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Analysis of bone microarchitecture related to anthropometry in climateric women

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Abstract

Background: **Osteoporosis is one of the most important public health problems involving a high percentage of costs in the medical care system. Reliable diagnostic techniques for an early detection of bone deterioration and studies of factors that influence its development in menopausal women are crucial. The aim of the study was to determine the relationship between bone microarchitecture and anthropometry in climacteric women.**

Methods: **Women were recruited at the Menopause Clinic, University Hospital of FMRP/USP, and submitted to anthropometry and to the evaluation of bone quality (Ultrasound Bone Profile Index, UBPI) and quantity (Amplitude-dependent Speed of Sound, AD-SoS-) by phalangeal quantitative osteosonography (DBM Sonic BP). Descriptive analysis of the data was reported and a multiple linear regression was performed using the software SAS® 9.0.**

Results: **71 patients aged 58 ± 7 y were studied: 28% had BMI 18.5-24.9 kg/m², 35% BMI 24.9-29.9 and 37% BMI > 30. Mean AD-SoS was 2059±79 m/s and mean UBPI was 0.67 ± 0.13. Considering AD-SoS the dependent variable, there was no statistically significant relationship between age (p = 0.20), BMI (p = 0.76), fat mass by bioelectrical impedance (p = 0.42) and by anthropometry (p = 0.95). The variables had very low effect on the UBPI when it was considered the dependent variable.**

Conclusions: **The relation between bone microarchitecture and the anthropometry of the women studied shows that, the greater the bone quantity, the better the anthropometric parameters, without statistically significance. This work was a cross-sectional study on a small sample that needs to be validated in a prospective design.**

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Key words: *Climacteric. Osteoporosis. Osteosonography. Anthropometric parameters.*

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ANÁLISIS DE LA MICROARQUITECTURA ÓSEA RELACIONADA CON LA ANTROPOMETRÍA EN MUJERES POSTMENOPÁUSICAS

Resumen

Introducción y objetivo: **La osteoporosis es uno de los problemas más importantes de la Salud Pública e involucra un elevado porcentaje de los costos del Sistema de Salud. Es decisiva la aplicación de técnicas confiables de diagnóstico para la detección precoz del deterioro óseo y estudios de los factores que influencian su desarrollo en mujeres postmenopáusicas. El objetivo del estudio fue determinar la relación entre la micro arquitectura ósea y la antropometría de mujeres postmenopáusicas.**

Métodos: **Se reclutaron mujeres, en el dispensario de Climaterio del Hospital Universitario (FMRP/USP), que fueron sometidas a antropometría y evaluación de la calidad ósea (Índice Ultrasonográfico del Perfil Óseo-UBPI) y de la cantidad ósea (Velocidad del Sonido dependiente de la Amplitud-Ad-SoS) por medio de la osteosonografía cuantitativa de falange (DBM Sonic BP). Se realizaron análisis descriptivos de los datos y regresión lineal múltiple utilizando el software SAS® 9.0.**

Resultados: **Se estudiaron 71 pacientes con edad media de 58 ± 7 años: 28% tuvieron el IMC entre 18,5-24,9 kg/m², 35% entre 24,9-29,9 y 37% IMC arriba de 30. La media del Ad-SoS fue 2.059 ± 79 m/s y del UBPI fue 0,67 ± 0,13. Considerando el Ad-SoS como la variable dependiente, no hubo relación estadísticamente significativa entre la edad (p = 0,20), IMC (p = 0,76), masa grasa por la impedancia bioeléctrica (p = 0,42) y por la antropometría (p = 0,95). Las variables tuvieron un efecto muy bajo en el UBPI cuando este fue considerado la variable dependiente.**

Conclusión: **La relación entre la micro arquitectura ósea y la antropometría de las mujeres estudiadas mostró que cuanto mayor es la cantidad ósea, mejores son los parámetros antropométricos sin importancia estadística. Este trabajo fue un estudio transversal de una muestra pequeña, por lo cual necesita ser validado en un diseño prospectivo.**

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Introduction

The climacteric is characterized by reduced ovarian function and represents the physiological transition from reproductive to non-reproductive life in women.[1] Menopause occurs by about 51 years of age in approximately one third of all women[2] and is associated with bone mineral loss, possibly causing osteoporosis.[1,3]

