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Original Article

The relationship of absolute poverty and bone mineral density in postmenopausal Iranian women

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Summary

Objective: It is increasingly recognized that socioeconomic inequalities play an important role in bone health, with significantly higher fracture rates being reported in lower income groups. But the relationship between absolute poverty and bone mineral density (BMD) and/or osteoporosis has not been investigated.

Methods: A total of 1135 postmenopausal women under absolute poverty lines who received financial support from the Imam Khomeini Relief Foundation (IKRF) and 406 randomly selected healthy postmenopausal women were screened for osteoporosis using BMD testing.

Results: At all BMD sites, women under the absolute poverty lines had the lowest mean BMD values ($p<0.0001$). According to the WHO criteria, 252 subjects under absolute poverty lines (22.4 %) and 35 healthy postmenopausal women from the general population (8.7 %) were considered osteoporotic ($p<0.0001$). After adjustment for lifestyle factors for osteoporosis in logistic regression models, absolute poverty was associated with the age-adjusted prevalence of femoral neck osteoporosis and lumbar osteoporosis [OR = 2.50 (CI, 1.38–4.51; $p=0.002$); OR = 2.40 (CI, 1.56–3.70; $p<0.0001$), respectively].

Conclusion: Postmenopausal women under the absolute poverty lines had lower BMDs at all skeletal sites, independent of established osteoporosis risk factors.

Keywords: Poverty – Socioeconomic status – Menopause – Osteoporosis – Bone mineral density – Women.

The 2000/2001 World Development Report named health as a key dimension of poverty and discussed issues that must be addressed to mitigate this factor.[1] A growing body of literature points to significant disparities in mortality and morbidity outcomes between populations of varying socioeconomic status. Social and economic determinants of health, therefore, are playing a greater part in the discourse of poverty.[2]

Poverty is an important determinant of women's health and has a significant impact on the physical and mental well-being of older women. Women constitute around 70 % of the world's poor and in all regions earn significantly less than men. Millions of women live in absolute poverty, unable to meet their minimum needs for nutrition, shelter, and rest. For these women, there is often an unending cyclical relationship between poverty and ill health.[3]

Bone loss is a normal concomitant of ageing and occurs in both genders after peak bone mass has been attained. Starting from the middle of the third decade, women lose 35 % of their cortical bone and 50 % of their trabecular bone.[4] They experience accelerated bone loss at a rate of 3 % to 5 % per year for about 5 to 7 years following menopause, placing them at a particularly increased risk for fracture.[5] Hip fractures are responsible for excessive mortality, decreasing the 5-year survival rate by about 20 %. From an economic perspective, they represent a major source of expense, with direct costs in hospitalization, rehabilitation, and institutionalization. The incidence rate sharply increases after the age of 70.[6] It has been projected that more than half of the hip fractures in the world in the year 2050 will occur in Asia.[7]

It is increasingly recognized that socioeconomic inequalities play an important role in bone health, with significantly high-

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er fracture rates being reported in lower income groups.[8–10] It is highly plausible that the bone health of poor women may be compromised by unhealthy dietary or physical activity patterns related to socioeconomic factors either during childhood, later in life, or throughout life. A few studies in populations have reported a relationship between low socioeconomic status and bone health.[10–17] But to our knowledge, the relationship between absolute poverty and bone mineral density and/or osteoporosis has not been investigated. Absolute poverty refers to the set of resources a person must acquire to maintain a minimum standard of living for survival. It is therefore "a matter of acute deprivation, hunger, premature death and suffering."[18]

The goal of the present study was to determine whether absolute poverty is associated with lower bone mineral density (BMD) in postmenopausal women. We investigated this relationship in a large population of postmenopausal women living in absolute poverty.

