Risk for Osteoporosis in Elderly Nuns: Need for Better Recognition and Treatment

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ABSTRACT

Background: The risk for osteoporosis in Catholic sisters (nuns) may be even higher than that of the general female population given their longer life expectancy (82.0 to 89.0 years vs 79.6 years for the average white woman) and the use of a traditional habit as a young adult, resulting in limited sun exposure (ie, exposure to vitamin D).

Objectives: The aim of this study was to determine, in a group of elderly nuns attending an annual health screening day (Health Forum), how many met National Osteoporosis Foundation (NOF) treatment criteria using peripheral bone mineral density (BMD) measurements and risk factors; what proportion received adequate vitamin D; whether BMD was related to length of time that nuns wore a habit; and whether BMD measurement led to medical interventions. In addition, we compared the usefulness of calcaneal BMD with that of BMD at central sites for identification of those at risk for osteoporosis.

Methods: This cross-sectional study assessed BMD by calcaneal dual energy X-ray absorptiometry (DXA) and, for some participants, central DXA. A baseline questionnaire and follow-up mail survey also were included.

Results: Of the 230 nuns attending the Health Forum, 146 (63%) (mean age, 70 years; range, 48–90 years) participated in the study. Of these, 14% had calcaneal osteoporosis (T-score <−2.5) and 32% met NOF treatment criteria, indicating risk comparable to that of other postmenopausal American women. Sixty-four percent were receiving less than the recommended amount of vitamin D (≥ 400 IU/d for those aged <71 years and ≥ 600 IU/d for those aged ≥ 71 years). Calcaneal BMD was inversely related to the length of time nuns had worn a habit. Fifty-six women subsequently underwent central DXA. Using a calcaneal T-score of −1.2 to identify those with central osteoporosis, sensitivity and specificity of 78% and 76%, respectively, were obtained. According to

the mail survey, 11 of 42 respondents who had met NOF treatment criteria started new medications for osteoporosis.

Conclusions: Elderly nuns are at substantial risk for osteoporosis. Most receive inadequate vitamin D. For nuns and others who may have limited access to central DXA measurement, peripheral measurements may help identify those in need of further intervention. Further efforts, in addition to BMD measurements, are necessary to ensure appropriate therapy for those who meet treatment criteria. (*Curr Ther Res Clin Exp.* 2003;64:65–80) Copyright © 2003 Excerpta Medica, Inc.

Key words: postmenopausal osteoporosis, bone density, vitamin D, nuns.

INTRODUCTION

In the United States, >1.3 million osteoporotic fractures occur each year.^{1,2} According to the National Osteoporosis Foundation (NOF), the average 50-year-old white woman has 1 chance in 7 of experiencing a hip fracture during her lifetime.¹ The risk for Catholic sisters (nuns) may be even higher, given their longer life expectancy (82.0 to 89.0 years compared with 79.6 years for the average white woman) and use of a traditional habit as young adults.^{3,4} The traditional nun's habit, a religious garment, leaves only the hands and the central part of the face exposed. As vitamin D status is largely determined by sunlight exposure, it is possible that vitamin D insufficiency in young nuns may limit the attainment of peak bone mass, with the risk for fracture increasing with age.⁵ However, little published information is available on osteoporosis prevalence in nuns or how their risk compares with that of the general population of white women.⁶

Hypovitaminosis D is common with advancing age due largely to decreased time spent outdoors, decreased production of vitamin D from exposure to sunlight, and diminished vitamin D dietary intake.^{7–13} For these reasons, 600 to 800 IU of vitamin D daily often is recommended for older adults.^{14–17} However, most individuals fall short of this requirement.^{14–16} Whether nuns have adequate vitamin D intake is unknown.

Fracture risk is best assessed by bone mineral density (BMD) measurement. This test is recommended for many postmenopausal women by the NOF.¹ Only a small fraction of appropriate individuals have been tested, however, partly because of limited access to the expensive equipment used to measure hip and spine (central) BMD.^{18,19} For older nuns, as well as for other postmenopausal women at risk for osteoporosis, improved assessment of skeletal status is needed. Inexpensive, portable devices to measure BMD at peripheral sites have been developed, and such tests can help a physician decide whether to measure hip and spine BMD. Debate continues regarding the usefulness of peripheral measurements for predicting osteoporosis at central sites.^{20–22} Also, it is uncer-

tain whether findings from peripheral measurements lead to medical intervention. Resolution of these concerns may promote the use of peripheral devices so that detection, diagnosis, and, ultimately, treatment of osteoporosis will be improved in populations at risk.

