SARCOPENIA, BONE MINERAL DENSITY, AND VITAMIN D: EPIFLORIPA AGING STUDY 2013/2014

Sarcopenia, densidade mineral óssea e vitamina D: Estudo EpiFloripa Idoso 2013/2014

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ABSTRACT

OBJECTIVE: To verify associations between osteopenia/osteoporosis and vitamin D and sarcopenia in the older adult population of Florianópolis, Brazil. **METHODS:** A cross-sectional population-based study, with 604 older adults (60 years and over). The appendicular muscle mass index (AMMI) was used to identify sarcopenia, with cutoffs of AMMI (Kg/m^2) < 7.26 kg/m^2 for men and < 5.50 kg/m^2 for women indicating inadequate values (sarcopenia). The independent variable osteopenia/osteoporosis was measured using bone mineral density (BMD, g/cm^2): T-Scores for whole body BMD, lumbar spine BMD, and femoral neck BMD, categorized as normal (BMD ≥ -1 SD) or osteopenia/osteoporosis (BMD < -1 SD from the mean of the young adult reference population). Fasting serum samples were collected and assayed using the microparticle chemiluminescence (CMIA)/Liaison method. Vitamin D concentrations of < 30 ng/mL were defined as hypovitaminosis. Crude and adjusted logistic regression analyses were performed. **RESULTS:** Osteopenia/osteoporosis in the lumbar spine and femoral neck were associated with higher odds of sarcopenia in women and men. Osteopenia/osteoporosis in the whole body was associated with sarcopenia in women only. Vitamin D was not associated with sarcopenia in either sex. **CONCLUSIONS:** Having osteopenia/osteoporosis was associated with sarcopenia in this older adult population.

KEYWORDS: sarcopenia; osteoporosis; bone diseases, metabolic; aged.

RESUMO

OBJETIVO: Verificar a associação entre osteopenia/osteoporose e vitamina D com a sarcopenia na população idosa de Florianópolis. **METODOLOGIA:** Estudo transversal de base populacional, com 604 idosos (60 anos ou mais). O índice de massa muscular apendicular (IMMA) foi utilizado para identificar a sarcopenia, onde o IMMA (Kg/m^2) — < 7,26 kg/m^2 para homens e < 5,50 kg/m^2 para mulheres — indicava valores inadequados (sarcopenia). A variável independente osteopenia/osteoporose foi medida pela densidade mineral óssea (DMO, g/cm^2), foram calculados os T-escores para DMO corporal total, DMO da coluna lombar e DMO do colo femoral, categorizados como normais (DMO até -1 DP) ou osteopenia/osteoporose (DMO < -1 DP da média da população adulta jovem de referência). Amostras de soro em jejum foram coletadas pelo método de quimioluminescência de micropartículas (CMIA)/Liaison. Concentrações de vitamina D < 30 ng/mL foram definidas como hipovitaminose. Foi realizada análise de regressão logística bruta e ajustada. **RESULTADOS:** Osteopenia/osteoporose na coluna lombar e colo do fêmur foram associadas a maiores chances de sarcopenia em mulheres e homens. Osteopenia/osteoporose no corpo total foi associada à sarcopenia apenas em mulheres. A vitamina D não foi associada à sarcopenia em ambos os sexos. **CONCLUSÕES:** A presença de osteopenia/osteoporose associou-se à sarcopenia nesta população de idosos.

PALAVRAS-CHAVE: sarcopenia; osteoporose; doenças ósseas metabólicas; idoso.

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INTRODUCTION

Changes in body composition related to advancing age are well documented in the literature.[1,2] The decline in muscle mass between the ages of 40 and 80 years has been estimated at 30 to 60%, respectively.[3] In comparison, bone mass deteriorates gradually, with onset at middle age, at a rate of approximately 1% per year.[4]

The geriatric syndrome characterized by progressive loss of mass and muscular strength is called sarcopenia.[5] Loss and deterioration of bone mass is known as osteoporosis and is considered a multifactorial disease.[6] Both diseases are common and have negative impacts on the health of older adults, leading to inability to perform activities of daily living, worsening of quality of life, risk of fragility fracture, increased risk of falls, and mortality.[7-9]

