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Original Article

Association between bone mass and functional capacity among elderly people aged 80 years and over☆

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ABSTRACT

Objective: Analyzed the association of bone mass with the functional capacity of elderly aged 80 or more.
Methods: The sample consisted of 93 elderly aged 80 and 91 years (83.2±2.5 years) being 61 women (83.3±2.7 years) and 32 men (83.1±2.2 years) living in the city of Presidente Prudente – São Paulo/Brazil. The assessment of bone mass was realized by absorptiometry dual-energy X-ray (DXA), where have been measured values bone mineral content (BMC) and bone mineral density (BMD) of the femur and spine (L1–L4). The functional capacity was evaluated by means of walking speed tests, static equilibrium and strength of lower limbs contained in the questionnaire Wellness Health and Aging (SABE). The variables of bone mass and functional capacity were categorized according to the median values and score tests, respectively. For statistical analysis we carried out the chi-square test, the software used was SPSS (13.0) and the significance level was set at 5%.
Results: Elderly male with higher performance in the functional tests showed higher femur BMC compared to lower performance, result not found when evaluated women.
Conclusion: Thus, the bone of the femur for the oldest old male is associated with functional capacity. The constant assessment of the bone mineral mass and practive of physical activity throughout life would be measures to prevent falls in the elderly.

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Associação entre massa óssea e capacidade funcional de idosos com 80 anos ou mais

Palavras chave:
Idoso de 80 anos ou mais

RESUMO

Objetivo: Analisar a associação entre a massa óssea e capacidade funcional de idosos com 80 anos ou mais.

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Conteúdo mineral ósseo
Fêmur

Métodos: A amostra foi composta por 93 idosos entre 80 e 91 anos (83,2±2,5 anos), 61 mulheres (83,3±2,7 anos) e 32 homens (83,1±2,2 anos) da cidade de Presidente Prudente. A avaliação da massa óssea foi feita pela absorptiometria de dupla energia de raios X (DXA), na qual foram mensurados os valores de conteúdo mineral ósseo (BMC) e densidade mineral óssea (BMD) do fêmur e da coluna (L1–L4). A capacidade funcional foi avaliada por meio dos testes de velocidade para caminhar, equilíbrio estático e força de membros inferiores contidos no questionário Saúde, Bem-Estar e Envelhecimento (Sabe). As variáveis da massa óssea e capacidade funcional foram categorizadas de acordo com os valores de mediana e a pontuação obtida nos testes, respectivamente. Para tratamento estatístico fez-se o teste qui-quadrado, o software usado foi SPSS (13.0) e o nível de significância estabelecido foi de 5%.

Resultados: Os idosos do sexo masculino com maior desempenho nos testes funcionais apresentaram maiores valores de BMC de fêmur comparados com os de menor desempenho, resultado não encontrado quando avaliadas as mulheres.

Conclusão: Dessa forma, a massa óssea do fêmur para idosos longevos do sexo masculino está associada à capacidade funcional. A avaliação constante da massa mineral óssea e a prática de atividade física ao longo da vida seriam medidas para prevenção das quedas em idosos.

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Introduction

With increasing life expectancy and longevity, occurrences of health complication have also been increasing. These may include diminished bone mass, which is generally caused by disproportion between the activities of osteoclasts in relation to osteoblasts, in which there is greater consumption and/or lower production of bone.[1] This situation may lead to development of osteoporosis in older individuals.

Diminished bone mass and advanced age can be considered to be two of the main risk factors for fractures.[2] Bone fractures are one of the main causes of morbidity, mortality and hospitalization among the elderly and represent one of the biggest public health problems.[3] However, their development and consequences can be reduced by adopting preventive strategies such as examination using the technique of dual-energy X-ray absorptiometry (DXA), which was created in the 1980s.[4] This has the capacity to provide precise bone mineral density (BMD) measurements and thus may contribute towards organizing strategies for maintaining BMD within appropriate values.

