Prevalence of osteoporosis-osteopenia at lumbar spine and femur in an urban female population. An epidemiological study in the Athens Metropolitan area, Greece

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Abstract

The aim of this study is to determine the prevalence of osteoporosis and osteopenia in a female urban population. Dual energy X-ray absorptiometry measurements were done at the lumbar spine (6920 females) and at the femur (3222 females). Bone mineral density (BMD) and corresponding T-scores were analysed using multivariate regression models. In females, the prevalence rate of osteoporosis was 15.3% at the lumbar spine and of osteopenia 36.5%. In females osteoporosis rate at the femur was 17.7% for the neck, 30.65% for the ward's triangle and 1.86% for the trochanter, whereas the osteopenic rates were 53.3%, 44.7% and 32.09% respectively. A polynomial cubic model performed for age showed the steepest decline at the age of 55 years for the spine BMD (-0.973% change, 95% CI -1.031/-0.915) and at the age of 64 years for the femur BMD (-0.726% change, 95% CI -0.793/-0.658). Actually sensitive interventions for prevention of osteoporosis in urban population need serious concern.

Introduction

Osteoporosis, a major health problem worldwide,^{1,2} is characterized by low bone mass and microarchitectural deterioration of bone structure.^{3,4} Bone mass is determined by peak bone mass and the rate of bone loss. Dual-energy X-ray absorptiometry (DXA) is a widely used technique to assess bone mineral density (BMD) at different skeletal sites and therefore suitable to stratify individuals with low bone mass who are at risk of osteoporosis and fractures. BMD is influenced by genetic, environmental, and hormonal factors.⁵ Ethnic and racial variations of bone density are therefore expected.^{6,7} Moreover, age and sex have such a strong impact that reference values for BMD should be age- and sex-specific, and, accord-

ingly, for a reliable interpretation of such values, they need to be expressed in terms of established reference values derived from an appropriate healthy population.⁸

The World Health Organization (WHO) defined diagnostic criteria for osteoporosis in terms of BMD as measured by DXA,⁹ and although such criteria are based on observations in postmenopausal Caucasian females, they are widely used and applied to other at risk populations to confirm a diagnosis of osteoporosis.^{10,11} The aim of the present study was to assess the incidence and the prevalence of osteoporosis in a urban female population in Greece. For that reason, DXA measurements were collected and analysed retrospectively.

Materials and Methods

Data collection was conducted through a 4 year period (2003-2007) from the Radiology Department of the Henry Dunant Hospital in Athens, Greece. Evaluation of the DXA measurements was performed in individuals aged 29 to 89 years, first at the lumbar spine in 6920 females and second at the femur in 3222 females. Participants in the study had no history of atraumatic fractures, menstrual irregularities, or diseases known to affect bone, and were not on any medication known to affect bone metabolism other than oral contraception.

BMD measurements (g/cm²) was determined for the anteroposterior lumbar spine (L2-L4) and mean of proximal right and left femur (total and subregions) by DXA using a Lunar DPX-IQ (Lunar, Madison, WI, USA), according to standard protocol. BMD of the femur was expressed as the mean of the BMD values for the subregions: trochanter, Ward's triangle, and neck. All scans were performed and analysed by the same investigator. Quality control procedures were carried out in accordance with the manufacturer's recommendations.

Instrument variation was determined regularly by a daily calibration procedure using a phantom supplied by the manufacturer. Precision error of the phantom was 0.3% and for in vivo measurements was less than 1.2% for the spine and less than 2% for femoral regions. Lunar Italian normal database supplied by the manufacturer was used to derive Z scores (matched for age and weight) and T scores (reference age 20-90 years). Subjects were weighed on an electric scale wearing minimal clothing. Height was measured to the nearest centimeter using a stadiometer. Body mass index (BMI) was calculated as weight divided by height in meters squared (kg/m²). For data analysis, participants were grouped on the basis of 5-year age increments. The percentage of individuals with osteopenia or

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Key words: osteoporosis, osteopenia, bone mineral density, dual energy X-ray absorptiometry, T-score, spine, femur, urban population.

Received for publication: 7 September 2011.

Revision received: 15 November 2011.

Accepted for publication: 15 November 2011.

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Endocrinology Studies 2012; 2:e1

doi:10.4081/es.2012.e1

osteoporosis were calculated according to WHO) criteria.⁹

BMD measurements and the corresponding T-scores were analysed using multivariate regression models.¹² More specifically, due to nonlinear patterns observed in our data, all models used here included polynomial terms for age up to the third degree (cubic model). All models' assumptions were checked using appropriate tests and graphs. All regression models were also refitted using non-parametric methods as part of a sensitivity analysis. Separate analyses for the spine and femur (neck, Ward's triangle, trochanter) were performed. The significance of somatometric characteristics such as weight, height, and BMI was also investigated. All statistical procedures were performed using Stata 8.2 (Stata corp., TX, USA). The study was approved by the Ethics Committee of the Henry Dunant Hospital.

