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Perspective

How Many Women Have Osteoporosis?

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ABSTRACT

Osteoporosis is widely viewed as a major public health concern, but the exact magnitude of the problem is uncertain and likely to depend on how the condition is defined. Noninvasive bone mineral measurements can be used to define a state of heightened fracture risk (osteopenia), or the ultimate clinical manifestation of fracture can be assessed (established osteoporosis). If bone mineral measurements more than 2 standard deviations below the mean of young normal women represent osteopenia, then 45% of white women aged 50 years and over have the condition at one or more sites in the hip, spine, or forearm on the basis of population-based data from Rochester, Minnesota. A smaller proportion is affected at each specific skeletal site: 32% have bone mineral values this low in the lumbar spine, 29% in either of two regions in the proximal femur, and 26% in the midradius. Although this overall estimate is substantial, some other serious chronic diseases are almost as common. More importantly, low bone mass is associated with adverse health outcomes, especially fractures. The lifetime risk of any fracture of the hip, spine, or distal forearm is almost 40% in white women and 13% in white men from age 50 years onward. If the enormous costs associated with these fractures are to be reduced, increased attention must be given to the design and implementation of control programs directed at this major health problem.

INTRODUCTION

OSTEOPOROSIS IS A DISEASE characterized by abnormalities in the amount and architectural arrangement of bone tissue that lead to impaired skeletal strength and an undue susceptibility to fractures.[1,2] The most frequent and important of the related fractures are those of the proximal femur, vertebrae, and distal forearm, but fractures commonly occur at many other locations as well.[3] Before the onset of fractures, osteoporosis can be diagnosed by noninvasive bone mineral measurements made at various sites.[4] The magnitude of the problem, then, can be assessed both by the prevalence of low bone mass (osteopenia) and by the frequency of fractures in a setting of low bone mass (established osteoporosis). The objectives of this article are to summarize data on bone loss in women, to relate these data to the occurrence of fractures, and, based upon this relationship, to estimate the size of the affected population. Because of limitations in available data, emphasis is on the magnitude of the problem among white women, but men and women of other ethnic groups are also affected.[5]

ESTABLISHED OSTEOPOROSIS

It has been recognized for over a century that hip fractures are a manifestation of osteoporosis in the elderly,[6] and vertebral fractures have been virtually synonymous with postmenopausal osteoporosis since the time of Albright.[7] Only in the last decade, however, has it become

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clear that osteoporosis is an enormous public health problem, causing multiple fractures in the elderly and huge health care costs. Although it is difficult to partition the relative contributions of osteoporosis and trauma to these fractures, since bone strength and bone loading interact to produce each one,[8] it is not disputed that the majority of patients have reduced bone mass at the fracture site relative to optimal levels in young adults. In conjunction with an increasing frequency and severity of trauma from falling,[9,10] then, increasing skeletal fragility with aging causes the incidence rates for fractures of the hip, vertebrae, and distal forearm to rise in both sexes, although they are greater among women than men at any age (Table 1). The rates are quite high, so that the cumulative incidence of hip fractures, for example, reaches 33% in white women and 17% in white men by 90 years of age.[3] Fracture rates are greatest, however, at ages that are not attained by everyone; the average life expectancy of white women at birth is 78.9 years and of white men only 72.3 years. Thus, the size of the affected population is better assessed in terms of lifetime risk, that is, the proportion of the population that can be expected to experience fractures over a life of average length.