Despite the risk for hypovitaminosis D, few studies are available on the prevalence of osteoporosis in nuns. Accordingly, the aims of the current study of nuns in Wisconsin were as follows: to determine the prevalence of low BMD; to establish the proportion of nuns meeting NOF treatment criteria; to assess the adequacy of current vitamin D intake; to assess the relationship between years of wearing a habit and BMD; and to determine whether study participation led to subsequent medical interventions affecting bone health. In addition, the sensitivity and specificity of calcaneal dual energy X-ray absorptiometry (DXA) measurement for prediction of osteoporosis at central skeletal sites were to be determined for a subgroup of nuns who underwent central DXA measurements.

PATIENTS AND METHODS

This project, which was approved by the University of Wisconsin Health Sciences Human Subjects Committee, was carried out at a private hospital as part of a 1-day annual event, "Taking Care: A Health Forum for Women Religious" (Health Forum), at which nuns attended a series of presentations and were offered various health screening and preventive services, including measurement of cholesterol levels, blood glucose levels, and blood pressure; flu vaccination; and coupons for mammograms. Recruiting notices were posted at the Health Forum, and subjects enrolled in this study after providing written informed consent. Postmenopausal women without prior BMD measurements were eligible. At enrollment, each woman was offered the opportunity to undergo central (hip and spine) DXA within the next 2 months at no charge.

Calcaneal BMD measurements were carried out with 5 peripheral instantaneous X-ray imagers ([PIXIs] GE Lunar Corp., Madison, Wisconsin). This DXA device requires 30 seconds per measurement. Analysis is automated, with the software selecting a region of interest within the calcaneus. Printed results include a calcaneal image with region of interest and BMD expressed both as g/cm^2 and relative to the reference database or T-score. For any individual, the T-score is the number of standard deviations above or below the mean for the normal reference population. For the PIXI, the reference population included 2200 women aged 20 to 45 years.²³ BMD precision (% coefficient of variation) reported by the manufacturer is 1.5%.

Following the example of the National Osteoporosis Risk Assessment study,^{24,25} the World Health Organization criteria were applied to peripheral BMD measurements. Thus, women were classified as having calcaneal osteoporosis if their T-score was < -2.5 .^{24,25} In addition, a woman was categorized as meeting NOF treatment criteria if her calcaneal T-score was < -2 , or if it was -1.5 in the presence of 1 or more of the following risk factors: current cigarette smoking,

history of adult fracture, adult fracture in a first-degree relative, or body weight <127 lb (57.2 kg).^{1,24,25}

Enrollees completed a bone health questionnaire. Questions relating to past and present vitamin D status were asked, including the number of years the traditional habit had been worn, how many hours per week are currently spent outdoors, and vitamin D intake from supplements/multivitamins (400 IU/multivitamin) and milk (100 IU per 8 fl oz [240 mL]). Daily calcium intake was estimated by recording the consumption of milk, yogurt, cheese, and calcium supplements. To assess the women's awareness of their skeletal status, the questionnaire included the question, "Has anyone ever told you that you had osteoporosis?"

Each participant was given a printout of her BMD test results, and the recruiter explained how the subject's BMD compared with that of the female young adult reference population. Subjects were given NOF educational pamphlets, and the recruiters answered questions about osteoporosis, calcium, vitamin D, and related lifestyle issues. Women were encouraged to consult their primary health care providers regarding the test results or other questions about osteoporosis. Participants' physicians were sent copies of the BMD test and questionnaire, the NOF *Physician's Guide to Treatment and Prevention of Osteoporosis*,²⁶ and a cover letter describing the study and providing information about the use of calcaneal BMD as a screening tool.²⁷

Measurements of femoral and lumbar spine BMD were carried out using DXA (Lunar DPX-IQ, GE Lunar Corp.) by one of the investigators (N.C.B.) in the usual clinical manner. The investigator, who was blinded to the calcaneal test results, interpreted the central BMD measurements and sent a report to each woman's physician as a courtesy.