Osteoporosis is currently considered to be the most frequent metabolic disease, impairing the bone microachitecture composed of collagen and minerals. It may result in non-traumatic fractures, which are often the first symptoms of the disease.[4,5] The risk factors involved in the reduction of bone mineral density (BMD) usually are age, genetic and racial factors, hormonal condition, eating habits, life style, the use of some classes of medications such as corticoids, and some diseases such as anorexia nervosa and premature ovarian failure,[6] as well as other diseases that lead to reduced nutrient absorption.[7]

Osteoporosis has become a public health problem due to the social costs related to the increased number of fractures and their later consequences.[8] Thus, an early detection of the changes that occur in bone microarchitecture and in bone components is of great importance. In addition, osteoporosis is aggravated by other factors such as excess body fat,[9] recurrent in climacteric women due to the reduced estrogen production.[10]

A reliable diagnostic technique for the identification of women at risk to suffer fractures is fundamental. Particularly important among such techniques is osteosonography/osteosonometry, which provides quantitative (AD-SoS) and qualitative (UBPI) information about bone mass.[11,12] Among the advantages of this method are the absence of exposure to ionizing radiation, a low cost, rapidity and portability, with its use becoming increasingly more frequent for the prediction of the risk of fracture.[4]

Mann et al. (2008)[13] described that the phalanges are composed of predominantly cortical bone. The DBM Sonic Bone Profiler (IGEA, Italy) was designed to transmit a single ultrasound wave through the distal metaphyses of the proximal phalanges. Bone resorption leads to a descrease in the ultrasound velocity and alter the characteristics of the signal arriving at the receiver probe. Besides, the hand is very sensitive to these changes and is adequate for the assessment.

AD-SoS values show a high sensitivity to the first changes in postmenopausal bone tissue. After correction for potential confounders, AD-SoS shows the same ability of lumbar spine BMD in assessing bone status and risk of fracture.[14]

On this basis, the aim of the present study was to determine the relationship between bone microarchitecture and anthropometric characteristics in a group of women attended at the Multidisciplinary Climacteric Outpatient Clinic of the University Hospital, Medicine School of Ribeirão Preto, University of São Paulo (HCFMRP-USP).

Methods

Patients

Female patients were recruited at the Multidisciplinary Climacteric Outpatient Clinic of the University Hospital of Ribeirão Preto-USP (HCFMRP-USP), where they were being followed up. The patients were interviewed and underwent anthropometric evaluation and determination of bone quality and quantity. The study was approved by the Ethics Committee of HCFMRP-USP and all patients gave written informed consent to participate.

Anthropometric evaluation

Anthropometric evaluation consisted of the determination of body mass index (BMI), abdominal circumference (AC) and hip circumference (HC), skinfold measurements (triciptal, biciptal, subscapular, suprailiac) and determination of weight and height.[15] BMI was obtained by the formula BMI = W/H,[2] where W is weight in kg and H is height in meters[16]. Percent body fat was obtained as the sum of 4 skinfold thicknesses according to the method of Durning and Wormsley.[17] Bioelectrical impedance (BIA) was determined using a model 450 Biodynamics instrument.[18]

Evaluation of bone quality and quantity

Bone quality and quantity were determined by osteosonography using a DBM Sonic BP instrument (IGEA s.r.l., Carpi, Italy), 3rd generation model equipped with Fuzzy Logic Artificial Intelligence. The instrument evaluates the quantitative (Amplitude-dependent Speed of Sound, AD-SoS) and qualitative (Ultrasound Bone Profile Index, UBPI) bone parameters, based on the following reference values:

– for AD-SoS: low bone quantity: < 2,054 and normal quantity: > 2,054.
– for UBPI: < 0.44 = deteriorated quality, 0.44 < inadequate < 0.69, > 0.70 = adequate.[9]

Statistical analysis

Data was submitted to descriptive analysis and to determine the relation between bone microarchiteture and anthropometric characteristics of the group, a multiple linear regression analysis was performed. This model studies the relationship between a single dependent variable and several independent variables. Data was analyzed using the software SAS® version 9.0 (SAS Institute, Inc., Cary, North Carolina).

The dependent variables considered were AD-SoS and UBPI, and the independent ones were age, BMI,

Table I *Descriptive data of the sample*	
Age (years)	58 ± 7[b]
Weight (kg)	68 ± 11
Height (m)	1.56 ± 0.07
BMI (kg/m^2)[a]	28 ± 5
Fat mass by anthropometry (%)	43 ± 4
Lean mass by anthropometry (%)	57 ± 4
Fat mass by bioeletric impedance (%)	45 ± 5
Lean mass by bioeletric impedance (%)	55 ± 5
Abdominal circumference (cm)	92 ± 12
Hip circumference (cm)	104 ± 9
AD-SoS (m/s)	2,059 ± 79
UBPI	0.67± 0.13

[a]BMI= Body Mass Index; [b]Mean ± SD values.

abdominal and waist circumferences, fat and lean mass by anthropometry, fat and lean mass by bioelectric impedance, resistence and reactance.