Diminished bone mass also has an influence on the functional state of older individuals.[5] One of the options for easing the physiological alterations that occur in the musculoskeletal system due to the aging process, and for maintaining functional capacity, is to regularly practice physical exercise throughout life. Exercise causes weight to be placed on specific bone regions, which generates tension or deformation as an external stimulus and provides an osteogenic effect.[6]

For better diagnosis, it is important to choose the best regions for determining bone mass. The lumbar spine and the total femur are the most precise localities.[7] It also needs to be emphasized that with advancing age, one of the greatest fracture rates among elderly people is in the region of the femur.[7,8] However, there is a scarcity of studies in the literature investigating the relationship between bone mass in the total femur and lumbar spine regions and functional capacity among elderly people aged 80 years and over. Thus, the aim of the present study was to analyze the association between bone mass and functional capacity among elderly people aged 80 years and over.

Material and Methods

Sampling

This was a study with a cross-sectional design that was conducted in the city of Presidente Prudente between October 2009 and May 2010. This city has 210,000 inhabitants[9] and is located in the west of the state of São Paulo, with a Human Development Index (HDI) of 0.846 (ranked 14th in the state).[10] According to the Brazilian Institute for Geography and Statistics (IBGE), the number of Brazilians aged 80 years and over was predicted to be 2,653,060 in 2009, i.e. 1.1% of the country's population. From this principle, the current estimate for the number of elderly people within this age group in Presidente Prudente is 2100 inhabitants. The Municipal Health Department supplied names, addresses and telephone numbers of individuals aged 80 years and over. From this information, 226 individuals were randomly drawn and were contacted by telephone. Those who were unable to walk, were bedridden, lived in the rural zone, were institutionalized or used pacemakers, and those whose data in our database were incomplete, were excluded from the sample. In this manner, the sample for the present study was composed of 93 individuals of both sexes.

The individuals who were invited to participate in the present study were given explanations about the objectives of the study and the methodology used to gather data, and they were told that they could drop out of the study at any time. Only those who signed the free and informed consent statement formed part of the sample. All the protocols were reviewed and approved by the Research Ethics Committee of Universidade Estadual Paulista (Procedural number 26/2009). It should also be emphasized that all the elderly people participating in the study had access to the results from the tests that they underwent.

Bone Mass (Femur and Spine)

To analyze the bone mass of the total femur and lumbar spine (L1–L4), a dual-energy X-ray absorptiometry (DXA) machine was used (Lunar, model DPX-MD; software 4.7). The DXA technique is based on measuring the attenuation by the patient's body, of a beam of radiation generated by an X-ray source with two energy levels. The exposure to radiation is lower than that of conventional X-ray examinations. The technique makes it possible to estimate the bone mass for the entire body and per body segment. The duration of the examination is approximately 15 min. The measurement method is simple and does not require any assistance from the individual under evaluation, who should remain positioned in dorsal decubitus, without making movements inside the machine. The results were transmitted to a computer that was interconnected with the apparatus. The bone mineral content (BMC) and bone mineral density (BMD) were subsequently analyzed and categorized according to median values. Elderly individuals whose BMC and BMD were above the median values were considered to have higher BMC and BMD, while those below the median were considered to have lower BMC and BMD.

Functional Capacity

Functional capacity was analyzed by means of the tests on static balance, walking speed and lower-limb strength that appear in section L of the SABE questionnaire.[11] The balance test had three stages, which were done in sequence (10 s each). In the first stage, the elderly individual needed to stand up, with feet together; in the second stage, stand with the heel of one foot next to the big toe of the other foot; and in the third stage, stand with one foot in front of the other. The scores from the three stages were summed and the final result was obtained from the sum.

In the walking test, the elderly individual needed to walk for three meters at the same speed used to perform his daily activities. The time taken was measured and registered by the evaluators.