Several statistical techniques can be used to model fracture risk in subjects followed over their anticipated lifetimes. One approach uses Monte Carlo simulations in a Markov model to estimate the lifetime risk in a cohort of 10,000 individuals who are 50 years old at baseline.[11] With this method, and using the fracture incidence rates in Table 1, the estimated lifetime risk of a hip fracture is 17.5% in white women and 6.0% in white men (Table 2). These are similar to previous estimates in whites (15.6% in women and 5.2% in men) made with the same incidence rates but using survival methodology.[12] The incidence rates come from the population of Rochester, Minnesota[13] and are employed here because first fracture incidence rates are not available nationally for the age groups required. Incidence rates for first fractures alone are needed for these calculations because interest lies with the number of people affected, not the total number of fractures. However, Rochester hip fracture rates overall are about 2% lower than those reported for U.S. elderly whites generally.[14] As a consequence, these estimates may be slightly conservative. The lifetime risk of hip fracture has been estimated at 5.6% for black women and 2.8% for black men from age 50 onward.[12]

The lifetime risk of a clinically diagnosed vertebral fracture is 15.6% in white women and 5.0% in white men (Table 2). These estimates are based on the incidence of vertebral fractures that came to clinical attention among Rochester residents in 1985–1989.[15] Because a substantial proportion of vertebral fractures are asymptomatic and never diagnosed, these should be considered low estimates. If the vertebral fracture incidence rates used in the model are those derived from prevalence rates, thereby presuming that all vertebral fractures are diagnosed,[16] the resulting estimate is higher.[11] However, it is unlikely that all morphometrically defined vertebral fractures represent clinically significant events.[15,17]

The lifetime risk of a distal forearm fracture is 16.0% in white women and 2.5% in white men (Table 2). These are similar to estimates (15.0% in white women and 2.4% in white men) made previously using a different mathematical modeling technique.[12] The forearm fracture incidence rates in this instance also come from Rochester, but from an earlier time period.[18] No other data are available for

TABLE 1. FIRST FRACTURE INCIDENCE RATES PER 100,000 PERSON-YEARS AMONG ROCHESTER, MINNESOTA MEN AND WOMEN

Subjects	*Proximal femur 1950–1982*	*Vertebra 1985–1989*	*Distal forearm 1945–1974*	
Subjects				
<50	5.5	19.3	398.5	
50–54	12.5	58.6	118.4	
55–59	36.9	82.4	92.9	
60–64	58.0	40.8	74.3	
65–69	139.7	143.2	113.3	
70–74	241.7	154.8	90.6	
75–79	423.2	466.1	111.8	
80–84	850.6	421.0	123.5	78.3
≥85	1719.5	1326.7	0	
Women				
<50	3.8	12.1	248.1	
50–54	69.5	123.0	355.4	
55–59	135.4	248.2	494.9	
60–64	169.6	283.3	639.8	
65–69	314.2	463.5	537.6	
70–74	493.5	634.0	669.8	
75–79	1033.2	938.7	517.8	
80–84	1669.3	1224.2	526.9	
≥85	2552.5	1213.5	688.2	

TABLE 2. ESTIMATED LIFETIME FRACTURE RISK IN 50-YEAR-OLD WHITE WOMEN AND MEN[a]

	Women % (95% CI[b])	*Men* % (95% CI)
Proximal femur fracture	17.5 (16.8, 18.2)	6.0 (5.6, 6.5)
Vertebral fracture[c]	15.6 (14.8, 16.3)	5.0 (4.6, 5.4)
Distal forearm fracture	16.0 (15.2, 16.7)	2.5 (2.2, 3.1)
Any of the three	39.7 (38.7, 40.6)	13.1 (12.4, 13.7)

[a]Age 50 years was chosen because this is about the average age of menopause in women.
[b]Confidence interval.
[c]Using incidence of clinically diagnosed fractures only.

the United States, but studies elsewhere in the world suggest that forearm fracture rates may be rising.[19,20] Thus, it is likely that these estimates are low, even though forearm fractures are influenced by icy conditions and might be more common in a northern locale like Rochester than elsewhere in the country.[3]