Sarcopenia and osteoporosis appear to be related[8,10] and have several aspects in common, ranging from more frequent incidence in women and prevalence that increases with age, to their complications, impact on health, and social repercussions.[8] Previous studies have shown that physical activity, testosterone levels, estrogen, growth hormone, interleukin-6, and vitamin D[8,10] are all factors associated with both sarcopenia and bone mineral density (BMD). The importance of vitamin D to bone density is well established. However, in relation to sarcopenia, a growing body of literature suggests a possible mechanism of action through interaction with the vitamin D receptor (VDR) present in muscle cells, showing that related studies are required.[10]

There are other factors also related to development of sarcopenia, such as behavioral habits, disabling injuries, and biochemical and physiological changes.[11] Similarly, loss of bone mass depends on behavioral and environmental factors and complex mechanisms that lead to greater risk of fragility fracture in older adults.[4] These conditions impose high cost burdens for healthcare and social support.[12] Data for the year 2000 from the United States estimated expenditure on sarcopenia of approximately US$ 18.5 billion in older adults, which equated to 1.50% of health expenditure that year.[13] The economic impact of sarcopenia may be comparable to that attributed to osteoporosis.[14] In the Brazilian Unified Health System, 3 252 756 procedures related to the treatment of osteoporosis were performed between 2008 and 2010, with a total cost of almost US$ 53 million.[12]

Data indicate that there is a relationship between loss of muscle mass and bone mass,[11,15] such that osteoporosis could be a predictor of sarcopenia.[3,8,16] Thus, assessment of osteoporosis would be one of the indicators for screening of individuals with sarcopenia.

Although sarcopenia is related to and has the same adverse health effects as osteopenia/osteoporosis,[8,9] it is seldom or rarely assessed by health professionals. The strategy of screening for sarcopenia through osteoporosis is intended to achieve diagnosis, accelerate treatment and direct interventions, and avoid further complications, enabling older adults to preserve autonomy and independence for longer.

Healthy aging is determined by older adults' autonomy and independence and is only achieved through integration between muscles, joints, and bones.[4] Study of the relationships between these elements is essential for development of intervention strategies[17] aimed at maintaining muscle and bone mass. Therefore, the objective of the present study was to verify associations between osteopenia/osteoporosis and vitamin D and sarcopenia in older adult residents in the city of Florianópolis, Santa Catarina (SC), Brazil.

METHODS

This cross-sectional study was carried out with information from the second wave of the survey entitled Conditions of the health of the older adults in Florianópolis — EpiFloripa Aging Study. The baseline study was conducted in 2009/2010 and the follow-up in 2013/2014. The EpiFloripa Aging Study is a population-based, household-based, longitudinal study that evaluates older adult individuals of both sexes aged 60 years and older living in the urban area of Florianópolis, Santa Catarina, Brazil.

A prior publication[18] has described the population and study sample in greater detail. Briefly, the sample calculation indicated the need for at least 1 599 interviews (2009/2010) to represent the city's older adult population. The sample was selected in two stages: first, the urban census tracts of the city were systematically drawn and stratified in ascending order of the average monthly income of the head of the family; the second stage was selection of households in these sectors, which were also systematically drawn.

Data from the present study come from the second wave of the EpiFloripa Aging Study. Data were collected during face-to-face structured interviews (November 2013 to November 2014) and by imaging exams, laboratory tests, and physical-functional capacity tests conducted at the Universidade Federal de Santa Catarina (March 2013 to March 2014).

The baseline sample (2009/2010) comprised 1702 older adults. Of these, 505 were lost to the sample. There were 217 deaths, 159 could not be located, and 129 refused to participate. The sample for the home visit stage of the second wave comprised 1 197 older adults (80.60%), and 604 (50.40%) of these participated in laboratory tests, imaging exams, and physical-functional capacity tests. The analytical sample of this study comprised 598 older adults after six were excluded because the information from their imaging exams was incomplete.