To evaluate lower-limb strength, the test of standing up from and sitting down on a chair was applied. In this, the elderly individual had to keep his arms crossed on his chest and then, on a signal from the evaluator, had to stand up from and sit down on a chair as quickly as possible, five times without any pause. Individuals who were unable to do the test in less than 60 s were disqualified.

The scores for each test ranged from 0 to 4 points. To classify the elderly individuals' performance, the sum of the scores obtained in the three tests was used. Individuals were considered to present lower functional capacity if their score was 0–2 points, and higher capacity if their score was 3–4 points.

Statistical Analysis

For the numerical variables, the normality of the dataset was analyzed using the Kolmogorov–Smirnov (K–S) test. Since the data fitted into a Gaussian distribution model, the descriptive statistical analysis was composed of mean values (central trend) and standard deviations (dispersion). The individuals were distributed according to sex and the mean values for each variable were compared according to sex, with analysis by means of Student's *t*-test for independent samples.

The chi-square test was used to test the association between performance in the functional capacity tests and bone mass. The statistical treatment was done using the SPSS software (SPSS Inc., Chicago, IL, USA), version 13.0, and the significance level was set at 5%.

Table 1 – Description of the sample, according to sex.

Variables	Mean ± SD		*P*
	Male (*n*=32)	Female (*n*=61)	
Age (years)	83.1±2.2	83.3±2.7	0.684
Weight (kg)	71.5±15.6	57.4±11.1	≤0.001
Height (cm)	164.3±7.1	149.8±6.8	≤0.001
Femoral BMC (g)	33.1±6	23.0±5.6	≤0.001
Spinal BMC (g)	73.3±19.3	45.1±12.5	≤0.001
Femoral BMD (g/cm^2)	0.89±0.14	0.74±0.15	≤0.001
Spinal BMD (g/cm^2)	1.16±0.24	0.93±0.17	≤0.001

BMC: bone mineral content; BMD: bone mineral density.

Results

The values presented in Table 1 are expressed as means and standard deviations of the general characteristics and variables of the bone mass of the sample studied, stratified according to sex. There was no difference regarding the age of the elderly people participating in the study. The variables of weight, height, femoral BMC, spinal BMC, femoral BMD and spinal BMD ($P \leq 0.001$) presented significant differences between the groups.

In Table 2, the percentage values of the associations between the variables of bone mass and performance in the three functional tests, according to sex, are presented. The elderly men with better performance in the functional tests presented higher femoral BMC values than did those with worse performance ($P \leq 0.001$), while there were no significant differences relating to the variables of spinal BMC, femoral BMD or spinal BMD. In the female group, there were no differences in performance in the functional tests in relation to the bone mass variables.

In Table 3, the percentage values of the associations between the bone mass variables and the performance in each of the functional tests in the male group are presented. The elderly men with better performance in the speed and balance tests presented higher femoral BMC values than did those with worse performance (P=0.009 and 0.006, respectively). The variables of spinal BMC, femoral BMD and spinal BMD did not present significance in any of the tests.

In Table 4, the percentage values of the associations between the variables of bone mass and the performance in each of the functional tests in the female group are presented. There were no differences in performance in the functional tests in relation to the bone mass variables.

Table 2 – Association between bone mass and performance in the three functional tests on elderly people of both sexes.

Bone mass	Male			Female		
	Performance in the tests		P	Performance in the tests		P
	Worse	Better		Worse	Better	
Femoral BMC (g)						
Low	81.3%	18.7%	≤0.001	54.8%	45.2%	0.705
High	18.8%	81.2%		50%	50%	
Spinal BMC (g)						
Low	56.3%	43.7%	0.480	61.3%	38.7%	0.160
High	43.8%	56.2%		43.3%	56.7%	
Femoral BMD (g/cm²)						
Low	64.7%	35.3%	0.077	55.3%	44.7%	0.573
High	33.3%	66.7%		47.8%	52.2%	
Spinal BMD (g/cm²)						
Low	50%	50%	1.000	57.6%	42.4%	0.311
High	50%	50%		44.4%	55.6%	

BMC: bone mineral content; BMD: bone mineral density.

