Bone mineral normative data in Malmö, Sweden

Comparison with reference data and hip fracture incidence in other ethnic groups

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The bone mineral mass was measured in 324 residents of the city of Malmö, Sweden, by dual energy roentgen absorptiometry (DEXA) using the Lunar DPX equipment—total body, hip, and lumbar vertebrae. The bone mineral content of the wrist was also measured with single photon absorptiometry (SPA) in 88 of the individuals. Weight, height, and vertebral height, as well as body fat, lean body mass, menarcheal age, menopausal age, and hand grip strength were determined. Measurements were compared with reference bone mineral content values from the United States, Japan, and France—also hip fracture incidence was compared.

All bone mineral values decreased with age. A good correlation was found between the DEXA technique of total body bone mineral and the forearm SPA values. The bone mineral content was correlated with lean body mass and weight.

The Malmö bone mineral content was on the same level as in the United States, but higher than in Japan and France. The comparatively high risk of fragility fractures in the Scandinavian countries compared with most other settings cannot be explained by low bone mass.

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Updating of normative bone mineral data is important since regional differences and secular changes are sources of bias. Gärdsell et al. (1991a, b) found a difference between an urban and a nearby rural area using forearm single photon absorptiometry (SPA) (Nauclér et al. 1974). The selection process may influence the outcome. Anthropometric variables, such as body size, may also be taken into account and, if possible, be corrected for.

The dual energy X-ray absorptiometry (DEXA) is a new technique with few reference data studies. (Yamasaki et al. 1990, Lunar News 1991).

The aims of our study were to provide normative data in a Scandinavian country and to find out whether the difference in fracture incidence is based on bone mineral content differences in the different ethnic settings. Scandinavian DEXA reference data are necessary for future use of the method but are also of interest for comparison with other catchment areas.

Material and methods

The bone mineral content (BMC) was measured in 146 men (age 20–87) and 178 women (age 20–87). Half of the probands were randomly selected from the city population files and half were volunteers, mostly hospital employees. 50 percent of those invited from the city files attended. Only individuals with a Swedish ethnic background were included.

All the probands were measured by DEXA using the Lunar DPX equipment. The Lunar DPX calculates automatically the total body bone mass, the spine (L2+L3+L4) and 3 regions of the hip, i.e., the femoral neck, Ward's triangle and the trochanter (Figure 1). Beside these regions the total body measurement was used to calculate the BMC of the head, arms, legs,

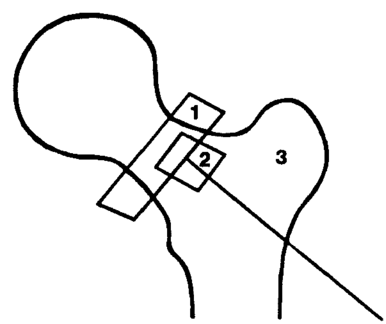

Figure 1. Pre-programmed measurements for hip bone mineral measurements: 1 neck, 2 Ward's triangle, and 3 trochanteric region.