Dependent variable

Sarcopenia was identified from muscle mass analysis using a Dual Energy X-ray Absorptiometry (DXA) dual-density densitometer (Lunar Prodigy Advance Model, General Electric). The appendicular muscle mass index (AMMI) (lean muscle mass of the arms [kg] + lean muscle mass of the legs [kg] / height^2 [m]) was used to evaluate sarcopenia with cutoffs of ≤ 2 standard deviations (SD) in relation to the mean according to sex for the young adult population in the Rosetta Study[7] used to classify participants as positive for this condition. Thus, AMMI (kg/m^2) < 7.26 kg/m^2 for men and < 5.50 kg/m^2 for women were defined as greater than normal loss of muscle mass and classified as sarcopenia.

Independent variables

Osteopenia was grouped with osteoporosis and classified by means of bone mineral density (BMD, g/cm^2), measured using DXA. T-Scores[19] (calculated using the SD for mean BMD at peak bone mass in young adults) were calculated for T-score whole body BMD, lumbar spine BMD, and femoral neck BMD. We defined values as normal if they were no less than -1 SD of the mean from the reference population of young adults of the same sex from the EpiFloripa Adult Study. Osteopenia/osteoporosis was defined as present for each measure when BMD < -1 SD[20] of the mean from the reference population of young adults of the same sex from the EpiFloripa Adult Study. Presence of osteopenia/osteoporosis was analyzed individually for each measure performed.

Vitamin D (Vitamin D 25 Hydroxy or 25-OH Vitamin D) — Fasting serum samples were collected and frozen in a freezer at -80°C. Vitamin D was measured between November 2016 and April 2017 using the microparticle chemiluminescence (CMIA)/Liaison method. Concentrations of vitamin D between 30 and 100 ng/mL were considered normal, whereas values < 30 ng/mL were defined as hypovitaminosis (which combines the cutoff points for insufficiency and deficiency), according to the recommendations for older adult populations of the Brazilian Society of Endocrinology and Metabolism (Sociedade Brasileira de Endocrinologia e Metabologia [SBEM]),[21] Because vitamin D concentration is partially dependent on exposure to sunlight, higher serum levels are identified in the spring and summer, necessitating adjustment of the model for the season of the year in which the blood sample was collected, to minimize seasonal effects.[21]

Adjustment variables

Based on data in the literature,[7,16] the following adjustment variables were used: age (continuous), schooling measured in years of study (no formal study; 1 to 4; 5 to 8; 9 to 11; or ≥ 12 years), smoking (never smoked; former smoker, quit; or currently smoking), ingestion of alcoholic beverages (not consuming; non-abusive consumption; or abusive consumption), physical activity in leisure and displacement[22] (insufficiently active [< 150 minutes of physical activity in leisure and weekly displacement] or physically active [≥ 150 minutes of leisure-time physical activity and weekly displacement]), fall last year (yes or no) and dependency for activities of daily living (ADL)[23] (no [dependence or dependence for up to 3 activities] or yes (dependence for 4 or more activities]).

Data analysis

For all analyses, we used sample weightings, which consider the effect of the cluster sampling design. All variables were expressed as proportions and 95% confidence intervals (95%CI). Likewise, prevalence and 95%CI of sarcopenia were described for each sex according to independent variables.

Logistic regression was used to investigate associations, estimating the *Odds Ratio* (OR) and its respective 95%CI in crude and adjusted analyses. Three adjustment models were esimated for the associations between each osteopenia/osteoporosis variable and sarcopenia:

- Model 1) Adjusted for age and schooling;
- Model 2) Adjusted for age; schooling; smoking; alcohol consumption; physical activity; falls; and ADL dependency;
- Model 3) Adjusted for age; schooling; smoking; alcohol consumption; physical activity; falls; ADL dependency; vitamin D level; and season.

For the association between Vitamin D and sarcopenia, the following models were estimated:

- Model 1) Adjusted for age; schooling; and season;
- Model 2) Adjusted for age; schooling; smoking; alcohol consumption; physical activity; falls; ADL dependency; and season;
- Model 3) Adjusted for age; schooling; smoking; alcohol consumption; physical activity; falls; ADL dependency; season; T-score whole body, T-score BMD lumbar spine; and T-score BMD femoral neck.

The statistical program Stata / SE 13.0 (Stata Corp., College Station, USA) was used to perform the analyses.

