Endokrynologia Polska/Polish Journal of Endocrinology
Tom/Volume 62; Numer/Number 1/2011
ISSN 0423–104X

Forearm SXA densitometry in 1,122 Polish women — a cohort study

Badanie gęstości kości metodą SXA w grupie 1122 kobiet — badanie kohortowe

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Abstract

Introduction: The aim of this study was to estimate forearm bone mineral density (BMD) and bone mineral content (BMC) using single-energy X-ray absorptiometry (SXA) in a group of Polish women that included both pre- and post-menopausal subjects.
Material and methods: The study was carried out in a cohort of 1,122 otherwise healthy women with no history of previous fractures.
Results: We showed a gradual decline of BMD and BMC with age, and the presence of suspected correlations of densitometric results with age and selected anthropometric parameters.
Conclusions: Our study confirmed the utility of densitometric screening using forearm SXA measurements. These measurements discriminated clearly between pre- and post-menopausal subjects. Densitometric results correlated negatively with age and age at menopause, but positively with anthropometric indices related to body and skeletal size. Age was the greatest factor in terms of impact on bone loss. **(Pol J Endocrinol 2011; 62 (1): 8–13)**

Key words: *osteoporosis, menopause, forearm, SXA*

Streszczenie

Wstęp: Celem pracy była ocena gęstości mineralnej kości (BMD, *bone mineral density*) i zawartości tkanki kostnej (BMC, *bone mineral content*) przedramienia za pomocą metody SXA w licznej grupie polskich kobiet zarówno przed, jak i po menopauzie.
Materiał i metody: Badanie przeprowadzono w grupie 1122 zdrowych kobiet bez złamań.
Wyniki: Wykazano stopniowe obniżanie się wartości BMD i BMC wraz z wiekiem i obecność spodziewanych zależności wyników badań densytometrycznych od wieku i wybranych parametrów antropometrycznych.
Wnioski: Wyniki badania potwierdziły przydatność skriningu densytometrycznego przedramienia metodą SXA (*single X-ray absorptiometry*). Pomiary różnicowały wyraźnie pacjentki przed menopauzą od pomenopauzalnych. Wyniki densytometrii korelowały negatywnie z wiekiem i okresem czasu po menopauzie, a pozytywnie ze wskaźnikami antropometrycznymi zależnymi od wielkości ciała i kośćca. Czynnikiem o największym wpływie na ubytek kości był wiek. **(Endokrynol Pol 2011; 62 (1): 8–13)**

Słowa kluczowe: *osteoporoza, menopauza, przedramię, SXA*

Introduction

Osteoporosis is an important public health problem. In post-menopausal women, a lack of oestrogen leads to the stimulation of a bone resorption process which overcomes bone formation. The consequence is bone mass loss [1, 2]. Lowered bone mass can be an important risk factor in osteoporotic fractures [3–5]. It has been estimated that about 75 million women in Europe, the USA and Japan suffer from osteoporosis [6]. Polish data shows a prevalence of osteoporosis based on lumbar spine densitometry in 18.4%; femoral neck 14.8%; total hip 2.4%; and forearm 17.2% in peri- and post-menopausal women [7, 8]. The most important clinical consequences of osteoporosis are fractures. There are estimated to be about 20,000 proximal femur fractures in Polish women each year [9]. Statistics regarding excess mortality following osteoporotic fractures are clear [10].

Axial skeleton densitometry using dual-energy X-ray absorptiometry (DXA) is a widely used method of confirming a diagnosis of osteoporosis and estimating potential fracture risk [5, 11]. Peripheral bone studies are useful for screening purposes, but their results must be verified by proximal femur or lumbar spine examination and clinical risk factor assessment before the best therapy can be established. Among peripheral techniques, single-energy X-ray absorptiometry (SXA) is used when axial densitometry is not available. Other

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Table I. *Clinical characteristics of studied women*
Tabela I. *Charakterystyka kliniczna badanych kobiet*