Methods

Community sampling

The Imam Khomeini Relief Foundation (IKRF) is the largest government organization in the country working for the relief and welfare of people in need. It was founded in 1963, but got the real thrust in its operation after the Islamic Revolution in Iran on March 5, 1979, through a decree of the late Imam Khomeini. With headquarters in Tehran, the foundation has branches in all cities in Iran and in some foreign countries. Today, the IKRF reaches 4.5 million of Iran's 68 million residents, and by its own tally caters to 92 % of Iran's poorest people in 52,800 towns and villages.

Bushehr province is the southern province of Iran. This province has the greatest border with the Persian Gulf. A total of 1135 postmenopausal women received financial support from the IKRF in Bushehr port. These women were living below absolute poverty lines. According to the IKRF, absolute poverty lines are the thresholds below which households cannot maintain a minimum standard of living.

In a collaborative health care project, Bushehr University of Medical Sciences and the provincial branch of the IKRF in Bushehr port, these women were screened for osteoporosis using BMD testing during the study period October 2004 to March 2005.

A non-exposed group (a sample of women from the general Iranian population) was taken from an age-stratified random sample of postmenopausal women who participated in the extension part of the Iranian Multi-central Osteoporosis Study (IMOS), in which 6000 subjects were randomly selected from five major cities throughout Iran. The main objectives of the multi-center study and details of the sampling process have been described previously.[19] Bushehr port was one of five urban centers that participated in IMOS.

All the households in Bushehr port were covered by the local health centers of Bushehr University of Medical Sciences and Health Services (13 local health centers). A multi-stage stratified cluster random sampling technique was used to select households in the coverage area of each local health center. The total number of households selected in the area of each local health center was proportional to the total number of households in that area. The study goal of the extension of IMOS was to recruit 120 postmenopausal women in each age decade in Bushehr port.

Publicity concerning the study appeared in local newspapers and on TV. The selected subjects were informed of the study through a letter given door-to-door by the survey groups of the IMOS. After primary education about osteoporosis and its associated risk factors, community-dwelling postmenopausal women were invited to participate in the study on the following morning at the Persian Gulf Health Research Center, part of Bushehr University of Medical Science and Health Services, for BMD testing.

Measurements

All subjects answered a detailed questionnaire covering demographic and behavioral information as well as medical history of conditions that could influence bone mass and metabolism. The questionnaires were compiled from interviews by expert nurses at the Persian Gulf Health Research Center. The women were also asked about their medical history such as diabetes mellitus, inflammatory bowel diseases, epilepsy, chronic liver or renal diseases, cancer, and self-reported hip or lumbar fractures. In addition, information was collected on reproductive history, including age at menarche and menopause, parity, use of postmenopausal hormone replacement therapy, and calcium and/or vitamin D supplementations.

Smoking was considered to be present when the subject smoked cigarettes or used hubble-bubble in a regular daily fashion. Respondents were classified as active at the recommended level if they reported sufficient physical activities of moderate intensity (i.e., ≥30 minutes per day, ≥5 days per week) or of vigorous intensity (i.e., ≥20 minutes per day, ≥3 days per week).[20]

Height and weight were measured using a stadiometer. Heavy outer garments and shoes were removed before measuring height and weight. Waist circumference was defined at the midway level between the costal margins and the iliac crests. Hip circumference was measured at the level of the greater trochanters. Body Mass Index (BMI) was calculated. Obesity was defined by a BMI ≥30.

Bone mineral density (BMD) was determined for lumbar spine (L2–L4) and proximal femur (neck) using dual-energy x-ray absorptiometery (DXA) on an Osteocore II bone densitometer (Osteocore II Osteodensitometer, Medilink, France). The accuracy of the measurements was checked by scanning phantoms and analyzing the scans. The precision errors were calculated using the root mean square method. The coefficients of variation (precision) of measurements of the lumbar spine and femoral neck were 0.8 % and 1.6 %, respectively.

Statistical analysis

The significance of the difference in the results of any two groups was determined by chi-square analysis using 2x2 contingency tables. A two-tailed t-test was used to compare the mean values across groups. $P<0.05$ was considered statistically significant.

