Quantitative ultrasound and risk of fractures in elderly women

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Summary

Objective: To verify the prevalence of women with risk of fractures estimated by ultrasonometry of the calcaneus (UOC) in a population of elderly women and its association with clinical risk factors. **Methods:** Cross-sectional study of which sample was randomly selected and submitted to a structured questionnaire about risk factors for fractures. All women underwent UOC. **Results:** We studied 168 Caucasian postmenopausal women, with a mean age of 69.56 ± 6.27 years; 81% of these women had abnormal test results and 41% of the abnormal results were considered higher risk. Women with abnormal test results had lower weight, height and BMI, and had lower values of SOS, BUA, BQI and T-score. After adjustment, BMI remained significant for abnormal UOC (OR = 3.37, 95% CI: 1.19-9.56, p = 0.02), and history of previous fractures for UOC of the higher-risk range (OR = 4.44, 95% CI: 1.16-16.96, p = 0.03). **Conclusion:** We observed a high prevalence of risk of fractures determined by the UOC. Our prevalence was higher than those in other Brazilian studies. There was an association between UOC and BMI and previous history of fractures.

Keywords: Bone fractures; elderly; calcaneus; postmenopausal; osteoporosis; postmenopausal.

Study conducted at the Medical School of Unochapecó, Chapecó, SC, Brazil

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Introduction

Osteoporosis and its resulting fractures are a major worldwide public health problem. In addition to the economic and social impact, with reduced quality of life, it also affects morbidity and mortality.

It is estimated that femur neck fractures reduce life expectancy by around 12%, with a mortality rate of 20% in the first months after the occurrence of the event[1]. As for spinal column fractures, even if asymptomatic, they increase the risk of new vertebral and non-vertebral fractures[2-4] in addition to increasing overall mortality[5].

The identification of populations at risk for fractures is essential for its prevention. Although bone densitometry is the gold standard for identification of osteoporosis, other types of equipment have been scientifically recognized for fracture risk assessment. The latest consensus of the Brazilian Society of Densitometry[6] recommends the use of quantitative ultrasound of the calcaneus bone (UOC) for this purpose, suggesting that the results of this examination associated with clinical risk factors could be used to initiate pharmacological treatment in populations where the densitometry is not accessible, if the chance of fracture is high enough.

Studies have shown that UOC is capable of estimating the risk of fractures due to spine and hip fragility and overall fragility in postmenopausal women regardless of densitometry results. There also seems to be an association between low values in UOC and increased risk of mortality in the long term[5]. These devices are easy to handle, as they do not depend on operator's analysis as in other radiological examinations. Moreover, they have fast performance, are low cost, portable and there is no radiation exposure for the patient[7].

This study aimed at estimating the prevalence of risk of fracture through UOC in a Brazilian population of elderly women and assessing its association with clinical risk factors to bone fractures.

Methods

This was a cross-sectional study with 168 women selected by random sampling in a population of elderly women living in southern Brazil (Chapecó/SC). Data were collected through a structured questionnaire, carried out during home visits between the months of May and December 2007 by a team of previously trained medical students. After the questionnaire, patients were referred to the quantitative UOC.

Inclusion criteria were: female sex; Caucasian ethnicity (self-reported); age older than 60 years; clinical diagnosis of menopause (defined as the absence of menstruation for at least 1 year) and permanent resident of the city of Chapecó/SC. Exclusion criteria were: personal history of diseases known to affect bone metabolism, either directly or indirectly (such as rheumatoid arthritis, lupus erythematosus, hyperparathyroidism, osteogenesis imperfecta); malignant neoplasms, except basal cell skin carcinoma; presence of metal pin or edema with Godet sign in both feet, or physical impossibility to place the feet placement in the UOC apparatus.

A structured questionnaire[8] was used to evaluate factors related to osteoporosis and fracture. Anthropometric data were measured according to the criteria adopted internationally, and body mass index (BMI) was calculated by weight/height^2 (kg/m^2)[9].

The quantitative ultrasound measurements were performed using a UOC Sonost 2000 equipment (OSTEOSYS CO., Ltd., Korea) using the left foot and gel. The device provides the following parameters according to the emission and reception of sound waves through the assessed material: speed of sound (SOS) in m/s, sound attenuation (BUA) in dB/MHz and bone quality index (BQI) calculated based on the first two. This last measure is similar to the stiffness index (SI) of other equipment[7]. The results are expressed as standard deviation of the mean in young adults (T-score). Equipment calibration was performed daily before the start of examinations.