Table 1. Bone mineral data in men. Mean *SD*

Age group	20–29 n 22		30–39 n 18		40–49 n 21		50–59 n 24		60–69 n 20		70–79 n 22		80–89 n 19	
Total body (BMD)	1.26	*0.07*	1.25	*0.11*	1.19	*0.09*	1.17	*0.06*	1.11	*0.23*	1.09	*0.27*	1.13	*0.11*
Spine BMD L2–L4	1.30	*0.13*	1.29	*0.16*	1.17	*0.14*	1.15	*0.15*	1.14	*0.22*	1.18	*0.23*	1.19	*0.19*
Hip BMD neck	1.16	*0.15*	1.06	*0.15*	0.98	*0.13*	0.97	*0.11*	0.95	*0.15*	0.87	*0.15*	0.88	*0.14*
Hip BMD Ward	1.13	*0.18*	0.99	*0.20*	0.89	*0.15*	0.84	*0.11*	0.81	*0.20*	0.73	*0.16*	0.74	*0.15*
Hip BMD trochanter	1.03	*0.14*	0.95	*0.13*	0.89	*0.13*	0.94	*0.13*	0.90	*0.16*	0.87	*0.20*	0.89	*0.15*
L2–L4 height (mm)	14.4	*0.7*	14.5	*0.8*	14.4	*0.8*	14.3	*0.8*	14.1	*1.0*	13.5	*0.9*	12.9	*1.7*
Total body fat content (%)	16.6	*7.8*	19.6	*5.4*	21.9	*6.0*	20.6	*8.4*	25.7	*6.0*	27.6	*5.0*	25.2	*6.0*
Lean body mass (kg)	64.1	*7.6*	62.7	*6.8*	61.2	*7.6*	60.9	*13.7*	58.0	*7.2*	54.8	*5.9*	54.5	*6.8*
Body mass index (kg/m^2)	24.0	*2.8*	24.8	*2.5*	25.1	*3.1*	25.3	*3.0*	25.0	*2.9*	25.8	*3.4*	24.7	*2.8*
Body height (cm)	182	*7.3*	180	*7.5*	180	*5.6*	178	*5.4*	177	*6.5*	174	*5.1*	175	*6.3*
Body weight (kg)	79.4	*10.6*	80.6	*9.7*	81.4	*12.8*	80.8	*5.4*	80.1	*10.7*	77.8	*11.1*	75.2	*7.5*

Table 2. Bone mineral data in women. Mean *SD*

Age group	20–29 n 28		30–39 n 23		40–49 n 22		50–59 n 26		60–69 n 20		70–79 n 39		80–89 n 20	
Total body (BMD)	1.12	*0.08*	1.13	*0.07*	1.14	*0.08*	1.09	*0.10*	0.99	*0.08*	0.95	*0.10*	0.94	*0.08*
Spine BMD L2–L4	1.21	*0.13*	1.22	*0.12*	1.20	*0.11*	1.09	*0.16*	0.97	*0.17*	0.94	*0.16*	1.00	*0.20*
Hip BMD neck	1.01	*0.13*	0.95	*0.11*	0.99	*0.15*	0.89	*0.14*	0.79	*0.14*	0.74	*0.12*	0.75	*0.19*
Hip BMD Ward	1.00	*0.17*	0.90	*0.16*	0.90	*0.16*	0.79	*0.16*	0.67	*0.12*	0.61	*0.15*	0.59	*0.25*
Hip BMD trochanter	0.83	*0.12*	0.78	*0.09*	0.80	*0.11*	0.77	*0.13*	0.69	*0.12*	0.66	*0.14*	0.72	*0.18*
L2–L4 height (mm)	13.4	*0.62*	13.9	*0.88*	13.5	*0.16*	13.5	*0.64*	13.1	*0.79*	12.8	*0.16*	12.3	*0.25*
Total body fat content (%)	28.6	*5.3*	30.2	*6.8*	33.4	*6.7*	35.6	*6.4*	39.2	*6.7*	37.3	*7.8*	36.2	*7.9*
Lean body mass (kg)	40.8	*4.2*	40.7	*4.6*	40.2	*3.2*	39.4	*3.1*	38.5	*3.6*	37.6	*3.6*	39.5	*5.2*
Body mass index (kg/m^2)	21.2	*2.0*	22.3	*2.7*	22.6	*3.3*	23.7	*2.9*	24.6	*3.1*	24.1	*4.4*	24.2	*4.1*
Body height (cm)	167	*7.6*	165	*6.4*	166	*3.9*	164	*4.7*	162	*6.5*	163	*5.5*	163	*5.8*
Body weight (kg)	59.5	*7.8*	60.9	*9.1*	62.3	*9.9*	63.5	*7.8*	64.3	*9.9*	64.0	*11.7*	64.2	*11.4*
Menarcheal age	13.1	*1.3*	12.3	*2.7*	12.7	*1.3*	13.1	*1.0*	13.4	*1.5*	14.2	*1.5*	14.7	*3.2*
Menopausal age	–		–		45.0	*1.4*	48.1	*3.6*	47.9	*4.4*	48.2	*5.7*	48.5	*3.2*
					n 2		n 21							

trunk, ribs and pelvis. The precision of our Lunar DPX apparatus is for BMD total body 0.4 percent, BMD spine (L2–L4) 0.5 percent, BMD hip (neck) 1.6 percent. The vertebral area, vertebral width and height were measured. The precision is for area (L4) 1.1 percent and width (L4) 2.9 percent. The fat and lean body composition were also determined with a precision of 0.5 percent for lean body mass and 4.1 percent for fat percentage. The body mass index was calculated as kg/m^2. Age, sex, height, weight, hand grip strength, menarcheal and menopausal age were recorded.

