Original Article

Relationship between obesity, sarcopenia, sarcopenic obesity, and bone mineral density in elderly subjects aged 80 years and over

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A B S T R A C T

Objective: This study sought to analyze the relationship between the components and aggravations of body composition (obesity, sarcopenia, and sarcopenic obesity) and bone mineral density in elderly subjects aged ≥80 years.

Methods: A cross-sectional study design was utilized to assess 128 subjects aged between 80 and 95 years. Body composition and bone mineral density were measured by dual energy X-ray absorptiometry. Gait speed was assessment by walking test. The statistical analyses included Spearman’s correlation, one-way analysis of variance, the chi-squared test, and binary logistic regression analysis.

Results: The elderly subjects with sarcopenia had lower bone mineral density compared to the obesity group, with higher risk for presence of osteopenia/osteoporosis in the spine (OR: 2.81; CI: 1.11–7.11) and femur (OR: 2.75; CI: 1.02–7.44). Obesity was shown to be a protective factor for osteopenia/osteoporosis in the spine (OR: 0.43; CI: 0.20–0.93) and femur (OR: 0.27; CI: 0.12–0.62).

Conclusion: It was found that lean mass is more directly related to bone mineral density (total, femur, and spine) and sarcopenia is associated with osteopenia/osteoporosis. Obesity represents a possible protective factor for osteopenia/osteoporosis in elderly subjects aged 80 years and over.

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Introduction

The prevalence of osteoporosis is high in the elderly. This disease damages functional capacity in this population, since it may increase the prevalence of falls and fractures and lead to dependency in performing activities of daily living (ADL), for example, standing up, sitting and climbing a flight of stairs, among others.

Bone mineral density (BMD) is determined by the amount of mineral content in the bone area, and may be influenced by several factors, among them, body composition. Some studies have investigated the individual relationships between BMD and its components (body fat and lean mass). Genaro et al. observed that lean mass is more associated with BMD in osteoporotic postmenopausal women than body fat, on the other hand Blecher et al. suggested that the loss of body fat is more associated with BMD in men aged over 70 years.

There is an assumption that both components (body fat and lean mass) could contribute to the maintenance of BMD, by generating a mechanical overload on the bones favoring the absorption of calcium, however, recent evidence has shown that excess body fat is not a protective factor for BMD in older individuals. In relation to lean mass, studies show that this variable is directly associated with bone mass and a decrease in the quantity and quality of both is related to aging. This marked decrease in muscle mass that occurs with aging, associated with low muscle strength or low physical performance, is defined as sarcopenia and, in the event that this condition coexists with excess body fat, it is called sarcopenic obesity.

Methods

Sample characteristics

This was a cross-sectional study with a convenience sample, conducted between October 2009 and May 2010 in the city of Presidente Prudente (~210,000 habitants), located in the southeastern region of Brazil.

Elderly residents aged 80 years and over of both sexes, were invited to participate in the study. The Presidente Prudente municipal health department provided the names, addresses and telephone numbers of individuals who used the public health service of the city. The invitation was made by telephone and the survey was also publicized in the media. A total of 135 subjects responded to the invitations. Individuals who were unable to walk, bedridden, residents of rural areas, institutionalized, those with pacemakers and individuals with incomplete data in the database were excluded. Thus, the sample consisted of 128 subjects.

The objectives and methodology used for data collection were explained and the subjects were informed that they could withdraw from the study at any time. Only those who signed the “Informed Consent” were included in the sample. All protocols were reviewed and approved by the Research
Ethics Committee of the University Estadual Paulista (Case number 26/2009).

**Body composition**

For body composition analysis Dual Energy X-ray Absorptiometry (DXA) equipment of the Lunar brand, model DPX-MD, software 4.7 was used. Data were transmitted to a device connected to a computer on which the results of lean mass, body fat and bone mineral density (BMD) were recorded. For analysis of the BMD, total proximal femur, lumbar spine (L1–L4) and total whole-body BMD were assessed. The examinations were performed following the manufacturer’s recommendations.

**Definition of groups (obesity, sarcopenia and sarcopenic obesity)**

The sample was divided into four groups: (i) normal group (NG): subjects who were not obese or sarcopenic; (ii) obesity group (OG): subjects classified with a fat percentage above the 60th percentile (33.9% and 43.6%) for men and women, respectively, according to the recommendations of Baumgartner et al.; (iii) sarcopenia group (SG): subjects with low muscle mass and gait speed were classified as sarcopenic. For muscle mass classification, the appendicular lean mass (ALM) index was used (upper limb + lower limb lean mass [kg]/stature [m]²), being that low muscle mass was considered as present in individuals with an ALM index below 7.59 kg/m² and 5.57 kg/m² for men and women, respectively. The adoption of these cutoff points was based on 2 standard deviations below the mean of a reference group of young adults (n = 60; 25 men and 35 women) aged between 20 and 30 years, as suggested by Baumgartner et al. Individuals with a gait speed below 0.8 m/s, in a 3 m walking test, were considered as having low gait speed, according to Cruz-Jentoft et al. (iv) sarcopenic obesity group (SOG): subjects who presented both obesity and sarcopenia conditions.