Ethical considerations

The Human Research Ethics Committee at the Universidade Federal de Santa Catarina approved the project (CAAE nº 16731313.0.0000.0121). The interviewees all signed a free and informed consent form.

RESULTS

The sample comprised 598 subjects (aged from 63 to 93 years), 391 (65.41%) of whom were women. Mean age was 72.46 (± 6.24) years for women and 72.00 (± 6.35) years for men. The proportions of women and men who had sarcopenia were 17.03% (95%CI 12.40 – 22.87) and 28.81% (95%CI 21.35 – 37.67) respectively.

Table 1 shows the characteristics of the sample by sex. There were more women than men and the most prevalent categories among women were 1 to 4 years of study, no alcohol consumption, never smoked, physically active, no functional dependence, and no history of falls in the previous year. In relation to bone density variables, a majority of women did have osteopenia/osteoporosis in the whole body, in the lumbar spine, and the neck of the femur, and a majority did have hypovitaminosis D. Among men, the most prevalent categories were 12 years or more of study, alcohol abuse, ex-smokers, physically active, without functional dependence, and no history of falls in the previous year. In relation to bone density variables, a majority of men did not have osteopenia/osteoporosis in the whole body or lumbar spine, but did have osteopenia/osteoporosis in the femoral neck and did have hypovitaminosis D.

The results of the analyses of associations between sarcopenia and the osteopenia/osteoporosis variables for women and men are presented in Tables 2 and 3, respectively. For women, all osteopenia/osteoporosis variables were associated with sarcopenia, even after adjustments in models 1, 2, and 3. For men, all osteopenia/osteoporosis variables were associated with sarcopenia in the crude analysis, except for osteopenia/osteoporosis in the whole body. Vitamin D was not associated with sarcopenia in the crude analysis for either sex. Despite this non-association, it was nevertheless decided to adjust the analysis between vitamin D and sarcopenia to verify the results. However, vitamin D was not associated with sarcopenia in any of the adjusted models.

DISCUSSION

The results showed osteopenia/osteoporosis in the lumbar spine and femoral neck was positively associated with sarcopenia in both sexes. However, osteopenia/osteoporosis in the whole body was only associated with sarcopenia in women. Additionally, we did not find any association in the models adjusted by vitamin D.

Osteopenia/osteoporosis in the lumbar spine and femoral neck was associated with sarcopenia in both sexes. Several potential mechanisms for sarcopenia, as well as the relationship between sarcopenia and osteopenia/osteoporosis, have been investigated.[10,16,17] However, sarcopenia was treated as an independent variable in most studies.[20,24] Few studies have been conducted with sarcopenia as an outcome, as in the present study. Yoshimura et al.[16] showed mutual associations between sarcopenia and osteoporosis in the lumbar spine and/or the femoral neck, in a cross-sectional analysis. Even after adjusting for confounding variables, presence of osteoporosis remained associated with sarcopenia (OR = 2.86; 95%CI 1.59 – 5.13). Furthermore, these authors found results in a longitudinal analysis (4 years), in which osteoporosis was a predictor of sarcopenia. However, they did not present an explanation for this relationship or propose hypotheses for the association found.[16]

Some possible hypotheses were reviewed in a recent study indicating that there is a relatively new concept in which the bone functions as an endocrine organ with some derivative factors that can affect the muscle such as osteocalcin, sclerostin, prostaglandin E2, protein-dentin matrix 1, endopeptidases on the X chromosome, and TGF-β, among others.[15]

In two other studies in which sarcopenia was the outcome, there were no associations between sarcopenia and osteopenia/osteoporosis. In a study by Pongchaiyakul et al.,[25] there was no association between osteopenia/osteoporosis (femoral neck) and sarcopenia for men or women (20–84 years) from Bangkok, Thailand. Figueiredo et al.[26] investigated older men from the city of São Paulo, SP, Brazil, and also found no associations between lower bone mineral density parameters (lumbar spine BMD and femoral neck BMD) and sarcopenia.