Multiple logistic regression analysis was used to ascertain the associations between lumbar or femoral osteoporosis and risk factors for osteoporosis. The odds ratios of the relationship between osteoporosis (at the femoral neck and lumbar areas) and poverty were adjusted for age, obesity, physical inactivity, and smoking.

Statistical analysis was performed with an IBM computer using the SPSS 9.05 statistical software package (SPSS Inc., Chicago, IL).

Results

A total of 1135 postmenopausal women under the absolute poverty lines were compared with 408 postmenopausal women in the general population as the non-exposed group. There were no non-responders to study among the women under the absolute poverty lines, but the response rate of individuals in the non-exposed group (the general population) was 93.1 %. The characteristics of the study participants are shown in Table 1. There were no significant differences in age and years since menopause between the groups. Of the studied population in the absolute poverty lines, 61.3 % was <60 years, 10.3 % was between 60 and 64 years, 16.0 % was between 65

	Poor women (n = 1135)	General population (n = 408)	p values
Age	59.64 (7.40)	58.89 (7.49)	N.S
BMI (kg/m^2)[a]	25.44 (5.15)	28.31 (4.77)	<0.0001
WHR[a]	0.93 (0.08)	0.92 (0.03)	0.03
Age at menarche (years)	15.44 (13.93)	14.23 (8.85)	N.S
Parity	8.07 (3.63)	7.02 (3.10)	<0.0001
Years since menopause (years)	10.78 (8.34)	10.72 (9.31)	N.S
BMD (g/cm^2)[a]			
Lumbar area	0.856 (0.195)	0.943 (0.183)	<0.0001
Femoral neck	0.787 (0.304)	0.844 (0.180)	<0.0001
Wards triangle	0.452 (0.257)	0.606 (0.248)	<0.0001
Trochanter	0.567 (0.142)	0.631 (0.146)	<0.0001
Osteoporosis			
Femoral neck	111 (9.9 %)	14 (3.5 %)	<0.0001
Lumbar area	199 (17.7 %)	28 (6.9 %)	<0.0001
Physical activity			
Moderate intensity	114 (10.0 %)	68 (16.7 %)	<0.0001
Vigorous intensity	52 (4.6 %)	9 (2.2 %)	0.02
Smoking			
Past	317 (27.9 %)	110 (27.0 %)	N.S
Current	454 (40.0 %)	91 (23.3 %)	<0.0001

Table 1. Basic characteristics of bone-related variables of postmenopausal women in the absolute poverty lines, in comparison to the non-exposed group (general population).

Data are mean (SD) or number (percent).
a. BMI, WHR, and BMD indicate body mass index, waist-to-hip ratio, and bone mineral density, respectively.

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and 69 years, 9.7 % was between 70 and 74 years, and 2.7 % was between 75 and 79 years. Approximately all the studied subjects (99.0 %) were unemployed women.

Based on medical history, the prevalence of diabetes mellitus, epilepsy, and thyroid disorders were similar in the two groups. There was a positive history of chronic liver disease and chronic renal failure in 7 (0.6 %) and 16 (1.4 %) subjects of the exposed group. Nineteen of the poor women (1.7 %) and four non-exposed subjects (1.0 %) reported postmenopausal estrogen use ($p > 0.05$). But the exposed group reported higher calcium and vitamin D usage (5.6 % and 4.2 %, respectively) than the non-exposed group [(0.8 % and 0.7 %, respectively); $p < 0.0001$]. The self-reported history of hip fracture was more common among the poor women than the non-exposed group (2.5 % versus 0.6 %).

On average, the poor women smoked more daily than the non-exposed group (40.0 % versus 22.3 %; $p < 0.0001$), but there was no difference in past smoking history between the groups. Subjects in the non-exposed group were more obese than exposed subjects (32.9 % versus 17.8 %; $p < 0.0001$). The poor women had a higher rate of vigorous intensity and lower moderate intensity physical activities than the non-exposed group (Table 1).