Parameter	Group I (315) mean ± SD	Group II (807) mean ± SD	p-value
Age (years)	44.52 ± 5.29	58.3 ± 6.59	0.00000
Height [cm]	162.1 ± 5.1	160.4 ± 6.4	0.000033
Weight [kg]	64.77 ± 10.99	67.42 ± 11.76	0.00059
BMI [kg/m^2]	24.64 ± 3.97	26.3 ± 6.39	0.000021
Age at menopause (years)	–	48.95 ± 4.66	–

Table II. *Clinical characteristics in the subgroups of subjects divided according to age*
Tabela II. *Charakterystyka kliniczna podgrup badanych podzielonych w zależności od wieku*

Parameter	Age ranges (number of women)				
	< 40 (50) mean ± SD	40–49 (319) mean ± SD	50–59 (488) mean ± SD	60–69 (228) mean ± SD	> 69 (37) mean ± SD
Age (years)	34.9 ± 5.87	46.46 ± 2.48	55.4 ± 2.85	64.63 ± 2.6	73.7 ± 3.12
Height [cm]	161.9 ± 6.2	162.2 ± 5.1	160.6 ± 5.2	15 9.5 ± 8.5	161.0 ± 4.7
Weight [kg]	59.3 ± 10.24	66.35 ± 11.16	66.87 ± 11.66	67.97 ± 11.98	68.86 ± 10.5
BMI [kg/m^2]	22.67 ± 3.7	25.2 ± 4.01	25.91 ± 4.42	27.08 ± 9.74	26.59 ± 3.82
Age at menopause (years)	–	45.72 ± 3.09	49.32 ± 4.15	49.7 ± 4.89	51.6 ± 4.06

peripheral methods are peripheral DXA (pDXA), quantitative ultrasound (QUS) or peripheral quantitative computed tomography (pQCT) [12–15].

The aim of our study was to estimate forearm BMD and BMC using SXA in a substantial group of Polish women that included both pre- and post-menopausal subjects.

Material and methods

The study was carried out in 1,122 otherwise healthy women. The women had no history of previous fractures, no known causes of secondary osteoporosis, and had not received osteoporosis-focused therapy. They were recruited from an urban population following advertisements in the local press. They were divided into two groups: group I comprised 315 women yet to experience the menopause, and group II comprised 807 post-menopausal women. The clinical characteristics of the women studied are set out in Table I. Subjects were also divided according to age: there were 50 women aged under 40, 319 women aged 40–49, 488 women aged 50–59, 228 women aged 60–69, and 37 women aged 70 and above (Table II).

Forearm densitometry was measured using the SXA method with Osteometer DTX-100 apparatus (Osteometer A/S, Rodovre, Denmark). The non-dominant forearm was placed in a water bath, with X-ray source emitted energy of 29 keV. The BMD and the BMC of the radius and the ulna in the distal and ultradistal parts of the bones were measured. The results are presented as BMC in g, BMD as g/cm^2, and as percentage of peak values (young adult), age-matched, T-score and Z-score. All studies were performed by one experienced operator.

Statistical analysis was performed using Statistica for Windows. Student's *t*-test and correlation analysis using Pearson's test were applied. The level of statistical significance was set at $p < 0.05$. Analysis of the selected parameters (age, age at menopause, body mass, BMI, height) influence on BMD and BMC was carried out using stepwise multiple regression.

Results

The results of SXA densitometry differed statistically significantly among the groups studied. There were statistically significant higher values of both distal and ultradistal BMC and BMD expressed as units measured, percentage of age-matched and reference age values, Z-score and T-score values in the premenopausal women than in the post-menopausal ones (Table III).