UOC examinations were categorized by risk ranges based on the T-score results in two categories: normal (> -1.1) or altered (≤ -1.1) and low (> -1.0), medium (between -1.1 and -2.4) and high risk (≤ -2.5). These ranges were analyzed according to anthropometric and reproductive characteristics of the studied population, and categorized into 10-year ranges.

The bivariate analysis of data was performed considering the presence of altered UOC as the dependent variable and clinical factors as independent ones. The level of significance was set at 5%, and values between 5% and 10% were considered borderline. Multivariate logistic regression was used to obtain estimates of odds ratios (OR) and adjusted confidence intervals. The criterion for inclusion of variables in the logistic model was the association with vertebral fracture at the $p < 0.20$ level in the bivariate analysis. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 17.0.

This study followed the ethical criteria recommended by Resolution 196/96 of the National Health Council (CNS) of the Ministry of Health, having been previously approved by the Ethics Committee of Universidade Comunitária Regional de Chapecó (Unochapecó).

Results

A total of 168 women, aged 60 to 91 years, were evaluated. The division of the study population by the T-score values showed that 81.0% (n = 136) of the sample had some type of alteration in examination (T-score ≤ -1.1). When stratified into the three proposed risk ranges, it was observed that the group considered to be at higher risk (41.1% of the sample) consisted of women with lower weight, height and BMI (p < 0.05) (Table 1). Although not statistically significant, these women were also older and had more time of menopause than the other groups.

Because of the tendency of the association between age and abnormal test results, we divided the population in 10-year age ranges and analyzed the T-score categories according to each range (Figure 1). We observed an increase in the prevalence of abnormal tests with increasing age (p = 0.02).

Table 2 shows the results of bivariate and multivariate analyses for altered UOC (T-score ≤ -1.0). BMI was the only statistically significant factor in the adjusted model. Low calcium intake appears to increase the risk of abnormal tests, but the result was not statistically significant. We chose not to use age-adjustment due to the collinearity with the time of menopause.

The same sequence of analysis was used to evaluate the association between risk factors and the most altered range at the UOC tests (T-score ≤ -2.5) (data not shown in table). Statistical significance was also observed for BMI (OR = 0.21, 95% CI: 0.74-0.62, p = 0.005), dietary calcium intake (OR = 3.58, 95% CI: 0.09-13.82, p = 0.005), history of fracture due to bone fragility (OR = 5.16, 95% CI: 1.42-18.68, p = 0.01) and time since menopause (OR = 1.06, 95% CI: 0.99-1.15, p = 0.04). However, after adjustment, only history of fracture due to bone fragility (OR = 4.44, 95% CI: 1.16-16.96, p = 0.03) remained statistically significant.

Discussion

This study showed a high prevalence of risk of fracture estimated by UOC in a population of elderly women in Southern Brazil, which was higher than those described in other countries[10,11]. When compared to a study of 385 postmenopausal women living on the island of Paquetá/RJ[12],

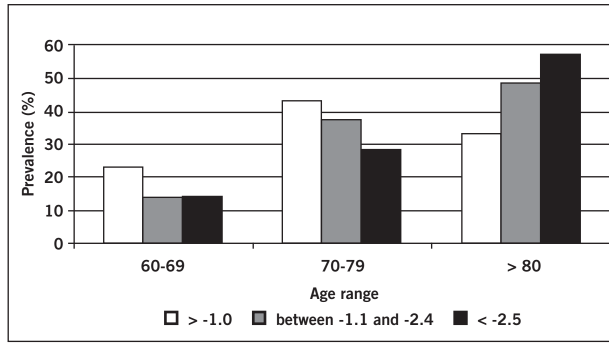

Figure 1 – Prevalence of altered T-score according to age range (n = 168).

we also observed a higher percentage of at-risk population (81% versus 59.22% of UOC examinations with T-score < -1.0 and 41.07% versus 16.88% with T-score < -2.5). Although the women from Rio de Janeiro were younger (64.63 ± 9.93 years versus 69.56 ± 6.27 year) and had a shorter time of menopause (17.00 ± 10.76 years versus 21.08 ± 69.34 years) than that in our study, we believe that difference could also be due to the influence of habits and ethnic origin of this population, as the first had 42.84% of non-Caucasian women. Both studies found variation in quantitative ultrasound parameters with age, time since menopause, weight and BMI.

