinal follow-up of the participants is needed to determine a temporal association. Another limitation refers to the sample of community-dwelling women: the absence of men restrains the generalizability of the results, and the prevalence of OSO could be higher if hospitalized and institutionalized individuals were included. Also, the study did not have power to demonstrate differences among participants with OSO, sarcopenic obesity, sarcopenia, and obesity alone.

In conclusion, we found that OSO is frequent in Mexican middle-aged and older women, and it is independently associated with frailty and poor physical performance. These findings call attention to the condition, as it seems to be an early marker of adverse outcomes.

Table 3
Multiple-Logistic Regression Models With OSO as the Dependent Variable

Characteristic	Model With the Frailty Phenotype		Model With the GFST		Model With the FRAIL Scale	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Age >70 y	1.82 (0.98-3.38)	.056	2.11 (1.16-3.84)	.014	2.32 (1.28-4.19)	.005
Poor physical performance of lower extremity (SPPB score ≤9)	2.11 (1.15-3.89)	.016	2.15 (1.18-3.92)	.012	2.29 (1.27-4.15)	.006
Frailty	4.86 (2.47-9.55)	<.001	1.90 (1.11-3.25)	.019	1.69 (0.85-3.36)	.137
Hosmer-Lemeshow Goodness of fit:	P = .618		P = .154		P = .091	
AUROC:	0.73		0.70		0.68	

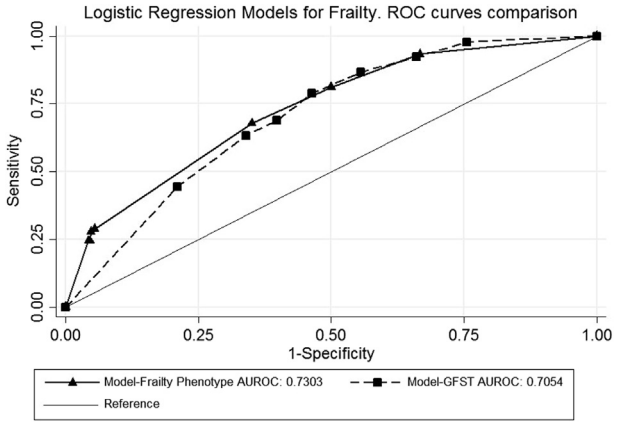

Fig. 3. Comparison of the ROC curves between the logistic regression model with the Frailty Phenotype and the logistic regression model with the GFST.

The OSO definition proposed by our group comes forth as a sensible option, because the literature still lacks explicit criteria. Further studies are needed to better determine the criteria of the condition and to establish the longitudinal association with frailty and physical performance.

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