When subsequent age ranges (decades) were analysed, the differences were also very clear, in parallel with ageing (Table IV). In particular, the differences

Table III. *Results of forearm densitometry in pre- and post-menopausal women*
Tabela III. *Wyniki badania densytometrycznego przedramienia kobiet przed i po menopauzie*

Measurement	Pre-menopausal mean ± SD	Post-menopausal mean ± SD	p-value
Distal BMC [g]	3.20 ± 0.43	2.85 ± 0.54	0.000000
Distal BMC Z-score	–0.29 ± 0.91	–0.15 ± 1.03	0.024
Distal BMC T-score	–0.26 ± 0.91	–1.02 ± 1.14	0.0000
Distal BMD Z-score	0.22 ± 0.81	0.01 ± 1.13	0.0010
Distal BMD T-score	–0.23 ± 0.827	–1.27 ± 1.27	0.00
Ultradistal BMC [g]	1.19 ± 0.64	1.06 ± 0.57	0.00134
Ultradistal BMD (g/cm^2]	0.40 ± 0.06	0.33 ± 0.07	0.00
Ultradistal BMD Z-score	0.64 ± 1.21	0.42 ± 1.38	0.0203
Ultradistal BMD T-score	0.62 ± 1.22	–0.69 ± 1.55	0.00

Table IV. *Results of forearm densitometry in age groups (decades)*
Tabela IV. *Wyniki badania densytometrycznego przedramienia w grupach wiekowych (dekady)*

Measurement	< 40 years mean ± SD	40–49 years mean ± SD	50–59 years mean ± SD	60–69 years mean ± SD	> 69 years mean ± SD
Distal BMC [g]	3.18 ± 0.52	3.21 ± 0.41	2.94 ± 0.49	2.62 ± 0.54	2.41 ± 0.56
Distal BMC T-score	–0.30 ± 1.12	–0.23 ± 0.87	–0.80 ± 1.02	–1.54 ± 1.13	-1.95 ± 1.21
Distal BMD (g/cm^2)	0.49 ± 0.15	0.48 ± 0.09	0.34 ± 0.23	0.38 ± 0.09	0.36 ± 0.17
Distal BMD T-score	–0.29 ± 1.05	–0,33 ± 1.01	–0.98 ± 1.08	–1.90 ± 1.31	–2.68 ± 1.21
Ultradistal BMC [g]	1.32 ± 0.63	1.15 ± 0.64	1.07 ± 0.60	1.04 ± 0.51	0.97 ± 0.42
Ultradistal BMD [g/cm^2]	0.39 ± 0.06	0.40 ± 0.05	0.35 ± 0.07	0.30 ± 0.07	0.28 ± 0.06
Ultradistal BMD T-score	0.53 ± 1.49	0.63 ± 1.15	0.38 ± 1.39	–1.50 ± 1.49	–1.82 ± 1.41

were statistically significant when the younger group (those in their fourth and fifth decades) was compared to older subjects (sixth, seventh and eighth decades). Paradoxically, some densitometric parameters were higher in fifth decade patients than in fourth decade patients (Table IV).

In the entire group, and in the post-menopausal subjects, there were statistically significant ($p < 0.05$) negative correlations between age and distal BMC (r = –0.39 and –0.37, respectively) and between age and ultradistal BMD (r = –0.48 and –0.43, respectively). These were not observed in pre-menopausal subjects. In the entire group, and in the post-menopausal subjects, there were statistically significant ($p < 0.05$) negative correlations between years since menopause and distal BMC (r = –0.39 and –0.32, respectively), and between years since menopause and ultradistal BMD (r = –0.47 and –0.36, respectively). In almost all the groups, there were positive correlations between height, body mass and BMI on the one side, and densitometric parameters studied on the other side (Table V).

When we analysed the above mentioned correlations according to particular age group, we found no correlation between age at menopause and densitometric measurements in any decade of post-menopausal patients. Only in the sixth decade were there negative correlations between current age and both distal BMC and ultradistal BMD (r = –0.19 and –0.22, respectively). A very high negative correlation was present between age and ultradistal BMD in the oldest group (r = –0.72). The correlation coefficients between years since menopause and densitometric measurements were highest in the oldest subjects' decade, and lowest in early post-menopausal patients. Anthropometric parameters in most cases correlated positively with densitometric measurements. The highest correlations were observed between body mass and BMI and distal BMC in the oldest group (r = 0.58 and 0.54). They were absent regarding ultradistal BMD in this decade. Correlations between height and densitometric measurements were rare and rather weak (Table VI).