**Osteopenia/osteoporosis**

Elderly subjects were classified as having osteopenia or osteoporosis according to the criteria established by the World Health Organization.

**Gait speed**

Gait speed was defined by the performance achieved in a 3 m walking test. Subjects were instructed to walk naturally, and the lowest time (in seconds) obtained from two attempts was recorded.

**Anthropometric measurements**

Body weight was measured by an electronic scale and height was measured by a fixed stadiometer. These measurements were used for calculating BMI [weight (kg)/height (m)²], and were performed following the procedures described by Freitas Júnior.

**Smoking**

Smoking was referred by elderly subjects through interviews. The questions and answers options are described below:

- i) Do you currently smoke?
- ii) Have you smoked before?

**Statistical analysis**

Descriptive statistics consisted of mean and standard deviation. The average values for each variable were compared between the groups, using the analysis of variance (ANOVA) followed by the One-way post hoc Tukey test. Spearman’s correlation was used to analyze the relationship between BMD and body composition. To compare BMD between the groups (NG, OG, SG, SOG) the one-way analysis of variance (ANOVA) test followed by the post hoc Tukey test were used. The chi-square test was used to analyze the association between obesity, sarcopenia, sarcopenic obesity and the presence of osteopenia/osteoporosis. Binary logistic regression analysis was used to express the magnitude of associations in values of odds ratio (OR) and their confidence intervals, 95%. Statistical analysis was performed using SPSS software (SPSS Inc., Chicago, IL), version 17.0 and the significance level was set at 5%.

**Results**

The participation of women in the study was higher compared to men (63% vs. 37%), most of elderly subjects were aged between 80 and 84 years (78% vs. 22%) and (38%) of sample were smokers or currently smoke.

Table 1 presents the general characteristics of the sample and comparison analysis according to the groups. There was no difference between the groups for height and total lean mass. The OG presented lower age compared to the SOG (p = 0.024). The SG group presented lower weight compared to the OG and SOG groups (p ≤ 0.001), lower BMI compared to the other three groups (p ≤ 0.001) and lower appendicular lean mass compared to the NG and OG groups (p = 0.007). The OG e OSG groups presented higher fat mass compared to the NG e SG groups (p ≤ 0.001).

Table 2 presents the values of the Spearman correlations between the variables of body composition and femur, spine, and total BMD. FM showed correlations of 0.39, 0.32 and 0.41 (p ≤ 0.001) with total proximal femur, spine and total BMD, respectively, lean mass showed correlations of 0.55, 0.52 and 0.67 (p ≤ 0.001) and ALM of 0.53, 0.42, 0.62 (p ≤ 0.001).

Fig. 1 shows the comparison of BMD between the four groups investigated. The mean of total proximal femur and total whole-body BMD of the OG (0.87 g/cm² and 1.06 g/cm², respectively) was different to the NG (0.78 g/cm² and 1.00 g/cm²) and SG (0.75 g/cm² and 0.98 g/cm²) groups.

Table 3 shows the association between the presence of osteopenia/osteoporosis (spine and total proximal femur) and obesity, sarcopenia and sarcopenic obesity. Obesity was shown to be a protective factor for osteopenia/osteoporosis in the spine, as well as in the total proximal femur. The elderly
Table 1 – Sample characteristics and comparisons according to group.

| Variables            | Normal (n = 57) | Obesity (n = 38) | Sarcopenia (n = 20) | Sarcopenic obesity (n = 13) | p   |
|----------------------|----------------|-----------------|---------------------|-----------------------------|-----|
| Age (years)          | 83.3 ± 3.1abc  | 82.5 ± 1.8a     | 84.2 ± 3.0abc       | 84.8 ± 2.7abc               | 0.024|
| Weight (kg)          | 59.8 ± 13.3c   | 73.1 ± 12.3b    | 54.2 ± 10.2a        | 67.5 ± 12.3bcd              | <0.001|
| Height (cm)          | 155.9 ± 11.0   | 155.1 ± 9.1     | 157.8 ± 9.0         | 156.6 ± 7.7                 | 0.794|
| BMI (kg/m²)          | 24.3 ± 3.1a    | 30.2 ± 3.2b     | 21.7 ± 3.1e         | 27.4 ± 3.5d                 | <0.001|
| Fat mass (kg)        | 18.369 ± 6.6a  | 31.114 ± 6.9b   | 15.199 ± 4.8e       | 27.008 ± 6.0b               | <0.001|
| Lean mass (kg)       | 36.914 ± 12.6  | 37.791 ± 9.5    | 35.589 ± 7.4        | 37.295 ± 8.2                | 0.903|
| ALM (kg/m²)          | 6.9 ± 1.1a     | 6.8 ± 1.0a      | 6.1 ± 0.8b          | 6.4 ± 1.10abc              | 0.007|

SD, standard deviation; BMI, body mass index; ALM, appendicular lean mass.

Different letters are used to identify differences among groups (normal, obesity, sarcopenia and sarcopenic obesity).