Follow-up questionnaires were mailed to participants 9 months after the Health Forum. Participants were asked if they had discussed the test results with their physician and if there had been any change, either physician-recommended or self-initiated, in calcium supplements, multivitamin intake, or osteoporosis therapy since the Health Forum.

Statistical Analysis

Sensitivity and specificity of a range of calcaneal T-scores for discriminating women with T-scores <−2.5 at either lumbar spine or femur were calculated. Ninety-five percent CIs for proportions were calculated using the large sample approximation for binomial variables.²⁸ For proportions in a small sample set ($n \times p \times [1 - p] < 10$, where p is the proportion of individuals with a given response), 95% CIs were obtained with a graphical method based on the binomial distribution.²⁹ The chi-square test was used to test for significance of differences between proportions.²⁸ Linear regression was used to determine the significance of correlations between independent categoric or numeric variables and dependent numerical variables.³⁰ Multiple linear regression was used in a stepwise fashion to assess the contribution of variables (age, body weight, and years

spent wearing the habit) to the outcome variables of calcaneal, hip, or spine BMD.³⁰

RESULTS

Of the 230 nuns attending the Health Forum, 146 (63%) (mean age, 70 years; range, 48–90 years) participated in this study. With the exception of 1 Asian, all participants were white. BMD testing was efficient, with all 146 women enrolled and tested within 2 hours. Mean (SD) calcaneal BMD was 0.419 (0.107) g/cm² (median, 0.422 g/cm²). Twenty women (14%) (95% CI, 8–19) were osteoporotic, as indicated by T-scores < -2.5 measured at the calcaneus. Fifty-two nuns (36%) (95% CI, 28–43) had osteopenia ($-2.5 \leq \text{T-score} < -1$). Of 146 nuns, 47 (32%) (95% CI, 25–40) met NOF treatment criteria, 34 (23%) due to low BMD and 13 (9%) on the basis of BMD plus a risk factor (Figure 1). In contrast to the 14% of American women aged 65 to 74 years who smoke, and in accordance with other studies about nuns, only 2 (1%) of the nuns in the present study currently smoke (a recognized risk factor for osteoporosis).^{1,31,32}

Among those with calcaneal T-scores < -2.5 , only 3 of 20 (15%) (95% CI, 0–30) had previously been advised that they were osteoporotic. In addition, of the 47 women who met NOF treatment criteria, only 12 (26%) (95% CI, 13–38) were aware of their low bone mass.

Figure 1. Nuns who met National Osteoporosis Foundation criteria for antiresorptive therapy. NOF treatment criteria include those women with a T-score < -2 or with a T-score < -1.5 with 1 or more specific risk factors.

The mean daily vitamin D intake of the nuns, taken as supplements and milk, was 358 IU (Figure 2). Only 53 nuns (36%) (95% CI, 29–44) received their recommended daily intake of vitamin D (≥ 400 IU/d for those aged <71 , and ≥ 600 IU/d for those aged ≥ 71).¹⁷ No significant relationship was found between calcaneal BMD and current intake of vitamin D or current time spent outdoors.

Fifty-six women in the study agreed to have central BMD measured. No significant difference in age or in calcaneal BMD was found between this group and the subjects who did not receive central DXA. Figures 3 to 5 depict the relationships among measurements at 3 skeletal sites. The correlation between calcaneal and total proximal femur BMD in 55 women ($r = 0.731$; $P < 0.001$) (Figure 4) was similar to that between total proximal femur BMD and lumbar spine BMD in these women ($r = 0.770$; $P < 0.001$) (Figure 5).

Additionally, the usefulness of calcaneal BMD as a screening test was assessed. Using a calcaneal BMD threshold T-score of -1.2 , we determined the ability of calcaneal measurement to discriminate between those with osteoporosis (T-score < -2.5 at ≥ 1 central site) and women without central osteoporosis. Using this threshold, the PIXI provided a sensitivity of 78% and a specificity of 76% for identifying women with osteoporosis. We also obtained a positive

Figure 2. Nuns' daily intake of vitamin D from milk and supplements. Intake is shown separately for nuns aged 70 years or younger ($n = 74$) and those aged 71 years or older ($n = 72$), corresponding to the recommended vitamin D minimum intake of 400 IU/d and 600 IU/d, respectively.