In all post-menopausal women there were negative correlations between age and distal BMC T-score and ultradistal BMD T-score (r = –0.39 and –0.44, respectively), and between years since menopause and above mentioned T-score values (r = –0.33 and –0.36, respec-

Table V. *Correlation coefficients between age, anthropometric data and densitometric results in subjects studied*

Tabela V. *Współczynniki korelacji między wiekiem i danymi antropometrycznymi a wynikami badania densytometrycznego*

	Distal BMC	Ultradistal BMD
Entire group		
Age	–0.39	–0.48
Height	0.30	0.13
Body mass	0.26	0.13
BMI	0.16	0.10
Age at menopause	–0.12	–0.16
Years since menopause	–0.39	–0.47
Post-menopausal		
Age	–0.37	–0.43
Height	0.24	NS
Body mass	0.31	0.20
BMI	0.24	0.19
Age at menopause	0.04	NS
Years since menopause	–0.32	–0.36
Pre-menopausal		
Age	NS	NS
Height	0.40	0.5
Body mass	0.26	0.16
BMI	0.12	NS

tively). The correlation coefficients were highest in the oldest decade subjects. We found some correlations between anthropometric parameters and T-scores (more often regarding distal BMC than ultradistal BMD), and these mainly in the oldest subjects (Table VII).

In our subjects, age was recognised as the factor with the greatest influence on densitometric results. The following formulae assessing the influences of the parameters studied on distal BMC results were calculated:

Distal BMC = 0.082 – 0.51*age +0.23*height + + 0.125*body mass + 0.135*BMI + 0.158 age at menopause (for entire group), $R^2 = 0.302$, SEE = 0.449, $p < 0.000001$;

Distal BMC = 1.335 – 0.427*age + 0.168*height + + 0.186*body mass + 0.08*age at menopause (for post-menopausal group), corrected $R^2 = 0.273$, SEE = 0.463, $p < 0.0001$.

Discussion

We have analysed SXA densitometry in a substantial group of Polish post- and pre-menopausal women. Unsurprisingly, the results of densitometry were higher in pre-menopausal women compared to post-menopausal subjects. Similarly, there was an almost uniform decline with ageing. Only when pre-menopausal patients were compared to early post-menopausal ones, were some different trends observed.

There have been no such extensive measurements of the Polish Lower Silesian population previously. A similar Bulgarian study, carried out on an even larger population, showed a presence of osteoporosis assessed by SXA densitometry of 20.45% and osteopenia of 32.5%

Table VI. *Correlation coefficients between age, anthropometric data and densitometric results in particular decades of post-menopausal subjects studied*

Tabela VI. *Współczynniki korelacji między wiekiem i danymi antropometrycznymi a wynikami badania densytometrycznego w poszczególnych dekadach wiekowych badanych kobiet po menopauzie*

	Distal BMC	Ultradistal BMD
Post-menopausal		
Age	–0.37	–0.42
Height	0.24	0.08
Body mass	0.31	0.21
BMI	0.24	0.19
Age at menopause	NS	NS
Years since menopause	–0.32	–0.36
Age > 69		
Age	NS	–0.72
Height	NS	NS
Body mass	0.58	NS
BMI	0.54	NS
Age at menopause	NS	NS
Years since menopause	–0.56	–0.59
Age 60–69		
Age	–0.18	NS
Height	0.26	0.15
Body mass	0.48	0.40
BMI	0.44	0.40
Age at menopause	NS	NS
Years since menopause	–0.20	NS
Age 50–59		
Age	–0.19	–0.22
Height	0.19	NS
Body mass	0.27	0.15
BMI	0.21	0.16
Age at menopause	NS	NS
Years since menopause	–0.13	–0.18
Age < 50		
Age	NS	NS
Height	0.39	NS
Body mass	0.26	0.14
BMI	0.12	0.11