Results

Seventy one climacteric women participated in the study. The mean age of them was 58 ± 7 years. Regarding the anthropometric aspects, the majority had a high abdominal circumference and percentage of fat mass, considering both methods (BIA and anthropometry). In respect of their bone health, 62% had inadequate bone quality (UBPI < 0.69) and 52% had normal bone mass (AD-SoS > 2,054). These characteristics were presented in table I.

The results regarding the multiple linear regressions were presented in table II and III. In table II, AD-SoS was considered the dependent variable and in table III, UBPI was the dependent variable. The variable lean body mass was not considered because it had a perfect correlation with the variable fat mass (R = -1). In other words, we had to opt for one of them (in this case, the fat mass), because the variables incorporated the same information.

There was no significant relation between AD-SoS and the anthropometric measures, which shows that none of them was capable to exert a significant effect on bone quantity assessed by phalangeal ultrasonography. Despite the non-significant results, there was an inverse relation between AD-SoS and BMI, age and fat mass.

According to table III, the effect of the anthropometric variables on the UBPI results was very low and non-significant, which means that the high percentage of fat mass, BMI and abdominal circumference as well as age did not exert an strong effect on bone quality assessed by phalangeal ultrasonography.

Discussion

The present study showed that most of the climacteric women attended at the Multidisciplinary Climacteric Outpatient Clinic of HCFMRP/USP presented excess weight and fat body mass, inadequate bone quality, and normal bone mass.

Regarding body weight, 28% were eutrophic, 35% were overweight and 37% were obese, 27% of them being grade I obese, 7% grade II and 3% grade III. These results agree with the worldwide epidemic of obesity that affects the population today.[19] In Brazil, the frequency of overweight and obesity in the climacteric population is 67%.[20] One of the factors that lead to body weight gain is energy imbalance, with energy consumption being higher than energy expenditure, a fact possibly related to excess food intake or an insufficient practice of physical activity.[21]

On average, the percentage of fat mass (see table I) was above recommended levels, i.e., 23% of body weight according to Lohman et al.[19]. It is known that fat mass increases concomitantly with a reduction of lean mass with the aging process, leading to a fall in basal metabolism. In addition, genetic and environmental factors, life style and inadequate practice of physical

Table II
Multiple linear regression, considering AD-SoS as the dependent variable

Effect	*Estimation*	*S.D.*	*CI (95%)*		*p-value*
			L.L[a]	*U.L[b]*	
Age (years)	-2.3	1.7	-5.7	1.2	0.2
BMI (kg/m^2)[c]	-3.1	9.9	-23.0	16.9	0.8
Abdominal circumference (cm)	0.7	1.8	-2.8	4.2	0.7
Hip circumference (cm)	1.1	2.9	-4.8	6.9	0.7
Fat mass by anthropometry (%)	-1.2	18.8	-39.0	36.5	0.9
Fat mass by bioeletric impedance (%)	-9.6	11.7	-33.2	14.0	0.4
Resistence (ohms)	0.1	0.4	-0.8	1.0	0.8
Reactance (ohms)	1.2	1.6	-2.0	4.5	0.45

[a]L.L. = Lower Limit; [b]U.P. = Upper Limit; [c]BMI = Body Mass Index.

Table III
Multiple linear regression, considering UBPI as the dependent variable

Effect	*Estimation*	*S.D.*	*CI (95%)*		*p-value*
			L.L[a]	*U.L*[b]	
Age (years)	< 0.001	0.00	-0.01	0.00	0.14
BMI (kg/m²)[c]	-0.01	0.02	-0.05	0.02	0.45
Abdominal circumference (cm)	< 0.001	0.00	0.00	0.01	0.61
Hip circumference (cm)	< 0.001	0.01	-0.01	0.01	0.90
Fat mass by anthropometry (%)	-0.02	0.03	-0.09	0.05	0.53
Fat mass by bioeletric impedance (%)	< 0.001	0.02	-0.04	0.05	0.84
Resistence (ohms)	< 0.001	0.00	0.00	0.00	0.79
Reactance (ohms)	< 0.001	0.00	-0.01	0.00	0.78

[a]L.L. = Lower Limit; [b]U.P. = Upper Limit; [c]BMI = Body Mass Index.

activities, among others, lead to weight gain during the cimacteric.