Figure 3. Relationship between bone mineral density (BMD) of the calcaneus and that of the lumbar spine for the 56 women who agreed to undergo central BMD measurement.

predictive value for PIXI calcaneal BMD (percentage of those who test positive who have hip or spine osteoporosis) of 61%. The negative predictive value (percentage of those who tested negative who did not have hip or spine osteoporosis) was 88%.

The relationship between BMD and wearing of the traditional nun's habit also was examined. Most nuns entered the convent and began wearing a habit when young, at a median age of 18 years (range, 8–50 years); and some had worn the habit for up to 75 years, with a mean and median of 21 and 20 years, respectively. BMD at the calcaneus (Figure 6) and the femur (data not shown) was significantly lower in those who had worn the habit the longest ($P < 0.001$ and $P < 0.008$, respectively). However, as older nuns had worn the habit the longest, our observation could have reflected the effect of age on BMD. Because body weight also affects BMD, this was also a possible confounder. In examining calcaneal BMD as a function of age alone; or of age and body weight; and, finally, with age, body weight, and years of wearing the habit, we obtained increasingly good correlations (r^2) of 0.22, 0.39, and 0.42, respectively. Including the variable of years of wearing the habit contributed significantly ($P = 0.014$) to the ability to predict calcaneal BMD, even after age and body weight were taken into account. Likewise, total proximal femoral BMD was significantly ($P = 0.008$) related to the number of years the habit was worn, even after both age and body weight were taken into account. Lumbar spine BMD was not significantly

Figure 4. Relationship between bone mineral density (BMD) of the calcaneus and that of the total proximal femur. For 1 woman, proximal femur measurements were not available, so that the results for only 55 women are shown.

related to wearing of the habit. No significant relationships were observed between BMD and current calcium intake, personal history of fracture, or family history of fracture.

For the follow-up survey, which 117 nuns had previously agreed to complete, 101 of 117 (86%) nuns responded. Seventy-one respondents (70%) reported that they had discussed the BMD results with their physician. Of these 71 women, 40 reported they had never previously discussed osteoporosis with their physician. Of the 101 women who answered the survey, 25 reported taking a new medication for skeletal health since the study, either calcium, vitamin D, or prescription antiresorptive therapy (Figure 7). We also examined outcomes for those who had met NOF treatment criteria. Forty-two of 47 (89%) women meeting treatment criteria returned the survey, and 11 of these 42 (26%) had begun a new medication, either calcium supplement (1 woman), calcium supplement and vitamin D (3 women), or a prescription medication (7 women).

DISCUSSION

Relatively little is known about the skeletal health of nuns. In this study, 1 of 7 nuns had osteoporosis and 32% met NOF treatment criteria. Of those meeting NOF treatment criteria, 74% were unaware of their low BMD. Most received

Figure 5. Relationship between bone mineral density (BMD) of the lumbar spine and that of the total proximal femur. For 1 woman, proximal femur measurements were not available, so that the results for only 55 women are shown.

less than the recommended vitamin D intake. Calcaneal BMD provided good specificity and sensitivity for predicting osteoporosis at the hip or spine.

Given the number and variety of other health screenings and events offered concurrently with BMD testing at the Health Forum, the fact that most attendees (63%) participated in osteoporosis screening indicated a high level of interest in skeletal health in this group. This study also demonstrated that appropriate medical intervention or a change in behavior often follows when BMD screening has occurred outside the normal clinic setting.