Results

The prevalence rate of osteoporosis, based to the WHO criteria, at the lumbar spine in women was 15.3% and of osteopenia was 36.5% (Figure 1). The osteoporosis rate at the femur was 17.7% for the neck, 30.65% for the ward's triangle and 1.86% for the trochanter, whereas osteopenic rates at the femur were 53.3% for the neck, 44.7% for the ward's triangle and 32.09% for the trochanter (Figure 2). Initial exploratory analysis revealed that BMD and T-score age-related changes were not linear across the chronological range of our sample in the female population (20 to 90 years). For that reason, a polynomial cubic model was performed for age which showed good fit for the

observed data allowing also the estimation of age related slopes to T-scores values. The steepest decline was observed at the age of 55 years (-0.973% change, 95% CI -1.031/-0.915) for the spine BMD (Figure 3) and at the age of 64 years for the femur BMD measurements (-0.726% change, 95% CI -0.793/-0.658) (Figure 4).

According to our data, each anatomical region displayed a different rate of bone loss. In the female population, the mean yearly percent loss of BMD in the spine was increased until the age of 65 years and thereafter a progressive decrease was observed. Moreover, the mean yearly percent loss in BMD was much greater at the ward's triangle and the neck as compared to trochanter at the femur site (Table 1). Although, as expected, BMI was significantly correlated with BMD and T-scores, weight and height were directly associated with BMD at all measurements sites. No serious violations of the assumptions, for the regression models used in this analysis, were found. Moreover all models have been refitted, as a sensitivity analysis, using non-parametric techniques and all results remained practically unaffected.

Discussion

Our results showed that the prevalence rates of osteoporosis and osteopenia, according to WHO criteria, in the entire analysed population were at the higher upper limits as compared to similar studies performed in other countries,^{13,14} confirming the observations that racial differences do exist in BMD reference curves.^{15,16} The prevalence of osteoporosis and osteopenia increased with advancing age. Moreover, in females, the steepest decline for T-score values was observed at the age of 54 years for the spine BMD and at the age of 62 years for the femur BMD measurements. Previous studies in normal Greek population¹⁷ in 244 women reported that the total bone loss between ages 20 and 70 was 29.5% for the vertebrae and 32% for the femoral neck. In our study, the percentage of total bone loss in women between ages 35 to 84 was 14.36% at the spine (L2-L4), 22.97% for the femoral neck, 32.7% for the ward's triangle, and 16.27% for the tronerchanter. Concerning population studies, the influence of the body composition to the observed difference in BMD has long been prognostic. In particular, the NHANES III investigators have reported a marked effect of body weight on BMD values in the hip.¹⁸ In relevance to the above data, our results showed that weight and height had a better fit to the observed data than BMI. Based on the fact that BMI had a significant correlation with BMD and T-scores, we assume that our correlations were made possible due to the large number of the population tested.

It is well known that BMD relates to the risk of fracture, with decreased BMD resulting in increased fracture risk.^{4,19} In particular, bone density in elderly persons is highly relevant to the risk of osteoporotic fracture with the highest rates of osteoporosis-related fractures occurring in elderly women.²⁰⁻²⁴ Nevertheless, after adjustment for body size, race, and sex differences in regional and whole body, bone mass of adults remain at a low level.^{25,26}

According to the literature, men and women may achieve similar peak bone density at the spine and proximal femur.²⁷ Bone loss in women may occur earlier and the rate may be twice that in men,²⁸ although this sex difference may be smaller in later life.²⁹ Our data suggest that bone loss in females both at the spine and the femur occurs earlier in life, namely from 50 years old. The effect of sex steroids might be taken into account to explain

Figure 1. Mean bone mineral density of lumbar spine (L1-L4) in the female population aged 20-93 years.

Figure 2. Mean bone mineral density of femoral neck, ward's triangle and tronerchanter in the females aged 20-94 years.

the above data.

Heterogeneity of sites-related BMD was also observed in our female population. Namely, bone loss was first detected at the spine at the age of 50 years. For the same age, osteopenia was detected at the femoral neck and the ward's triangle but not at the trochanter. The steepest and earlier decline of bone loss was observed in the spine reaching T score ≤ 2.5 at the age of 70 to 74 years old. The femur, the neck and the ward's triangle were the primary sites of bone loss followed by the trochanter, reaching T score ≤ 2.5 at a later age, namely 80 to 90 years.

Conflict results have been reported by several investigators concerning the difference between BMD at various skeletal sites in postmenopausal women when compared with reference means. It has been previously shown^{30,31} that BMD of the spine and femoral neck in postmenopausal women aged 45-60 years tends to be similar when compared with reference means although 26% of the individuals tested had Z-scores sufficiently different to result in mischaracterization of the fracture risk at the non-measured site. Moreover, Davis *et al.*³² classified women aged 47-82 by tertiles of Z-score for BMD at any one of four skeletal sites and found heterogeneity in BMD at different skeletal sites within an individual. On the other hand, Bonnick *et al.*³³ showed that differences in Z-score between the BMD at the lumbar spine and proximal femoral sites are common in healthy premenopausal women and in women aged 30 and more these differences appear to be the result of a decline in BMD at the proximal femur combined with no significant change in BMD at the lumbar spine.