In addition to indicating a population at higher risk for fractures, current studies show that an altered UOC result may indicate current or previous fractures. Velho et al.[16] carried out a cross-sectional study with 52 women older than 60 years in the city of Campinas – SP to evaluate the discriminatory power of the UOC concerning the existence of hip fractures. This group also observed that the SI, BUA and T-score were significantly lower in the group with fractures. Although carried out with a very small number of patients, this study demonstrated the discriminatory power of the UOC also for non-axial fractures.

Table 1 – Comparison of groups with T-score categorized by risk of fractures regarding the general characteristics of the population (n = 168)

	Low risk (n = 32) (mean ± SD)	Medium risk (n = 67) (mean ± SD)	High risk (n = 69) (mean ± SD)	p
Current age (years)	68.50 ± 5.66	68.80 ± 6.25	70.79 ± 6.43	0.10
Age at menarche (years)	13.09 ± 1.82	13.89 ± 1.83	13.71 ± 1.99	0.22
Age at menopause (years)	50.13 ± 5.15	48.57 ± 5.38	49.09 ± 5.62	0.42
Time of menopause (years)	18.31 ± 8.00	20.86 ± 9.36	22.60 ± 9.70	0.09
Weight (kg)	75.94 ± 11.62 [a]	68.36 ± 12.98 [b]	63.08±14.95 [b]	< 0.001
Height (m)	1.57 ± 0.04 [a.b]	1.57 ± 0.06 [a]	1.53 ± 0.07 [b]	0.01
BMI (kg/m^2)	30.78 ± 4.49 [a]	27.67 ± 4.89 [b]	26.55 ± 5.44 [b]	0.001
W/H ratio *	0.91 ± 0.05	0.90 ± 0.05	0.94 ± 0.23	0.34

* n = 138; a,b different letters mean different means. BMI, body mass index; W/H ratio, waist-to-hip ratio; SD, standard deviation.

Table 2 – Results of the bivariate and multivariate analyses between risk factors and altered results at the CBU (n = 168)

Risk factor	Crude OR (95% CI)	p	Adjusted OR (95% CI)	p
Time of menopause (in years)	0.96 (0.91-1.00)	0.06	0.96 (0.91-1.01)	0.14
Age range				
60-69 years	1.00		–	
70-79 years	2.41 (0.95-6.10)	0.06		
> 80 years	2.80 (0.53-14.53)	0.22		
Family history of hip fracture				
No	1.00		–	
Yes	1.32 (0.44-3.91)	0.62		
Previous history of fracture				
No	1.00		1.00	
Yes	0.29 (0.08-1.00)	0.05	0.32 (0.87-1.15)	0.32
BMI				
Overweight/obesity	1.00		1.00	
Normal/low	3.78 (1.37-10.41)	0.01	3.37 (1.19-9.56)	0.02
Hormonal replacement therapy use > 1 year				
Yes	1.00		–	
No	1.48 (0.44-4.95)	0.53		
Use of calcium supplement				
Current	1.00		–	
In the past	0.57 (0.06-5.08)	0.61		
Never	0.65 (0.29-1.43)	0.28		
Smoking				
Nonsmoker	1.00		–	
Ex-smoker	1.12 (0.48-2.64)	0.79		
Smoker	0.75 (0.20-2.83)	0.67		
Alcohol consumption				
Never	1.00		–	
Regularly	1.24 (0.56-2.73)	0.59		
Current physical activity				
≥ 30 min/day	1.00		–	
None	1.14 (0.51-2.52)	0.75		
Daily calcium intake				
> 300 mg	1.00		1.00	
≤ 300 mg	2.90 (1.29-6.49)	0.01	2.22 (0.95-5.20)	0.06

BMI, body mass index.

Pinheiro et al.[14] performed a cross-sectional study of 275 postmenopausal Caucasian women in the city of São Paulo – SP, and also observed the UOC capacity to differentiate patients with a history of previous osteoporotic fractures, as well as demonstrating that this capacity is similar to that of bone densitometry. Although these studies[13,14] were performed with different UOC devices, all showed the possibility of discriminating groups with fractures. The UOC also seems to have good discriminatory power for fragility fractures at other sites rather than the spine and hip[15].

The association between altered UOC and mortality has been described by Pinheiro et al.[14] in a study with Brazilian women. After prospective follow-up, the authors observed that the reduction of 1 SD in the SI was associated with increased risk of new fractures and mortality from various causes. Therefore, in addition to the high prevalence of women with abnormal tests in our study being associated with high mortality, a waist/hip ratio > 0.90 would also help to increase the risk of mortality from cardiovascular disease.