Discussion

Decreases in bone mass in humans start to occur around the age of 40 years.[12] If no preventive action is taken, this process may contribute towards development of osteoporosis.[13]

BMD is the indicator most used for analyzing bone mass and for diagnosing osteoporosis.[7,14,15] However, in addition to BMD, BMC is also a good indicator for bone loss. Its use is important, because it takes into consideration more than just the morphological basis of bone loss (diminution of periosteal apposition and endosteal bone loss, which relates to loss from the trabecular, endocortical and intracortical surfaces).[16] In the study by Gupta et al.[12] on postmenopausal women, the BMC reduced significantly with age. In our study, the femoral BMC of the very elderly old men was the bone component that was most associated with functional capacity. One of the possible factors is that the femur is the biggest bone of the lower limbs in humans and thus aids in locomotion, posture and balance. With the bone in this important region compromised, performing some motor activities like walking became more difficult, thereby increasing the risk of falls and fractures.

Bone mass is one of the main determinants of fractures, but only a few studies so far have analyzed this in older men.[16–18] This is an alarming situation, given that the Brazilian Osteoporosis Consensus of 2002 (Pinto Neto et al.[19]) indicated that advanced age increases the risk of osteoporosis and fractures, independent of sex. Thus, evaluations on men of advanced age become essential.

Regarding evaluation of functional capacity, Kärkkäinen et al.[20] conducted an eight-year follow-up study and found that there was an association between functional incapacity and increased risk of fractures among postmenopausal women. Although the incidence of fractures is greater in

Table 3 – Association between bone mass and functional performance in men.

Bone mass	Performance in the tests								
	Speed		P	Balance		P	Lower-limb strength		P
	Worse	Better		Worse	Better		Worse	Better	
Femoral BMC (g)									
Low	87.5%	12.5%	0.009	50%	50%	0.006	81.3%	18.8%	0.127
High	43.8%	56.3%		6.3%	93.8%		56.3%	43.8%	
Spinal BMC (g)									
Low	68.8%	31.3%	0.710	31.3%	68.8%	0.694	68.8%	31.3%	1.000
High	62.5%	37.5%		25%	75%		68.8%	31.3%	
Femoral BMD (g/cm²)									
Low	76.5%	23.5%	0.169	29.4%	70.6%	0.863	76.5%	23.5%	0.316
High	53.3%	46.7%		26.7%	73.3%		60%	40%	
Spinal BMD (g/cm²)									
Low	72.2%	27.8%	0.373	27.8%	72.2%	0.960	55.6%	44.4%	0.068
High	57.1%	42.9%		28.6%	71.4%		85.7%	14.3%	

BMC: bone mineral content; BMD: bone mineral density.

Table 4 – Association between bone mass and functional performance in women.

Bone mass	Performance in the tests								
	Speed		P	Balance		P	Lower-limb strength		P
	Worse	Better		Worse	Better		Worse	Better	
Femoral BMC (g)									
Low	71%	29%	0.717	41.9%	58.1%	0.332	77.4%	22.6%	0.510
High	66.7%	33.3%		30%	70%		70%	30	
Spinal BMC (g)									
Low	77.4%	22.6%	0.142	35.5%	64.5%	0.923	74.2%	25.8	0.939
High	60%	40%		36.7%	63.3%		73.3%	26.7	
Femoral BMD (g/cm^2)									
Low	68.4%	31.6%	0.925	39.5%	60.5%	0.476	76.3%	23.7%	0.561
High	69.6%	30.4%		30.4%	69.6%		69.6%	30.4%	
Spinal BMD (g/cm^2)									
Low	66.7%	33.3%	0.759	36.4%	63.6%	0.807	72.7%	27.3%	0.907
High	70.4%	29.6%		33.3%	66.7%		74.1%	25.9%	

BMC: bone mineral content; BMD: bone mineral density.

women, the relative risk and the consequences subsequent to the fracture are more severe in men.[21,22]