Table VII. *Correlation coefficients between age, anthropometric data and T-score values in particular decades of post-menopausal subjects studied*

Tabela VII. *Współczynniki korelacji między wiekiem i danymi antropometrycznymi a wynikiem T-score w poszczególnych dekadach wiekowych kobiet po menopauzie*

	T-score distal BMC	T-score ultradistal BMD
Post-menopausal		
Age	–0.39	–0.44
Height	0.24	NS
Body mass	0.31	0.20
BMI	0.24	0.19
Years since menopause	–0.33	–0.36
Age > 69		
Age	NS	–0.72
Height	NS	NS
Body mass	0.58	NS
BMI	0.53	NS
Years since menopause	–0.56	–0.59
Age 60–69		
Age	–0.18	NS
Height	0.21	NS
Body mass	0.46	NS
BMI	0.44	0.39
Years since menopause	–0.21	NS
Age 50–59		
Age	–0.20	–0.23
Height	0.21	NS
Body mass	0.29	0.15
BMI	0.22	0.16
Years since menopause	–0.13	–0.19
Age < 50		
Age	NS	NS
Height	0.40	NS
Body mass	0.25	NS
BMI	NS	NS

in the studied female population aged 50 and above [12]. This is similar to other data from Poland, when Dobreńko et al. examined urban women from the north of our country using SXA method. The presence of osteoporosis was 17.2% in their entire studied group. The authors pointed to a gradual increase in the percentage of osteoporotic results; from 8% in the sixth decade, through 30% in the seventh decade, up to 55% in the eighth decade of life of women studied [7]. Similar results were observed in a French study (the OFELY cohort) when DXA measurements were used [16]. We did not perform such a calculation regarding osteoporosis assessment by densitometry in our group, because according to International Society of Clinical Densitometry guidelines, peripheral densitometry should not be used for the routine diagnosis of osteoporosis based on BMD measurements. This can instead be done using DXA assessment of axial skeleton — proximal femur and/or lumbar spine [17], although in the past, forearm bone densitometry has also been used to predict osteoporotic fractures [18, 19]. It has been shown to be mostly evident in the 50-69 age range, when single photon gamma absorptiometry (SPA) was used [18]. Moreover, the role of densitometry for the initiation of a proper anti-osteoporosis therapy has diminished recently, according to the FRAX calculator; based on clinical factors, the femoral neck BMD result could be applied, but it is not necessary for the estimation of osteoporotic fractures risk [11].

We have analysed the possible relations between densitometric results on the one side, and age, age at menopause and some anthropometric parameters on the other side. For post-menopausal subjects, negative correlations of ultradistal BMC/BMD and current age were shown. Interestingly, it was not observed in pre-menopausal women. Similarly, negative correlations of distal BMC/ultradistal BMD and time since menopause were evident. On the contrary, in almost all subgroups, positive correlations between height, body mass and BMI on the one side, and densitometric parameters studied on the other side, were noted. Such correlations confirm a gradual decline of forearm bone mass and density with ageing in our subjects. This reflects physiological age-related post-menopausal bone loss [1, 2, 18]. It is interesting that the highest correlations were observed between body mass and BMI and distal BMC in the oldest group of our subjects, but they were absent regarding ultradistal BMD in patients within this decade of life. This may be explained by the fact that measurements were carried out in different sites composed of various bone tissue at distal and ultradistal sites of the forearm [13, 20].

Multiple regression analysis shows age to be the factor with the greatest influence on densitometric results and bone loss in our subjects. It was shown regarding distal BMC, especially in the oldest groups (analysis not shown).

Conclusions

Our study confirms the utility of densitometric screening using forearm SXA measurements. These measurements discriminate clearly between pre- and post-menopausal subjects. Densitometric results correlate negatively with age and age at menopause, but positively with selected anthropometric indices related to body and skeletal size. Age is the factor of greatest impact on bone loss.

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