Despite the fact that some of the fracture-specific estimates may be conservative, the lifetime risk of any of the three fractures is 39.7% for white women from age 50 years onward and 13.1% for white men (Table 2). This suggests that about 425,000 of the aproximately 1,070,000 white women who reach menopause annually in this country will ultimately be affected. Moreover, hip, forearm, and vertebral fractures are not the only fractures associated with osteoporosis. The Study of Osteoporotic Fractures has provided evidence that most fractures in the elderly are due, at least in part, to low bone mass.[21] Thus, the full burden of established osteoporosis may be even greater than is indicated here. It will certainly be greater in the future if fracture incidence rates increase[22] or if the population continues to age. Although it has been appreciated that aging of the population would cause the number of fractures to rise,[23] recent data show that the potential magnitude of this increase may have been greatly underestimated in the United States.[24]

OSTEOPENIA

Skeletal fragility is related to the amount of bone tissue present, its architectural arrangement, any abnormalities of bone matrix or mineralization, and the presence or absence of microfractures.[8] Of these, only the amount of bone can be easily assessed in vivo. Fortunately, bone mineral measurements are very highly correlated with bone strength and have been shown empirically to predict fractures.[8] Epidemiologic studies have documented an increase in hip fracture incidence with declining bone mineral density (BMD) in the proximal femur, an increase in vertebral fracture incidence and prevalence with declining BMD in the lumbar spine, and an increase in distal forearm fracture incidence with declining bone density or bone mineral content (BMC) in the distal radius.[25] Thus, the size of the population affected by osteoporosis can also be gauged by the prevalence of low bone mass.

Because the gradient of increasing fracture risk with decreasing bone mineral is continuous, it is necessarily somewhat arbitrary to identify a specific level of bone mineral as clinically significant. Indeed, the level at which bone loss can be considered pathologic is unclear at present and needs to be established by prospective studies quantitatively relating bone mass to fracture risk and the cost effectiveness of interventive therapy. Since current pharmacologic agents can preserve existing bone mass but cannot replace lost bone or restore normal biomechanical competence of the skeleton,[26] osteoporosis prophylaxis may need to be addressed to the large group of women with bone mass more than 1 standard deviation (SD) below the young normal mean.[27] Few would insist, however, that all these women have pathologically low bone mass. To increase the specificity of bone mineral measurements to predict fractures, it has been proposed that much lower levels be considered abnormal, for example, <3 or <4 SD.[28] This would exclude many of the women who ultimately will fracture, however. An intermediate level that is often suggested is 2 SD below the mean in young normals.[29] When measured in the spine or hip, this value incorporates 90% or more of the patients with spine or hip fractures[28,30] and thus corresponds to the empirical "fracture threshold."[31] What would be the prevalence of osteopenia were this latter definition to be chosen?

Innumerable studies have shown that bone mass declines with age in men as well as women. Shown in Fig. 1 are the distributions by age of BMD in the neck and intertrochanteric regions of the proximal femur, BMD of the lumbar spine, and BMC of the midradius in an age-stratified random sample of Rochester, Minnesota women. Defined as bone mineral more than 2 SD below the mean in young normal women, the prevalence of osteopenia rises dramatically with aging, from less than 1 in 20 women aged 30–39 years to half or more of the women aged 80 years and over (Table 3). When adjusted to the population structure of U.S. whites in 1990, these Rochester data indicate that 17.2% of white women aged 30 years or more have low spinal BMD, 16.3% have low BMD in either region of the proximal femur, and 13.3% have low BMC in the midradius. The prevalence of osteopenia at any one of the three sites is 25.1%. If the analysis were restricted to women 50 years of age or older, the Rochester data suggest that 31.8% would have low BMD in the lumbar spine, 28.8%