The findings of the present study point to the existence of a bidirectional relationship between muscle and bone tissues, extending the link beyond the purely mechanical perspective,[27] as is explored in most scientific articles. It is precisely the existence of physical, genetic, and molecular connections that make study of the different mechanisms of interaction between these types of tissues complex.[10]

A recent study showed that cells present in the bone marrow, such as osteocytes, are capable of releasing substances and factors that stimulate proliferation of muscle cells, in addition to regulating osteogenesis and reabsorption of bone tissues.[10] This may be a possible explanation for the results observed in the present study, providing a new perspective on the relationship between osteopenia/osteoporosis and sarcopenia. The magnitude of associations between exposures (osteopenia/osteoporosis in the lumbar spine and femoral neck) and outcome (sarcopenia) was high, especially in women.

Assessment and identification of sarcopenia are not routine examinations in primary care, whereas bone densitometry is more widely used and diffused in clinical practice. Thus, these results and possible changes may provide important information for screening of older adults, who are prone to developing sarcopenia.

Table 1. Description of the sample and prevalence of sarcopenia according to demographic, socioeconomic, lifestyle, and health status variables, and osteopenia/osteoporosis in older adults.

Variable	Female			Male		
	n	Mean	SD	n	Mean	SD
Age	391	72.46	6.24	207	72.00	6.35
	n	%	% (95%CI) Sarcopenia	n	%	% (95%CI) Sarcopenia
Educational level (in years)						
No formal education	26	6.21	8.93 (2.51 – 26.73)	14	5.24	38.31 (15.82 – 67.45)
1 to 4	155	39.19	17.08 (11.34 – 25.13)	60	24.51	31.87 (18.63 – 49.14)
5 to 8	72	18.36	14.19 (5.39 – 32.33)	34	20.24	31.31 (16.17 – 51.71)
9 to 11	70	18.50	19.26 (8.33 – 38.72)	24	16.92	38.24 (17.83 – 63.72)
12 or more	67	17.74	20.13 (10.46 – 35.11)	75	33.09	18.66 (9.81 – 33.00)
Alcohol consumption (598)						
No	270	69.00	20.91 (14.73 – 28.94)	76	33.72	30.89 (20.13 – 44.32)
Moderate	97	24.39	9.34 (4.95 – 17.11)	64	29.24	22.26 (12.01 – 37.73)
High	24	6.61	4.32 (0.87 – 18.51)	67	37.14	32.00 (18.32 – 49.69)
Smoking habit						
Never	300	74.70	14.44 (9.53 – 21.39)	75	31.00	27.92 (17.23 – 41.85)
Former smoker and quit	68	19.74	16.51 (7.02 – 34.33)	111	58.36	27.56 (18.24 – 39.53)
Currently smoking	23	5.66	52.86 (28.33 – 76.11)	21	10.64	38.20 (16.53 – 65.90)
Physical activity						
Insufficiently active	192	48.50	22.33 (15.44 – 31.12)	64	27.30	37.60 (22.20 – 56.02)
Physically active	199	51.50	12.00 (7.35 – 19.23)	143	72.70	25.49 (17.12 – 36.18)
Dependency for activities of daily living						
No	276	70.36	19.71 (13.52 – 27.73)	167	82.10	27.90 (19.61 – 38.06)
Yes	115	29.64	10.57 (6.01 – 17.99)	37	17.90	33.22 (19.21 – 50.95)
Falls (last year)						
No	260	66.13	15.70 (10.81 – 22.22)	160	76.18	28.42 (20.59 – 37.82)
Yes	131	33.87	19.64 (11.91 – 30.37)	47	23.82	30.11 (16.32 – 48.85)
Osteopenia/osteoporosis — T-score whole body						
No	159	41.37	2.50 (1.13 – 5.42)	195	95.10	27.01 (19.53 – 69.69)
Yes	231	58.63	26.82 (20.45 – 34.45)	12	4.89	63.54 (30.42 – 87.43)
Osteopenia/osteoporosis — Lumbar Spine						
No	128	31.94	2.47 (0.89 – 6.63)	141	71.80	23.52 (16.03 – 33.34)
Yes	262	68.06	23.43 (17.42 – 30.77)	66	28.10	42.34 (29.51 – 56.22)
Osteopenia/osteoporosis — Femoral Neck						
No	110	29.40	3.52 (1.53 – 7.99)	75	39.08	12.94 (7.03 – 22.74)
Yes	280	70.60	22.23 (16.12 – 29.93)	132	60.92	39.05 (29.49 – 49.41)
Vitamin D						
Normal	101	30.49	16.33 (9.1 – 27.62)	93	43.43	26.32 (17.01 – 38.44)
Hypovitaminosis D	271	69.51	18.02 (12.61 – 24.89)	106	56.57	30.75 (21.23 – 42.13)
Seasons						
Spring	55	15.72	19.63 (7.69 – 41.48)	29	18.05	34.12 (15.71 – 58.99)
Summer	44	9.40	7.22 (2.74 – 17.92)	19	9.55	27.87 (12.53 – 51.07)
Autumn	178	52.60	20.29 (13.12 – 29.86)	97	46.39	28.18 (18.43 – 40.70)
Winter	95	22.28	13.66 (7.74 – 23.45)	54	26.01	26.49 (15.61 – 41.42)