In 88 of the individuals single photon absorptiometry (SPA) measurements using Americium-241 (Naucler et al. 1974) were also performed. The BMC (areal density g/cm^2) of the forearm 1 and 6 cm from the tip of the styloid process of the ulna was calculated. The average of all 4 bones—radius, ulna, left and right—was used.

The BMC results obtained in this study were compared with data obtained by the same technique and with identical equipment in the United States and France (Lunar News 1991) as well as in Japan (Yamasaki et al. 1990). Recent data from Malmö on the age-adjusted incidence of hip fracture incidence (Sernbo 1988) were also compared with corresponding data from the United States (Silverman and Madison 1988), French-speaking Switzerland (Vader et al. 1990) (as French data are lacking) and Japan (Orimo et al. 1990).

Statistical analysis using the coefficient of variation and coefficient of correlation were used.

Results

Since there was no difference in any of the variables between the 2 groups of probands, data were pooled.

In men (Table 1) the decline of total body and spine BMC started in the age group 40–49. The hip BMC measurements decreased steadily from 20–29 on, leveling off in the 2 oldest age groups. The fat content increased at age 60–69. The lean body mass decreased from 20–29 throughout life. The body mass index increased to age 70–79. Finally, there was a decrease in height as well as weight with age.

Table 3. Bone mineral content (g/cm²) in women in the spine (L2–L4) and the femoral neck in different ethnic settings from 3 continents and in various age groups

Age	United States		Japan		France		Sweden	
	Spine	Femoral neck	Spine	Femoral neck	Spine	Femoral neck	Spine	Femoral neck
50–59	1.07	0.88	0.95	0.67	1.02	0.83	1.09	0.89
60–69	0.98	0.81	0.86	0.61	0.91	0.76	0.97	0.79
70–79	0.96	0.78	0.81	0.56	0.86	0.68	0.94	0.74

Table 4. Age-adjusted annual incidence of hip fracture in women/10,000 in 4 different ethnic settings. Japanese and Swiss data are estimates from figures. All data from the mid 80s (Sembo 1988, Silverman and Madison 1988, Orimo et al. 1990, Vader et al. 1990)

Age	Group	United States	Japan	Switzerland	Sweden
	60–64		5	15	20
60–69		22			
	65–69		9	17	32
	70–74		18	42	60
70–79		73			
	75–79		24	66	120

In women (Table 2) the total body bone mineral remained stable up to the age of 40–49 and then decreased. In the lumbar spine the major decrease was observed after 50. The octogenarians had, however, slightly higher values than women one decade younger. In the hip there was the same tendency in bone mineral pattern as in the lumbar region. The height of the vertebrae decreased after 60. The fat content increased up to the age of 60–69, and then decreased. The lean body mass in women decreased throughout life, except in the oldest. The body mass index increased up to the age of 60–69. The body height decreased after age 40–49 and the body weight increased up to the age of 60–69. The age at menarche had been higher in the oldest age groups as compared with the younger. There was no difference in the menopausal age.

The SPA measurements were correlated with the various DPX measurements. The best correlation was found in women at 6 cm from the tip of the styloid process of the ulna with the total body DPX measurements (r 0.9, $P < 0.001$).

The grip strength was positively correlated with most bone mass measurements in both sexes. The grip strength correlated best in men with total body DPX measurements (r 0.7, $P < 0.01$).

There was a good correlation between the BMC of the different regions as assessed by the DPX method in men and an even better correlation in women. The best correlation was found between the various hip measurements ($r > 0.8$) in both men and women. The least correlation was found between the spine and other regions, especially in women > 75 where the spine mineral measurements did not at all correlate with the various hip measurements.