A large number of clinical factors may be associated with increased risk of fractures and should be identified, especially those that can be reversible and capable of being identified, with the consequent implementation of strategies to control the disease, even when the densitometry is not performed[16]. Our study found an association between lower BMI and altered UOC, and prior history of fractures and UOC of the higher-risk range. The low BMI and a history of fractures have been previously described as being associated with increased risk of fractures, which nearly doubles in the presence of an established fracture[13]. What surprised us was that there was no similarity in risk between the group with UOC < -1.0 and < -2.5 regarding these factors, a fact perhaps explained by the small sample size.

Another very significant factor observed in this study was the reporting of low dietary calcium intake. For analysis purposes, we divided the population into two groups according to calcium ingestion, but there was no report of a calcium intake higher than 600 mg/day by any participant. This fact is of great concern, as calcium plays a central role in bone strength and the minimum amount recommended for elderly individuals is 1,200 mg/day[17]. Low calcium intake among older people has been previously reported in national[18,19] and international studies[20,21].

Economic studies seek to assess the cost-effectiveness of screening and treatment of osteoporosis/fractures in the population. Recent international studies[22,23] highlight the importance of assessing the relative risk for fractures and the gain in quality of life-years for therapeutic decision-making. King et al.[24] used a theoretical model to estimate incidence of fractures and costs in women older than 65 years for 3 years, and concluded that the increase in the diagnosis of osteoporosis and the adoption of interventions directed at women at high risk for fractures could significantly reduce the expenses, which are greater after the onset of complications.

In Brazil, Silva[25] built some theoretical models (decision tree) with the variables: performing densitometry or not versus therapy (alendronate, hormonal replacement therapy or calcium + vitamin D) based on data from the Brazilian Public Health System (SUS) available at the time. She concluded that the adoption of any one of these measures would be questionable, as the incremental cost of evaluation and therapy outweigh the cost of treatment of the fracture itself. To build this model, the author was based on limited data available in the country and the total number of reports of hospitalization due to hip fractures and SUS costs. Therefore, we believe that this model probably underestimated the true scenario, because: a) it did not take into account other types of fracture that could be prevented and their morbimortality and impact on quality of life; b) considered only SUS records, where 40% of admissions for treatment originate from the states of São Paulo and Rio de Janeiro, not taking into account other states with higher incidence of complications and cases of fracture that did not obtain hospital care; c) did not assess the impact on quality of life and mortality of the affected individuals; d) did not evaluate the direct and indirect costs to families (needs for caregiver, analgesics, etc.); e) the cost analysis was based on the SUS price list, which does not match the actual values of admission/treatment.

Conclusion

In conclusion, our study showed a high prevalence of risk of fractures estimated by the UOC in women over the age of 60 years, which was higher than those in other national studies. Moreover, it showed an association between the altered examination results and a history of fractures and anthropometry. This shows the need for public policies adapted to each region as well as faster and more effective screening methods. As the goal of treatment for osteoporosis is prevention of fractures, we suggest the use of the UOC, associated or not with clinical factors, for the selection of the population at risk for fractures so that early appropriate therapy can be established for a faster and less expensive screening in poorer regions or those of difficult access, regardless of the bone densitometry examination performance.

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References

1. Riggs BL, Melton III LJ. Medical progress: involutional osteoporosis. N Engl J Med. 1986;314:1676-86.
2. Heinegprd D, Johnell O, Lidgren L, Olle N, Bjorn R, Frank W, et al. The bone and joint decade 2000-2010. Acta Orthop Scand. 1998;69:219-20.
3. Ismail AA, O'Neil TW, Cooper C, Finn JD, Bhalla AK, Cannata JB, et al. European Prospective Osteoporosis Study Group. Mortality associated with vertebral deformity in men and women: results from the European Prospective Osteoporosis Study Group (EPOS). Osteoporos Int. 1998;8:291-7.
4. Kado DM, Brower WS, Palermo L, Nevitt MC. Vertebral fractures and mortality in older women. Arch Intern Med. 1999;159:1215-20.
5. Pinheiro MM, Castro CM, Szejnfeld VL. Low femoral bone mineral density and quantitative ultrasound are risk factors for new osteoporotic fracture and total and cardiovascular mortality: a 5-year population-based study of Brazilian elderly women. J Gerontol A Biol Sci Med Sci. 2006;61:196-203.
6. Posições oficiais SBdens 2008. [cited 2009 Oct 1]. Available from: http://www.sbdens.org.br/sbdens/pdf/Pos%20Oficiais%202008.pdf.