The risk for osteoporosis in nuns appears to be similar to that of other women. The prevalence of calcaneal osteoporosis (14%) in the current study is comparable to that reported at the lumbar spine (16.5%) and femur (17.4%) in women aged ≥ 50 years in Rochester, Minnesota,³³ and is similar to that reported for the femur (17%) for postmenopausal women in the National Health and Nutrition Examination Survey (NHANES) III study.^{18,19} For osteoporosis at the calcaneus, prevalence data are limited, but have been estimated at 7.2% for postmenopausal women²⁵ and between 6% and 27% for women in the age range of 65 to 84 years.^{20,34} In a group of women in rural Wisconsin ($n = 133$; mean age, 73 years), the prevalence of calcaneal osteoporosis was 20%.³⁵ Although older nuns may not be at higher risk than other postmenopausal women, their

Figure 6. Relationship between bone mineral density (BMD) of the calcaneus and the number of years that nuns wore the traditional habit ($n = 146$). Each point represents values for 1 individual.

risk is not small, with a significant minority having osteoporosis at both calcaneal and central sites. Increasing the availability of osteoporosis screening to detect such individuals appears reasonable.

The finding that many nuns did not obtain enough vitamin D is of concern because of the possibility of secondary hyperparathyroidism and bone loss that can accompany low vitamin D status in elderly individuals.^{7-13,36-39} Although inadequate, the nuns' vitamin D intake was higher than the mean for US adults. In NHANES II,⁴⁰ the mean vitamin D intake for women was estimated at 90 to 114 IU. A simple solution for many, depending on age and milk intake, would be to take 1 multivitamin daily, in combination with a calcium/vitamin D supplement.

Although nuns did not, on average, receive sufficient vitamin D, no significant relationship was found between BMD and current intake or sun exposure. This finding may have been due to the many factors that in addition to current vitamin D status contribute to BMD. Our small study may have had insufficient power to discern an effect of current vitamin D intake or outdoor time in the group studied. Another issue related to vitamin D status was the nuns' limited sun exposure over many years. As of 1972, wearing of the traditional habit was no longer required in most orders. Many elderly nuns living today, however, had worn the habit for many years prior to that, and some continued the practice

Figure 7. A follow-up survey indicated that 25 of 101 women reported taking one of the medications shown since participating in the study. Ca = calcium supplement; Vit D = vitamin D; ALN = alendronate; RALOX = raloxifene; CCT = nasal calcitonin.

after 1972. In the present study, nuns who had worn the habit for a longer time had lower BMD at the calcaneus and total proximal femur (but not at the lumbar spine), even when body weight and age were taken into account. However, in this observational study, we cannot rule out other confounding factors that may have led to this association.

Our observation of a relationship between low BMD and the wearing of the habit is consistent with other observations about sun exposure, vitamin D status, and skeletal health.^{8,9} Low vitamin D status is commonly seen in the elderly, due to decreased sunlight exposure and reduced cutaneous responsiveness to sunlight, often in combination with other medical problems.⁵ Two studies^{8,9} have underscored the importance of seasonal changes in vitamin D and bone. In elderly women, winter was associated with decreased levels of 25-hydroxyvitamin D (25-OH), increased parathyroid hormone, increased bone turnover, and decreased hip BMD.^{8,9} In addition, in some situations, otherwise healthy young individuals develop low vitamin D status. In northern climates, adequate cutaneous synthesis is not possible from November to February, even with prolonged exposure on a sunny day, so that even young persons depend on other sources or on body stores.⁵ Also, sunscreens severely reduce the production of vitamin D.⁴¹ A powerful example of the effect of social customs on vitamin D status was shown by a report on veiled Saudi Arabian women, studied when they presented with minor acute illnesses. Twenty-eight of the 31 women had 25-OH vitamin D concentrations below the normal range.⁴² Another group at high risk for hypovitaminosis D are submariners.⁴³ Given the risks for those with little sunlight exposure, it is reassuring that nuns today

are not required to wear a habit. However, because today's elderly nuns may have received little sunlight in their peak bone-forming years and for years beyond, it is important at the very least that these women now have adequate vitamin D intake and optimally have their skeletal health assessed.