BMDs at the lumbar spine and femoral neck were decreased progressively by increases in age ($p < 0.0001$). Significant differences between the poor women and the non-exposed subjects were observed in bone mineral densities at different sites ($P < 0.0001$). At all BMD sites, women under the absolute poverty line had the lowest mean BMD values (Table 1). According to the WHO criteria [21], 252 cases (22.4 %) and 35 controls (8.7 %) were considered osteoporotic (t-score ≤ –2.5; $p < 0.0001$).

At the femoral neck area, the prevalence of osteoporosis in poor women and non-exposed subjects in the five age groups (<60 years, 60–64 years, 65–69 years, 70–74 years, and 75–79 years) were (5.7 % *v* 2.6 %, 11.8 % *v* 2.7 %, 14.4 % *v* 6.7 %, 21.4 % *v* 8.1 % and 22.2 % *v* 0.0 %), respectively. At the lumbar area, the prevalence of osteoporosis in the poor women and non-exposed subjects in the above five age groups were (11.3 % *v* 4.1 %, 20.2 % *v* 8.1 %, 27.7 % *v* 8.9 %, 32.1 % *v* 18.9 %, and 28.6 % *v* 21.4 %), respectively.

Absolute poverty was associated with age-adjusted prevalence of femoral neck osteoporosis or lumbar osteoporosis in the studied subjects [OR = 2.88 (CI, 1.62–5.12; $p < 0.0001$); OR = 2.74 (CI, 1.80–4.18; $p < 0.0001$), respectively]. The results remained significant after adjustment for lifestyle factors for osteoporosis, including physical inactivity, obesity, current and/or present smoking, and age in logistic regression models; however, there was a slight change in the odds ratios [OR = 2.50 (CI, 1.38–4.51; $p = 0.002$) for femoral neck osteoporosis and OR = 2.40 (CI, 1.56–3.70; $p < 0.0001$) for lumbar osteoporosis] (Table 2).

Discussion

In this large study, lower BMDs at all skeletal sites were found among postmenopausal women under the absolute poverty line. The relationship of poverty to age-adjusted prevalence of osteoporosis after controlling for BMI, physical activity, and smoking was significant at all skeletal sites.

A few studies in the population have reported an association between low SES and increased hip fracture risk or lower bone density.[10–17] They assessed the extent of SES at the level of the individual by household income. Farahmand et al. categorized SES from data regarding occupation, education, the household's combined income, and housing.[10] Wang and Dixon for SES influences on bone health in postmenopausal women used the Poverty Income Ratio; the numerator was the midpoint of the observed family income category.[15]

We cannot understand connections between socioeconomic status and bone health until we have thought carefully about

Table 2. Multivariately odds ratios (OR) and 95 % confidence intervals (CI) relating osteoporosis at the femoral neck and lumbar area as dependent variables, and poverty and associated risk factors as independent parameters in the studied population.

	Femoral Neck			Lumbar area		
	OR[a]	CI	p value	OR[a]	CI	p value
Obesity	0.13	0.04–0.37	<0.0001	0.17	0.09–0.33	<0.0001
Physical inactivity	1.62	0.76–3.45	N.S	0.67	0.42–1.05	N.S
Smoking	1.23	0.81–1.86	N.S	1.07	0.78–1.46	N.S
Not taking calcium/vitamin D	1.67	0.47–5.94	N.S	0.75	0.21–2.62	N.S
Poverty	2.50	1.38–4.51	0.002	2.40	1.56–3.70	<0.0001

[a] The ORs of the relationship between osteoporosis (at femoral neck and lumbar areas) and poverty were adjusted for age and all the other reported variables.

and devised the best measures possible for poverty. Consistent with a clear consensus in the literature, it is argued that household income after taxes and transfers, appropriately adjusted to account for differences in family size and assigned to each individual within the family, is the best readily available measure of individual SES.[22] Limitations of this measure as a "true" measure of SES, however, are noted. For example, household income does not take into account the time required to earn income, and the measure does not pay attention to distribution within families or to wealth.[22] Thus, we used absolute poverty lines to measure SES in our population study.