Table 2 – Correlation between variables of body composition and bone mineral density in the elderly aged 80 years and over.

| Composition          | Density (g/cm²) |
|----------------------|-----------------|
|                      | Femur | Spine | Total |
|                      | r     | p     | r     | p     | r     | p     |
| FM total (kg)        | 0.39  | p ≤ 0.001 | 0.32 | p ≤ 0.001 | 0.41 | p ≤ 0.001 |
| LM total (kg)        | 0.55  | p ≤ 0.001 | 0.52 | p ≤ 0.001 | 0.67 | p ≤ 0.001 |
| ALM (kg/m²)          | 0.53  | p ≤ 0.001 | 0.42 | p ≤ 0.001 | 0.62 | p ≤ 0.001 |

Femur, total proximal femur; FM, fat mass; LM, lean mass; ALM, appendicular lean mass.

Fig. 1 – Comparison of mean and standard deviation of the bone mineral density (spine, total proximal femur and spine) between the normal, obesity, sarcopenia and sarcopenic obesity groups.

Regarding the relationship between sarcopenia and osteoporosis, recent studies have indicated this link, and it is suggested that further, more detailed investigations into this aspect are carried out, considering that the presence of these two conditions is the leading cause of disability, hospitalization and health care costs in the elderly. The results of this study demonstrated that elderly subjects with sarcopenia have approximately four times more chances of having osteopenia/osteoporosis in the femur. Similar to our findings, Go et al. observed that men over 50 years of age, with osteopenia and osteoporosis have more chance of presenting sarcopenia. Verschuren et al. found that middle-aged and elderly men aged 40–79 years were three times more likely to have osteoporosis. Sjöblom et al. investigated a group of postmenopausal women, aged 65–72 years, and observed that women with sarcopenia had 12.9 and 2.7 times more chances of having osteoporosis and fractures, respectively, and a 2.1 times higher risk of having had a fall in the preceding 12 months compared to their peers without sarcopenia. Our findings show that the chances of an elderly person aged over 80 years with sarcopenia presenting osteoporosis is greater compared to younger subjects.

Research indicates that sarcopenia and osteoporosis are associated clinical conditions and have the same etiology.
(inflammation, hormonal and nutritional deficiencies, and physical inactivity) and the same risk factors for musculoskeletal injuries. An increase in muscle mass causes elongation of collagen fibers and periosteum at the interface, resulting in stimulation of bone growth at the site. In addition, higher blood flow to the bone can lead to an increase in bone strength, and as the increase of blood flow in the limbs is proportional to the quantity of muscle mass, its decrease in these locations can lead to osteoporosis.

Recent evidence has indicated that obesity is not a protective factor for osteoporosis and fractures in older individuals due to the adverse effects caused by adipose tissue such as oxidative stress and the synthesis of pro-inflammatory adipokynes that affect bone metabolism. However, in our study involving elderly subjects over 80 years of age, the results revealed that in this age group obesity is a protective factor for osteopenia/osteoporosis in the spine and femur. Our findings corroborate with those found by Marwaha et al. in adults of both sexes and by Yang et al. in women aged over 50 years and support the traditional conclusion that obesity is beneficial to bone health because of the well-established positive effect of mechanical loading conferred by body weight on bone formation, since mechanical loading stimulates bone formation by decreasing apoptosis and increasing proliferation and differentiation of osteoblasts and osteocytes. It is noteworthy that the full effects of excess body fat on BMD have not yet been elucidated and may vary according to the type and distribution of fat (subcutaneous and visceral).

When comparing the mean values of BMD, the values for the elderly subjects with sarcopenic obesity were similar to those of the obesity group (Fig. 1); however, when analyzing the association between sarcopenic obesity and osteoporosis, although there was no statistical significance. This result indicates that the chance of osteoporosis in the elderly subjects with sarcopenic obesity is lower than for those with only sarcopenia, because it seems to be alleviated by excess body fat, but the association between obesity and sarcopenia does not eliminate the chance caused by sarcopenia of osteoporosis in the femur. These results are similar to those reported by Beck et al. in postmenopausal women, who observed that, in absolute terms, BMD and femoral geometric strength are greater in those with a higher BMI; however, this increase in BMD and geometric strength varies with the proportion of muscle mass and not with the body weight or fat mass, showing that lean mass exerts great influence on this relationship.

As a caveat, it is worth noting that the cross-sectional design of this study does not establish a causality relationship, however, a limited number of studies have aimed to verify such aspects in the elderly aged over 80 years. Another factor was the analysis of bone mineral density which was performed by DXA, the gold standard equipment for this type of diagnosis.

**Conclusion**

In summary, lean mass is more directly related to BMD (total, femur and spine) and sarcopenia is associated to
osteopenia/osteoporosis. Obesity represents a possible protective factor for osteopenia/osteoporosis in elderly subjects aged 80 years and over. Preventive measures such as physical activity throughout life can help to maintain muscle and bone mass thereby reducing the risk of sarcopenia, sarcopenic obesity and osteoporosis in older subjects.

Conflicts of interest
The authors declare no conflicts of interest.

Acknowledgements
We acknowledge support from Conselho Nacional de Desenvolvimento Científico e Tecnológico do Brasil.

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