7. Gnudi S, Ripamonti C. Quantitative ultrasound at the phalanxes discriminates osteoporótica women with vertebral but not with hip fracture. Ultrasound Med Biol. 2004;30:357-61.
8. Oliveira PP, Marinheiro LPF, Wender COM, Roisenberg F, Lacativa PGS. Prevalência de fraturas vertebrais e fatores de risco em mulheres com mais de 60 anos de idade na cidade de Chapecó, Santa Catarina, Brasil. Cad Saúde Pública. 2010;26:1777-87.
9. Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Health CW Jr. Body-mass index and mortality in a prospective cohort of U.S. adults. N Engl J Med. 1999;341:1097-105.
10. Kim CH, Kim YI, Chot CS, Park JY, Lee MS, Lee SII, et al. Prevalence and risk factors of low quantitative ultrasound values of calcaneus in Korean elderly women. Ultrasound Med Biol. 2000;26:35-40.
11. Franco LM, Ferazzoli E, Yélamo C, Barela R, Suárez I, Alcarra L, et al. Evaluation of bone mass by quantitative ultrasound (BUA) in a venezuelan population of 12,965 patients. Osteoporos Int. 2004;15(Suppl 1):S25.
12. Oliveira PP, Klumb EM, Marinheiro LPF. Prevalência do risco para fraturas estimado pela ultra-sonometria óssea de calcâneo em uma população de mulheres brasileiras na pós-menopausa. Cad Saúde Pública. 2007;23:381-90.
13. Velho LAZ, Bellangero W, Bahamondes L. Avaliação quantitativa ultra-sonográfica do calcâneo permite diferenciar mulheres com e sem fraturas ósseas recentes. Rev Assoc Med Bras. 2007;53:229-33.
14. Pinheiro MM, Castro CH, Frisoli A, Szejnfeld VL. Discriminatory ability of quantitative ultrasound measurements is similar to dual-energy X-ray absorptiometry in a Brazilian women population with osteoporotic fracture. Calcif Tissue Int. 2003;73:555-64.
15. Frost ML, Blake GM, Fogelman I. A comparison of fracture discrimination using calcaneal quantitative ultrasound and dual X-ray absorptiometry in women with a history of fracture at sites other than the spine and hip. Calcified Tissue Int. 2002;71:207-11.
16. Kanis JA, Burlet N, Cooper C, Delams PD, Reginster JY, Borgstrom F, et al. European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int. 2008;19:399-428.
17. NIH Consensus Conference Optimal calcium intake. JAMA. 1994;272:942-8
18. Pinheiro MM, Schuch NJ, Genaro PS, Ciconelli R, Ferraz MB, Martini LA. Nutrient intakes related to osteoporotic fractures in men and women - The Brazilian Osteoporosis Study (BRAZOS). Nutrition J. 2009;8:6.
19. Lanzillotti HS, Lanzillotti RS, Trotte APR, Dias AS, Bornand B, Costa EAMM. Osteoporose em mulheres na pós-menopausa, cálcio dietético e outros fatores de risco. Rev Nutr. 2003;16:181-93.
20. Devine A, Prince RL, Bell R. Nutricional effect of calcium supplementation by skim Milk powder or calcium tablets on total nutrient intake in postmenopausal womem. Am J Clin Nutr. 1996;64:731-7.
21. Payette N, Gray-Donald K. Dietary intake and biochemical indices of nutritional statusin in elderly population, with estimates of the precision on the 7-d foor record. Am J Clin Nutr. 1991;54:478-88.
22. Tosteson ANA, Melton 3 rd LJ, Dawson-Hughes B, Baim S, Favus MJ, Khosla S, et al. Cost-effective osteoporosis treatment threshold : The United states perspective. Osteoporos Int. 2008;19:437-47.
23. Dawson-Hughes B, Tosteson ANA, Melton LJ III, Baim S, Favus MJ, Khosla S, et al. Implications of absolute fracture risk assessment for osteoporosis practice guidelines in the USA. Osteoporos Int. 2008;19:449-58.
24. King AB, Saag KG, Burge RT, Pisu M, Goel N. Fracture reduction affects medicare economics (FRAME): impact of increased osteoporosis diagnosis and treatment. Osteoporos Int. 2005;16:1545-57.
25. Silva LK. Avaliação tecnológica em saúde: densitometria óssea e terapêuticas alternativas na osteoporose pós-menopausa. Cad Saúde Pública. 2003;19:987-1003.