Another objective in this study was to compare calcaneal, hip, and spine BMD measurements. Site discordance signifies the lack of a perfect match between skeletal sites.^{20,22} Using a threshold of -1.2 in the current work, the PIXI exhibited sensitivity and specificity of 78% and 76%, respectively, for identifying women with osteoporosis at axial sites. Correlation between calcaneal BMD and central BMD was good, with the relationship between BMD at the total proximal femur and calcaneus BMD ($r = 0.731$) similar to that between total proximal femur and lumbar spine ($r = 0.770$). Our findings are consistent with studies using other calcaneal measurement devices and with other studies using the PIXI. Greenspan et al⁴⁴ studied premenopausal and postmenopausal women with a variety of heel measurement devices (prior to PIXI availability) and with DXA measurements of the hip and spine. The calcaneal measurement devices showed a similar ability to discriminate normal individuals from those who were osteoporotic at the hip. Furthermore, in that study there was a good correlation between measurements at the hip and heel ($r = 0.70$ to 0.80), similar to the correlation of 0.731 we obtained between these sites. More recently, in a study⁴⁵ of 443 women (mean age, 60 years) referred for BMD measurements, a PIXI T-score threshold of -1.3 provided a sensitivity and specificity of 70% and 83%, respectively, for discriminating those with osteoporosis at either hip or spine. In a study of 91 women (mean age, 57 years), Langton and Langton,⁴⁶ using a T-score of approximately -1.1 , showed similar sensitivity (76%) and specificity (70%) for discriminating osteoporosis at either the hip or spine. The present findings, showing a sensitivity and specificity of 78% and 76%, respectively, for a PIXI calcaneal measurement in discriminating central osteoporosis, are thus comparable to findings in other studies. Based on these studies, a calcaneal DXA T-score threshold in the -1.1 to -1.3 range is reasonable for distinguishing those with osteoporosis at either the hip or spine.

Langton and Langton⁴⁶ also compared calcaneal measurements using the PIXI and ultrasonography. Because the authors concluded that the discriminatory performance of the 2 heel units was similar, other issues should dictate the choice of unit. The PIXI is convenient for many settings for 2 reasons: because (1) the scan time is only 30 seconds and (2) subjects can wear socks because no gel or water bath is used. In our study, 146 elderly women were recruited, consented, surveyed, and tested in approximately 2 hours, using 5 PIXIs. Based on our experience with the unit, in addition to the discriminatory ability discussed above, the PIXI appears to be well suited for osteoporosis screening.

For peripheral BMD screening to be valuable, test results must be translated into action. The follow-up survey showed that 70% of respondents discussed the results with their physicians and that some women began taking calcium, multivitamins, vitamin D, or antiresorptive therapy. Related studies⁴⁷⁻⁴⁹ have shown

that women receiving central DXA measurements were more adherent with therapy and lifestyle changes than women who were not tested. The current work demonstrates that when the results of BMD screening are provided to the patient and/or physician, appropriate and potentially beneficial interventions can result. Further efforts are required to ensure that women who are identified as being at risk do in fact receive appropriate interventions.

This study had limitations, including using a calcaneal T-score of <-2.5 to categorize subjects as osteoporotic, and categorizing women as meeting NOF treatment criteria based on a calcaneal T-score <-2 or a T-score of <-1.5 with at least 1 risk factor. As pointed out earlier, skeletal site discordance is well recognized, with the proportion of women with T-scores <-2.5 depending on the technology used and the skeletal site tested.²² T-score-equivalent values are currently being formulated to resolve these discrepancies. New treatment criteria based on site-specific T-score thresholds also are being developed.⁵⁰ However, until new criteria are established, we and others have used the published World Health Organization and NOF criteria.^{24,25} Another limitation is that subjects were self-selected and might not be representative of other nuns. However, because most volunteers are healthier and more motivated than the general population, osteoporosis prevalence, lack of awareness of osteoporosis risk, and inadequate vitamin D intake may be even higher for the average elderly nun than for those in our study.

CONCLUSIONS

Elderly nuns are at substantial risk for osteoporosis, but this risk appears similar to that for other elderly women. Many do not receive adequate vitamin D. Many years of wearing a habit was associated with lower BMD. For this group and others with limited access to central DXA testing, peripheral measurements may be suitable for identifying those most likely to have osteoporosis at the hip and spine. BMD measurement offered at the Health Forum had a positive impact on medical management of osteoporosis in these individuals. Further efforts, in addition to BMD measurements, are necessary to ensure appropriate therapy for those who meet treatment criteria.

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