Absolute poverty lines are a threshold below which households cannot maintain a minimum standard of living. With the exception of the USA, these thresholds are most often used in developing world contexts. In the developed world, relative income poverty lines are more often used to calculate poverty levels.[2] The idea that individuals are poor if they have insufficient income to purchase some "objective" minimum bundle of goods has a long history. In 1901, Rowntree classified families as poor if "their total earning is insufficient to obtain the minimum necessities for the maintenance of merely physical efficiency."[23] A major disadvantage of such measures is that it is extremely difficult to choose an objectively defined "minimum set of necessities," and that this minimum standard will necessarily change over time.[22]

The poverty threshold in Iran is usually determined by calculating the total cost of all essential goods that an average adult consumes in a year. This is needs-based in that an assessment is made of the minimum expenditure needed to maintain a tolerable life. A measure of absolute poverty quantifies the number of people below a poverty threshold that is independent of time and place. For the measure to be absolute, the line must be the same in different provinces. Measuring poverty by an absolute threshold has the advantage of applying the same standard across different locations and time periods, making comparisons easier. In 2005, the relative poverty threshold was 650,000 rials for urban areas and 514,000 rials for rural regions.[24]

Although up to 80 % of bone strength (including bone density and quality) might be genetically determined,[25] nutritional factors and the subject's physiological conditions – age and hormonal status – appear to be other important determinants of bone health.[16] Thus, osteoporosis risk is partially determined by the cumulative effects of unhealthy dietary and activity behaviors occurring throughout life; therefore, it is likely that adults of low socioeconomic position may be at increased osteoporosis risk because of inadequate nutrition during childhood, resulting in suboptimal achievement of peak bone mass earlier in life.[26,27] Concerning the background of poor nutritional status and low dietary intake of calcium, poverty appears to act as a trigger to shift the osteopenic T scores of postmenopausal women toward osteoporosis. In the present study, the prevalence of osteoporosis and osteopenia was very high in poor postmenopausal women, in comparison to postmenopausal women of the general population.

To our knowledge, the relationship between absolute poverty and bone mineral density and/or osteoporosis has not been investigated. The present study is the first large study on the relationship of absolute poverty and BMD. A few other studies have also concluded that SES is associated with bone health indicators.[10–17] Del Rio Barquero et al studied the bone mineral density of the lumbar spine in two healthy population groups in Spain with similar characteristics but with different socio-economic levels.[11] The researchers showed that most people at an advanced age from the low socio-economic group cross the fracture threshold earlier than the first group.[11] A multi-center, case control study of risk factors for low tibial speed of sound among residents of urban areas in Turkey suggested that SES was an important determinant of cortical bone status.[14] In the UK, a higher social deprivation score was associated with lower heel BMD in an older community population.[13] A population-based case-control study reported that low SES was a risk factor for hip fracture.[10]

Numerous studies have shown the close association between health education and poverty.[3] In a cohort of postmenopausal women, using the lowest educational level as the reference category, an increase in educational status was associated with a significantly reduced risk for osteoporosis.[8] Findings from the Third National Health and Nutrition Examination Survey, 1988–1994 (NHANES III) showed that education and/or income were positively associated with BMD among Black and White postmenopausal women.[15] Because education is defined as an important determinant of poverty, education was not included as an independent explanatory variable in our regression models. But higher education provides the literacy and social network helpful for improving health behaviors. The effects of SES on BMD are not independent of relevant education-based health behaviors (estrogen usage, pregnancy history, calcium intake, physical activity, and smoking).[15] Lower calcium and vitamin D use and higher smoking rates were more common among postmenopausal women in the absolute poverty group than the non-exposed subjects in our study. It is possible that education helps to improve knowledge about bone health behaviors. Therefore, provision of osteoporosis-related education is warranted for poor postmenopausal women.