SD: standard deviation; 95%CI: 95% confidence interval.

Table 2. Crude and adjusted analysis for osteopenia/osteoporosis associated with sarcopenia in women.

Variables	Female			
	Crude Analysis	Model 1	Model 2	Model 3
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Osteopenia/osteoporosis — T-score whole body				
No	1	1	1	1
Yes	14.51 (6.05 – 34.79)	14.99 (5.93 – 37.92)	15.06 (5.11 – 44.35)	15.70 (5.22 – 47.21)
Osteopenia/osteoporosis — Lumbar Spine				
No	1	1	1	1
Yes	12.00 (4.11 – 35.07)	13.27 (4.34 – 40.52)	11.32 (3.50 – 36.64)	11.32 (3.43 – 37.29)
Osteopenia/osteoporosis — Femoral Neck				
No	1	1	1	1
Yes	3.00 (1.82 – 4.95)	3.34 (1.91 – 5.83)	2.87 (1.59 – 5.18)	5.44 (1.74 – 16.94)
Vitamin D				
Normal	1	1	1	1
Hypovitaminosis	1.12 (0.53 – 2.36)	1.12 (0.51 – 2.46)*	0.98 (0.46 – 2.08)**	0.75 (0.35 – 1.63)***

OR: Odds Ratio; 95%CI: 95% confidence interval; Model 1: Adjusted for age and schooling; Model 2: Adjusted for age, schooling, smoking, alcohol consumption, physical activity, falls, and dependency for activities of daily living (ADL dependency); Model 3: Adjusted for age, schooling, smoking, alcohol consumption, physical activity, falls, ADL dependency, vitamin D, and season; *adjusted for age, schooling and season; **adjusted for age, schooling, smoking, alcohol consumption, physical activity, falls, ADL dependency, and season; ***adjusted for age, schooling, smoking, alcohol consumption, physical activity, falls, ADL dependency, season, T-score whole body, T-score BMD lumbar spine, and T-score BMD femoral neck.

Table 3. Crude and adjusted analysis for osteopenia/osteoporosis associated with sarcopenia in men.

Variables	Male			
	Crude Analysis	Model 1	Model 2	Model 3
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Osteopenia/osteoporosis T-score whole body				
No	1	1	1	1
Yes	4.70 (1.09 – 20.27)	3.49 (0.71 – 17.09)	3.94 (0.78 – 19.86)	4.24 (0.91 – 19.57)
Osteopenia/osteoporosis Lumbar Spine				
No	1	1	1	1
Yes	2.38 (1.22 – 4.64)	2.25 (1.07 – 4.72)	2.27 (1.05 – 4.89)	2.49 (1.14 – 5.43)
Osteopenia/osteoporosis Femoral Neck				
No	1	1	1	1
Yes	4.77 (2.51 – 9.06)	4.64 (2.39 – 9.04)	5.31 (2.44 – 11.58)	5.11 (2.11 – 12.35)
Vitamin D				
Normal	1	1	1	1
Hypovitaminosis	1.23 (0.63 – 2.42)	1.19 (0.59 – 2.40)*	1.05 (0.50 – 2.23)**	1.02 (0.48 – 2.19)***

OR: Odds Ratio; 95%CI: 95% confidence interval; Model 1: adjusted for age and schooling; Model 2: adjusted for age, schooling, smoking, alcohol consumption, physical activity, falls, and dependency for activities of daily living (ADL dependency); Model 3: adjusted for age, schooling, smoking, alcohol consumption, physical activity, falls, ADL dependency, vitamin D, and season; *adjusted for age, schooling, and season; **adjusted for age, schooling, smoking, alcohol consumption, physical activity, falls, ADL dependency, and season; ***adjusted for age, schooling, smoking, alcohol consumption, physical activity, falls, ADL dependency, season, T-score whole body, T-score BMD.