In neither men nor women was there any correlation between the total body bone measurements and the fat content. Neither did the total body bone measurements correlate with the body mass index. There was, however, a significant correlation between the total body bone measurement and the lean body mass as well as weight in both men and women.

BMC in women was similar to data from the U.S.A. on the spine as well as the femoral neck (Table 3) and higher than the French-Swiss and Japanese data. Even after correction for body weight the differences remained.

Discussion

Only half of those selected from the population files participated—a possible selection bias which may explain why there was no difference in any respect between population-based and volunteered data. The most fragile subset of the population cannot participate—if a 100 percent participation could be attained, the BMC would probably be lower, particularly in the oldest group. The present bone mineral values represent a relatively healthy Swedish urban population.

Bone mass in men appears to decrease after the age of 30–39 years in total body and spine measurements, whereas the hip measurements seem to decline from the youngest age group onwards. The decrease in percent of the peak bone mass level was 14 percent in total body, 13 percent in spine and 25 percent in hip measurements, respectively. In men the lean body mass follows the same pattern, also with a good correlation with the bone mineral measurements.

In women the main decline in bone mass was after the menopause when there was a total loss—from peak bone mass—of 16 percent in total body, 24 percent in spine and 39 percent in hip measurements. In the oldest age groups there is an increase in the spine measurements which could be explained, either as a cohort effect, or, more likely, that these vertebrae were compressed and therefore produced higher values.

The hip fracture incidence in Malmö has been followed for almost 50 years—the latest study was in 1988 (Sernbo 1988). The hip fracture incidence in the city is higher than in a nearby rural area (Sernbo 1988). Similar differences have been found in other parts of Sweden (Mannius et al. 1987) and seem to parallel bone mineral content differences as measured by forearm SPA (Gärdsell et al. 1991a).

With the introduction of the DEXA/DPX technique we can compare the bone mineral content also between countries and ethnic groups. Comparisons with data produced using identical equipment (Lunar DPX) in other countries and groups are feasible. The selection methods for the American, French and Japanese data are unknown—however, variations in inclusion criteria are unlikely to cause such obvious differences.

The age-adjusted incidence of fragility fractures, such as hip fracture, is higher in the Scandinavian countries and in whites in North America than elsewhere (Obrant et al. 1989, Maggi et al. 1991).

As there are no other reference data available than those presented here in medical journals, comparison between figures should, of course, be done with caution. However, we cannot think of any reason to doubt these figures. Malmö and US data differ from the Japanese; old Japanese women have about 15 percent less bone mineral in their spines and an even more pronounced difference in the hip. Old French women have less bone mineral content in their spines and hips as compared with age-matched women in the US and Malmö. After correction for their lower body weights the Japanese and French women have less bone mineral density.

It is difficult to find comparable geographical data on hip fracture incidence. The age-adjusted hip fracture incidence has, in the past, been increasing in successive generations (Obrant et al. 1989). The data compared in the present study are from 1984–1986. The age-adjusted hip fracture incidence rates from Sweden, the United States, Japan and French-speaking Switzerland are shown in Table 4. Data from the United States are presented in decades, whereas Japanese, Swiss and Malmö data are in quintiles. Although women in the United States and Sweden have higher bone mineral content, they run a substantially higher risk of sustaining a hip fracture than their Swiss or Japanese sisters. It has earlier been well documented, however, that women in Japan (Yamasaki et al. 1990), France (Duboeuf et al. 1991) and Sweden (Karlsson et al. 1991) who sustain a hip fracture have a lower than average bone mass. Bone mineral mass seems to be a good predictor of fragility fractures within an ethnic population (Gärdsell et al. 1991a). When comparing different ethnic settings, however, other factors, such as genetic, bone quality or environmental factors (Alffram and Bauer 1962), are of more importance to the fracture rate than is the bone mineral mass.

It was of interest to find out whether not only forearm BMD was correlated to the muscular strength, i.e., the grip strength, but also the BMD in other parts of the skeleton. Our results confirm that suspicion. The correlation between the SPA and DPX measurements is of interest, since the former has been found to predict fracture (Gärdsell et al. 1991b).

The DPX measurement may serve the same purpose within a defined population. In a mixed ethnic population the predictive value is probably less. Therefore, local normative data are of importance.

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