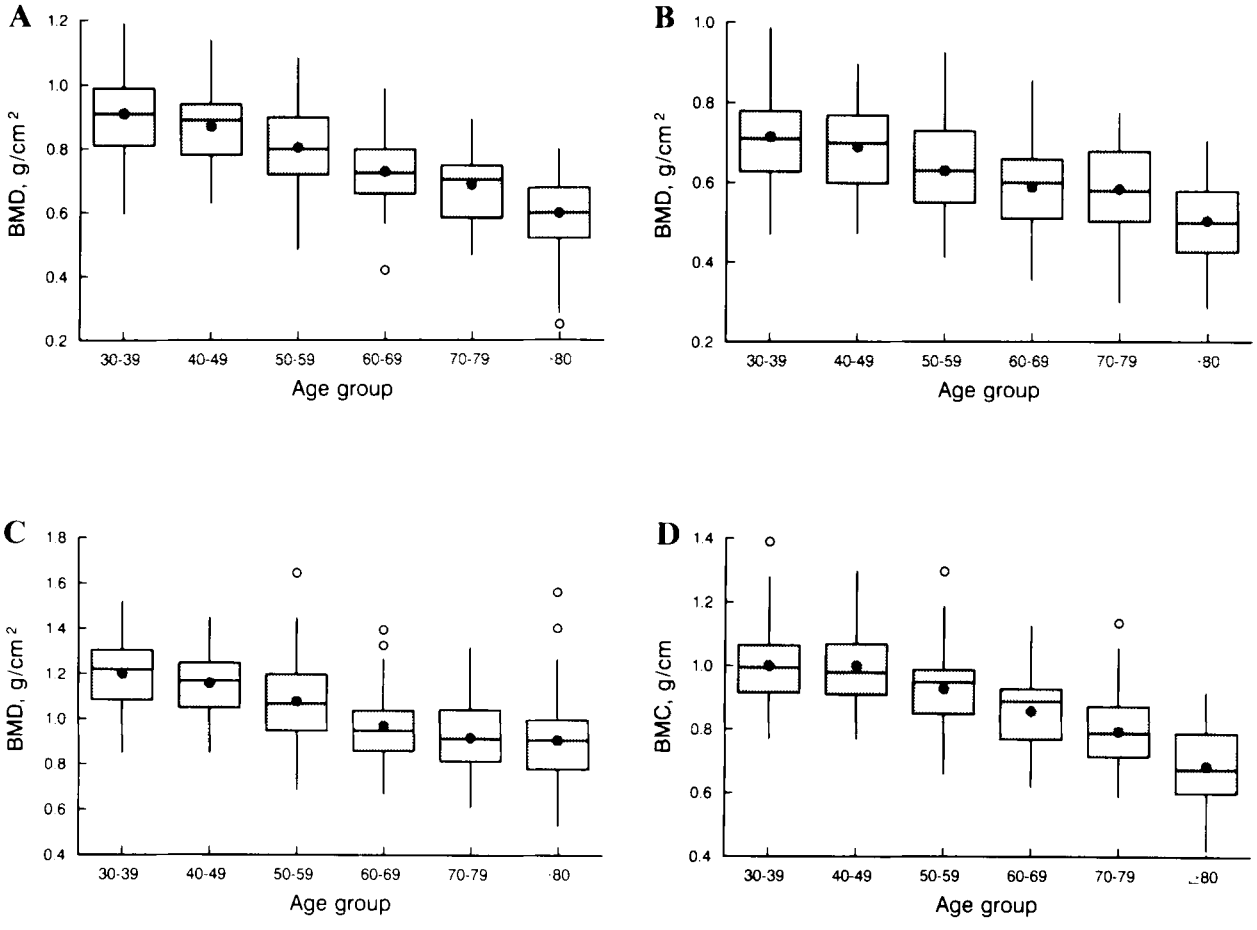

FIG. 1. Distribution of bone mineral density (BMD) at the neck (A) and intertrochanteric (B) regions of the proximal femur and the lumbar spine (C) and bone mineral content (BMC) at the midradius (D) among an age-stratified random sample of Rochester, Minnesota women.[12,31] Boxes extend from the 75th to the 25th percentiles, with a transverse line at the median and a dot at the mean; lines extend to the most extreme values within 1.5 interquartile ranges of the 75th and 25th percentiles; values outside these ranges are indicated individually. The hip and spine measurements were made by dual-photon absorptiometry and the radius measurements by single-photon absorptiometry, but the general patterns shown should be the same regardless of the technology used.