The results of the present study suggest that osteopenia/osteoporosis can be considered an indicator of risk for sarcopenia among older adults with the same characteristics as the present sample. Health professionals, including those working in primary health care, can address pateints' muscular health based on information on bone density. They can reinforce the importance of strategies capable of maintaining and/or increasing muscle mass, muscle strength, and balance, to reduce the risk of falls, fractures, functional disability, and death.[9]

Our results showed no association between osteopenia/osteoporosis and sarcopenia; after adjustment for vitamin D. This finding coincides, in part, with a recent meta-analysis of 12 observational studies with adults and older adults.[28] Luo et al.[28] showed a significant association between blood 25(OH)D concentrations and sarcopenia. However, in contrast with our study, the studies included in the meta-analysis assessed vitamin D as a continuous variable or using a cutoff of 20 ng/mL.[28] It is possible that the cutoff value for vitamin D used in the present study was high. There is an extensive discussion on the most appropriate cutoff point for vitamin D,[29] and we chose those recommended for the Brazilian population, where the focus is to keep blood levels above 30 ng/mL in the older adult population.[21]

Among the limitations of the study, we can cite the cross-sectional design, which makes it impossible to establish causal relationships between the exposures and the outcome. Another limitation concerns the losses occurred during the tests, which may lead to selection bias, since the older adults who attended at this stage had better health status than those who refused. Also, some minerals and hormones[30] that are important for analysis of osteopenia/osteoporosis were not evaluated in this study, which could affect the results. Additionally, indicators of muscle strength and motor performance were not considered in the definition of sarcopenia, due to unavailability of data. Another possible limitation is the decision to combine osteopenia and osteoporosis in a single variable, which was because of the low number of individuals with osteoporosis. The Brazilian Society of Endocrinology and Metabolism definition is based on recommendations in which the minimum cut-off point for "optimal" vitamin D status is 30 ng/ml and this is the same cutoff point used by the Endocrine Society and the American Geriatric Society, but the Brazilian Society of Endocrinology and Metabolism does not classify vitamin D below these levels, which may be a limitation of our study.

This study highlights performance of standardized procedures and examinations, especially with relation to body composition and bone densitometry, as well as administration of questionnaires with validated scales. It is worth emphasizing that sarcopenia should be investigated using the gold standard established in the literature.

We reiterate the need for longitudinal studies and interventions to better investigate the relationship between increased BMD and increased muscle mass, and its influence on reducing the risk of developing sarcopenia in the older adult population.

The combination of sarcopenia and osteopenia/osteoporosis can have social and economic impacts due to complications involving the health of the affected population. The consequences of these diseases favor development of disabilities, depression, and risk of fragility fracture, in addition to increasing rates of hospitalization and mortality, thus having a significant impact on public health services.

The results also show the importance of studying these characteristics in the older adult population, since they can contribute to implementation of healthcare actions capable of preventing deterioration, early diagnosis of at-risk individuals, and even to treatment and rehabilitation for those affected.

CONCLUSION

The results of this study show that osteopenia/osteoporosis was associated with sarcopenia, in both sexes, except for whole body osteopenia/osteoporosis in men. These results suggest that preventive strategies are needed to reduce/decelerate bone loss among older adults and to prevent loss of muscle mass and ameliorate its complications for the health of this population.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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AUTHORS' CONTRIBUTION

SCC: study concept and design, analysis and interpretation of data, drafting of the manuscript, revision and approval of the final version for publication and all aspects pertaining to the entire article's accuracy and integrity. LMO: study concept and design, analysis and interpretation of data, drafting of the manuscript, revision and approval of the final version for publication and all aspects pertaining to the entire article's accuracy and integrity. LPM: study concept and

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