According to Anderegg et al.,[22] excessive weight predisposes to the onset or aggravation of non-transmissible chronic diseases such as diabetes mellitus, hypertension, and dyslipidemias, among others. Similarly, abdominal circumference also is an indicator of risk for these diseases. In the present series, mean abdominal circumference was 92 cm, indicating a high risk for development of diseases associated to obesity.[23]

In regarding to bone assessment, an emerging alternative to DXA is the use of the osteosonography method for the assessment of fracture risk in the management of postmenopausal osteoporosis.[24] The attractiveness of this method lies in the fact that previous studies suggest that the ultrasound may give information not only about BMD, but also about elasticity and architecture, in other words, this technique can detect bone characteristics in addition to density.[25]

The study of Gambacciani et al. (1998) showed a significant relationship between AD-SoS, performed by DBM Sonic, and BMD, performed by DXA, even if they showed poor correlation coefficients.[24] Similarly, the study of Mann et al. (2008),[16] showed a moderate but significant correlations between phalangeal osteosonography and DXA parameters in a group of women with premature ovarian failure.

According Mussolino et al. (1997),[25] the human phalanx is one of the most metabolically active parts of the skeleton. Barkmann et al. (2000)[26] described that the phalanx is made up of trabecular bone (seen in greatest quantity at the epiphyseal and metaphyseal levels) and cortical bone (which constitutes the diaphysis and, in part, the metaphysis). At the epiphysis, trabecular organization together with bone mineral density is particularly important in transmitting the ultrasound impulse, since the cortical component is limited to a thin shell. In the distal metaphysis of the proximal phalanges regions, the geometric distribution of the cortical bone surrounding the medullary canal has the greatest role in transmitting the ultrasound signal, especially in older people, since the trabecular bone in this area is the first to be resorbed.

When bone quantity (AD-SoS) was analyzed separately, we found that the average value (2,059 ± 79 m/s) represents a population with adequate amount of bone mass. When relating anthropometric variables with AD-SoS it was observed that none was able to exert a significant effect.

We emphasize that the results showed, although not significant, an inverse relationship between AD-SoS and BMI, age and fat mass. Therefore, the greater the fat mass, the lower the quantity of bone. Thus, according to the present study, fat mass cannot be considered to be a protective factor of bone mass, in contrast to other studies that have shown that, the greater the body mass, the greater the bone quantity.[27] However, the studies are controversial regarding the role of body composition.

According to the WHO,[28] the aging process causes a reduction of lean mass, which in turn leads to a reduction of bone mass. A possible explanation is that increased muscle tension, which exists in a greater lean mass stimulates periosteal bone deposition at the same time that muscle efforts to stimulate mechanoreceptors of osteocytes.[29]

Several authors have pointed out that not only the amount, but also the distribution of fat affects BMD. Heiss et al.[30] showed that the distribution of body fat affects the circulating levels of estradiol and of proinflammatory cytokines such as tumor necrosis factor-alpha (TNF-α), interleulkin 6 (IL-6) and C-reactive protein, which act on bone remodeling.

Regarding bone quality, the average value was considered inadequate for the population (0.67 ± 0.13) and there was no significant relation between UBPI and the anthropometric values. The effect of variables on the bone quality was very low, as seen in table III.

Although the present study did not show that bone quality is influenced by BMI, Mann et al.[13] observed that, with increasing BMI, both women with premature ovarian failure and control women showed a reduction of bone quality (r = -0.78 and r = 0.25, respectively) and quantity (r = -0.69 and r = -0.48).

The present results support data reported by other authors who stated that bone quantity and bone quality do not always follow the same physiological behavior.[31] Women with adequate bone mass quantity did not always show adequate bone quality, a fact suggesting deficiency of other bone nutrients in addition to calcium. For this reason, the study of bone topology, which includes the simultaneous evaluation of bone quantity and quality, is necessary.

The reduced sample size used in this study, the use of a new and underexplored technique in our environment and not performing DXA to compare the results are the limitations of the study. The relationship between body composition and quantity/quality of bone may not reflect the reality due to the used technology.

Conclusion

In conclusion, the relation between bone microarchitecture and the anthropometric characteristics of the women studied here shows that, the greater the bone quantity, the better the anthropometric parameters, without statistically significance. This work was a cross-sectional study on a small sample that needs to be further validated in a prospective design.

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