In the study conducted by Sakai et al.,[23] it was found that performance in the balance test on a single foot was associated with BMD among Japanese women aged 30–82 years. Similar results were also found by Taaffe et al.,[24] who, in a study on elderly people of both sexes, observed that their performance in tests on sitting down on and getting up from chairs and on balancing on one foot was only related to femoral neck BMD and trochanteric BMD, respectively. In our study, in the female group, there was no association between bone mass and performance in tests on sitting down on and getting up from chairs and on balance. This result may indicate that for elderly women in this age group, other components of body composition, such as fat, are more associated with functional capacity (Rech et al.[25]), given that women present greater quantities of body fat, which generates a mechanical overload on the bones and may contribute towards maintaining BMD.[26]

The usual walking speed was associated with femoral neck BMD in White women aged 57–88, in a study by Brownbill et al.,[27] and with forearm BMD in postmenopausal Japanese women in a longitudinal study by Kwon et al.[28] Lindsey et al.[29] found an association between walking speed and hip, spinal, forearm and total BMD in a group of women of mean age 68 years. In the present study, no association was found between bone mass and performance in the test on usual walking speed, among the very elderly old women.

In studies such as that of Kärkkäinen et al.,[30] it was observed that women with femoral neck osteoporosis presented diminished functional capacity. In our study, no association was observed between bone mass and performance in any of the functional tests, in the female group. This evidence may signify that for elderly women over the age of 80 years, bone mass may have less influence on functional capacity than for women of lower mean age. This was observed by Miller et al.[31] in a study on men, and the results revealed that the relationship between muscle strength and aerobic capacity was stronger among middle-aged men than among old men.

In the present study, the functional capacity of the very elderly old men was associated with the bone mass of the femur, but not with the bone mass of the spine. When the performance of the male group in each of the functional tests was analyzed, the bone mass of the femur was found to be associated with the walking speed and balance tests. Kärkkäinen et al.[30] showed this relationship between the balance test and the femoral and spinal bone mass in postmenopausal women. In the study conducted by Miller et al.,[31] the BMC of some body regions such as the spine, pelvis and legs was correlated with lower-limb strength among middle-aged men, but there was no correlation between these variables among elderly men. In our study, there was no association between total femur and lumbar spine bone mass and performance in the lower-limb strength test among the very elderly old men.

According to Cawthon et al.,[32] the decrease in bone mass among men over the age of 85 years is twice as great as among 65-year-old men. This finding explains our results, since severe loss of bone mass (BMD and BMC) also intensifies the diminution of functional capacity. Another factor that reinforces our findings is that severe bone loss and occurrences of osteoporosis are related to hormone levels. Whereas women's estrogen losses begin around the age of 50 years, men's testosterone persists at functional levels until the seventh decade of life.[33]

The prevalence of osteoporosis and the incidence of osteoporotic fractures are less frequent in men than in women. This is because BMD and bone size are greater, and therefore bones are stronger in men than in women,[34] as observed in our sample. However, increasing numbers of men are presenting osteoporosis, along with the complications caused by this disease (falls, fractures and functional incapacity).

One of the limitations of our study was the absence of other physical tests, such as tests on manual grip strength, flexibility and coordination, in order to analyze functional capacity. However, it is emphasized that there is still a scarcity of studies aimed towards investigating these characteristics among elderly people over the age of 80 years.

Conclusion

Thus, the femoral bone mass of very elderly old men was associated with functional capacity. Preventive measures, such as physical activity practice throughout life targeting bone mass preservation, should be encouraged. It should also be emphasized that assessment of bone mineral mass among elderly people needs to be done constantly with advancing age, since this would be a means of working towards prevention of falls, which have high prevalence among the elderly. Although there was no relationship among females, limitations such as the absence of other tests and lack of assessment of dietary procedures, such as the use of calcium supplements among some elderly women, may have contributed towards the present findings.

Conflicts of Interest

The authors declare no conflicts of interest.

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