Obesity, defined as body mass index (BMI) between 25 and 39.9 kg/m^2, has a protective effect on bone.[28] The positive effect of obesity on bone is multi-factorial, as it is associated

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not only with the mechanical load but also with the secretion of bone-active hormones from the pancreatic beta cell (insulin, amylin, and preptin), and the secretion of bone-active hormones such as estrogens and leptin from the adipocyte.[29] Recently, in a cross-sectional study, it was confirmed that BMI was positively correlated with bone density at all sites, and the prevalence of osteoporosis was lower in the obese group.[30] Contrasting studies, however, suggest that excessive fat mass may not protect against osteoporosis or osteoporotic fracture.[31] Based on the current state of knowledge, it is unclear whether fat has beneficial effects on bone.[32] In our study, postmenopausal women of the general population were more obese than women in the absolute poverty group, and obesity was negatively associated with osteoporosis at all sites. However, in multiple regression analysis, poverty showed a significant association with osteoporosis independent of obesity.

One limitation of our study is that we had no longitudinal data for computation of longer-term measures of SES on bone mineral density. However, bone density measurements made after menopause can be considered to reflect the cumulative effects of suboptimal bone mineral acquisition early in life and early onset or a rapid rate of bone loss later in life. The cross-sectional study design of our study did not allow us to examine the cumulative effects of SES and BMD over the course of the participants' lives. In terms of poverty status, longitudinal data allow us to calculate factors such as the total duration of poverty and the percentage of a child's life spent in poverty, in order to distinguish short spells of poverty from situations of chronic deprivation. Longitudinal data also permit us to trace movements in and out of poverty and the reasons for these changes.[22]

In conclusion, in this large study, we found that postmenopausal women under the absolute poverty lines had lower BMDs at all skeletal sites, independent of established osteoporosis risk factors, implying a need for greater efforts to promote bone health among these women. It may be possible to reduce fracture incidence through the early diagnosis of individuals at risk by such techniques as bone mineral density testing. Thus, a higher utilization rate of BMD testing by poor women who are at higher fracture risk is desirable. But, within the context of a publicly funded health-care system, significant inverse associations were demonstrated between SES and BMD utilization rates.[33]

Leslie and et al have shown that a multidimensional approach to hip fracture risk stratification is feasible, and greatly modifies risk stratification based on BMD alone.[34] They developed a mathematical model of absolute hip fracture risk that incorporates patient age, BMD, and the results of eleven specific clinical risk factors. These clinical risk factors may have implications for decisions in screening strategy in low-income populations when BMD testing is not available.

Clinical risk factors alone predicted hip fracture with a gradient of risk (GR) of 2.1/SD change in risk score at the age of 50 years and decreased with age. The use of BMD alone provided a higher GR (3.7/SD), and was improved further with the combined use of clinical risk factors and BMD (4.2/SD).[35] However, a cost-effectiveness analysis was performed using decision-tree analysis and a Markov model. The results of this model, under the assumptions described in the paper, suggested that in women aged 70–80 years, screening all women with dual-energy X-ray absorptiometry (DXA) would be more effective than no screening or screening only women with at least one risk factor.[6]

Income has been shown to affect treatment initiation after the detection of osteoporosis for previously unscreened, postmenopausal women.[36] These issues highlight the fact that bone health among poor women is multidimensional in its symptoms, multivariate in its causes, dynamic in its trajectory, and quite complex in its relation to poverty. Research that begins to answer such complex associations will be very important in helping us to understand how policy can help both to alleviate poverty and to ameliorate the negative consequences of poverty for bone health.

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