In our study, the yearly mean percent loss in BMD for women was much greater in the ward's triangle and the neck as compared to trochanter at the femur site. Additionally, the yearly mean percent loss in BMD for women in the spine increased from the age of 50 years and, interestingly, a dramatic decrease occurred after the age of 65 years, presumably due to osteophytes and/or therapeutic interventions. Similar results concerning the annual reduction rate in BMD were obtained in the population of a northern part of Greece,³⁴ although the absolute values in our study tend to be slightly elevated. It was not possible to deduce similar information regarding the male population in our study due to discrepancy of the results obtained. The use of an Italian reference population could be considered only as a minor limitation of our study since it has been previously found³⁴ that this population's normal range is close to the Greek one and can be reliably used at least as T-scores are concerned whereas for Z-scores discrepancies are small.

It is well recognized that BMD and soft tissue mass are mutually dependent from exercise³⁵⁻³⁹ whereas both respond to intrinsic fac-

tors such as somatotrophic and sex hormones.⁴⁰ These common hormonal effects are not only important during the rapid growth during adolescence, in which dramatic gains in bone and muscle mass are observed,⁴¹ but also throughout adult life.

For the people in our study, living in a urban area, physical activity and exercise are not expected to be involved in an every day life accomplishments. Also, in nowadays, elderly in

Athens are exposed less to sunlight and are less active compared with the elderly of previous years. In addition, abuse of sedatives or the interaction between various drugs taken commonly by the elderly are often related to changes in life-style (urbanization of population, institutionalization of elderly) that may have adverse effects on BMD. Osteoarthritis of the spine has been associated with increased BMD at the spine, femoral neck,⁴² and total

Figure 3. Mean bone mineral density of lumbar spine (L2-L4) observed and predicted by a cubic age model in the female population aged 20-93 years.

Figure 4. Mean bone mineral density of femoral neck observed and predicted by a cubic age model in the female population aged 20-95 years.

body.⁴³ However, increased BMD in the region affected by osteoarthritis may be an artifact due to osteophytes, intervertebral joint space narrowing and sclerosis within the region of interest, or may reflect a generalized increase in BMD on the skeleton.⁴³ Our results are in agreement with the above data, in that an increase in BMD was observed in the spine after the age of 74 years presumably due to osteoarthritic changes.

Low bone density at the femur is a strong predictor of the increased risk for hip fracture. In one of the largest cohort studies of osteoporosis, the Study of Osteoporotic Fractures, women in the lowest quartile of BMD had an 8-fold increased risk of hip fracture compared with the women in the highest BMD quartile.⁴⁴ Earlier cross-sectional investigation study of femoral and radius BMD in the Framingham cohort showed that age was inversely related to BMD in both men and women.⁴⁵ Both cross-sectional and longitudinal studies have also reported age-related bone loss.⁴⁶

Conclusions

To our knowledge, this is the first large population based study of osteoporosis and osteopenia in the Greek female population. Provided that early identification of BMD and adequate treatment when indicated are needed to avoid osteoporosis-related fractures and disabilities and in the light of the longer life span, the findings of this study suggest that actually sensitive interventions on osteoporosis risk and prevention have to be seriously concerned.⁴⁷ In addition, work is needed to determine the impact of the lifestyle, the diet⁴⁸ and local environmental conditions on risk factors for health and disease.⁴⁹

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Table 1. Mean estimated % yearly rate of bone mineral density change of the spine and femur (neck, ward's triangle, trchanter) in the female population.

Age (years)	Region	Estimated % relative change per year	95% CI*
50	Spine L2-L4	-0.903	(-0.958, -0.847)
	Femur neck	-0.536	(-0.623, -0.448)
	Femur wards	-0.793	(-0.906, -0.680)
	Femur trochanter	-0.225	(-0.319, -0.131)
55	Spine L2-L4	-0.973	(-1.031, -0.915)
	Femur neck	-0.642	(-0.718, -0.565)
	Femur wards	-0.944	(-1.044, -0.845)
	Femur trochanter	-0.356	(-0.437, -0.275)
60	Spine L2-L4	-0.883	(-0.942, -0.825)
	Femur neck	-0.707	(-0.780, -0.633)
	Femur wards	-1.045	(-1.141, -0.948)
	Femur trochanter	-0.460	(-0.536, -0.384)
65	Spine L2-L4	-0.605	(-0.673, -0.536)
	Femur neck	-0.726	(-0.793, -0.658)
	Femur wards	-1.084	(-1.175, -0.993)
	Femur trochanter	-0.538	(-0.608, -0.468)
70	Spine L2-L4	-0.120	(-0.238, -0.002)
	Femur neck	-0.691	(-0.769, -0.614)
	Femur wards	-1.048	(-1.154, -0.942)
	Femur trochanter	-0.587	(-0.666, -0.508)
75	Spine L2-L4	0.552	(0.351, 0.753)
	Femur neck	-0.595	(-0.728, -0.462)
	Femur wards	-0.918	(-1.104, -0.732)
	Femur trochanter	-0.604	(-0.740, -0.469)

*Confidence Interval.

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