would have low BMD in either region of the proximal femur, and 26.1% would have low BMC in the midradius. (The midradius was chosen for comparability with other studies, but the analogous figure for distal radius BMC is 30.6%.) The proportion of women 50 years of age or older with osteopenia at any one of the three sites is 45.2% (or 48.2% if distal radius BMC is substituted for midradius BMC), which suggests that over 14 million postmenopausal white women have osteopenia in the United States at present. This represents the proportion of the population affected at a single point in time. As is evident from Fig. 1, however, a majority of women will end up with bone mass this low if they live long enough.

The notion that 45% of postmenopausal white women have osteopenia may raise philosophical questions about whether a condition so common should be considered a disease or part of the "normal" aging process. In the final analysis, however, the issue cannot be solely philosophical because osteopenia leads to fractures and fractures lead to substantial adverse health outcomes.[32] For example, among the Rochester women aged 80 years and over who had osteopenia, 57% had already experienced one or more fractures of the hip, vertebrae, distal forearm, proximal humerus, or pelvis, but the comparable figure among the oldest women without osteopenia was only 25%. Chrischilles and colleagues estimated that such fractures would cause an extra 6.7% of white women to become dependent in the activities of daily living, over and above background levels of dependency in the community, and precipitate admission of an additional 7.8% of women into nursing homes for long-term care.[11] Since it has been demonstrated in prospective studies that low bone mass is a major risk factor for fractures[3] and is, moreover, preventable,[26] it seems reasonable to include osteopenia within the scope of osteoporosis. If a condition causes clinical symptoms including death, has huge health care costs, and can

TABLE 3. PROPORTION OF ROCHESTER, MINNESOTA WOMEN WITH BONE MINERAL MEASUREMENTS MORE THAN 2 SD BELOW THE MEAN FOR YOUNG NORMAL WOMEN[a]

	Lumbar spine		*Either hip site*		*Midradius*		*Spine, hip, or midradius*	
Age group	n	%	n	%	n	%	n	%
30–39	48	2.1	45	4.4	48	0	48	4.2
40–49	50	2.0	49	2.0	50	0	50	4.0
50–59	53	15.1	51	11.8	54	7.4	54	25.9
60–69	51	31.4	50	22.0	51	17.6	51	37.3
70–79	52	44.2	49	36.7	52	36.5	52	57.7
≥80	50	48.0	40	67.5	50	68.0	50	84.0
Total	304	24.0	284	22.9	305	21.6	305	35.7
Adjusted[b]		17.2		16.3		13.3		25.1
(95% CI)		(13.7, 20.7)		(12.8, 19.9)		(10.6, 16.0)		(21.2, 28.9)

[a]Mean is from the 48 subjects under age 40 who were randomly sampled from the Rochester, Minnesota population. None of them was known to have any disorder that might influence bone metabolism.

[b]Age adjusted to the 1990 U.S. population structure of white women 30 years of age and older.

favorably be affected by intervention and treatment, then it must be considered a disease.

In conclusion, these data show that osteoporosis, assessed either on the basis of increased fracture risk as defined by bone mineral measurements (osteopenia) or by the occurrence of specific fractures (established osteoporosis), is a very common condition. The size of the population affected by osteoporosis is not without precedent, however, in other common chronic diseases. For example, 36% of Rochester women aged 45 years or over have hypertension,[33] and over 20% of all accident victims 30 years of age and older in Rochester have significant coronary disease.[34] Over their lifetimes, a majority of white women are affected by osteoporosis, as are many men and women of other ethnic groups. If the enormous costs associated with these fractures are to be reduced, organized programs of osteoporosis prophylaxis will be needed. Because so many people are affected, public health approaches to the problem will be crucial. However, research is also needed to identify effective strategies to find and treat high-risk individuals. Such efforts may be expensive, but the potential benefits are great as well.

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