Osteoporosis and Associated Bone Fractures in a Japanese Population

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Along with the lengthening life span, maintaining good quality of life in the elderly is an important goal. We determined frequency and risk factors for osteoporosis and associated fractures among a Japanese cohort in Hiroshima and Nagasaki, known as the Adult Health Study (AHS). We found lower bone mass and a higher vertebral fracture prevalence among Japanese women, compared to women of Japanese descent living in Hawaii and American Caucasians. However, the incidence of vertebral fracture has decreased progressively among successive younger Japanese birth cohorts. These findings suggested that environmental factors probably play an important role on occurrence of osteoporosis and vertebral fracture.

Age, sex, weight, menstrual history, and calcium intake were associated with bone mass and vertebral fracture prevalence. From the AHS cohort study, age, body mass index, age at menarche, and number of children, milk intake, alcohol intake, and prevalent vertebral fracture were related to the risk of hip fracture. Risk factors for falls, such as alcohol consumption, may be responsible for occurrence of hip fracture in addition to the risk factors related to bone mass. Elucidating risk factors related to bone mass, bone quality, and falls may lead to new strategies for preventing osteoporosis and associated fractures. 

In Japan, the average life expectancy was approximately 83 years for women in 1995, which is the longest in the world. Along with the lengthening life span, maintaining good quality of life in postmenopausal and elderly women is an important goal. Osteoporosis is a common disease among the elderly, especially women, and is characterized by abnormal decreases in the amount and architectural arrangement of bone tissue, which lead to an increased susceptibility to fracture. Vertebral fractures often cause back pain and other health problems. Hip fractures cause profound physical impairment and a reduction in quality of life in the elderly. Therefore, osteoporosis and osteoporotic fractures are a major public health problem, and postmenopausal osteoporosis constitutes a major part of the problem.

At the Radiation Effects Research Foundation (RERF), a longitudinal study of a fixed population of Japanese, known as the Adult Health Study (AHS), has been in progress since 1958. Results of epidemiological studies on osteoporosis from the AHS sample are discussed here.

MATERIALS AND METHODS

The original AHS cohort of approximately 20,000 people was selected from residents in Hiroshima and Nagasaki, on the basis of the 1950 national census. The primary objective of the AHS was to study the late effects of exposure to atomic bomb radiation. AHS members have undergone biennial health examinations at the RERF outpatient clinic since 1958, involving medical history, general physical examination, blood tests, chest and spine X-rays, and measurements of height and weight. Those who cannot come for examination are visited by a physician at a hospital or home. Spinal bone mineral den-

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BMD was measured using dual photon absorptiometry (DPA) between 1989 and 1993. Beginning in 1994, the AHS participants have undergone spine and hip BMD measurements using dual X-ray absorptiometry (DXA, QDR-2000, Hologic) at the biennial examinations.

The participation rate for the AHS cohort has been around 71 to 86 percent throughout the examinations. Attrition due to death ranged from 2 to 5% and rates of migration out of the cities ranged between 9 and 13% at each examination cycle. Details concerning recruitment and examination of the AHS participants were reported previously 1).

RESULTS

1. Osteoporosis

(1) Prevalence of Osteoporosis

In 1994, an expert panel of the World Health Organization (WHO) proposed diagnostic criteria of osteoporosis and osteopenia based on BMD. BMD values of -2.5 standard deviations (SD) or less compared to the mean of young adult females are classified as osteoporosis, and BMD values between -1 SD and -2.5 SD are classified as osteopenia 2).

Using these criteria together with BMD reference data for young adults in Japan 3), the prevalence of osteoporosis is 30% of the AHS women aged 60-69 years old, and 40% of women aged 70-79 (Fig 1).

Applying these figures to the entire population of Japan, it was estimated that 25% of women ages 50 years or older have osteoporosis.

(2) Factors Affecting Bone Mass in a Cross-Sectional Study

In a cross-sectional study, the relationship between spinal BMD measured by the DXA machine and potential risk factors, such as age, dietary factors, weight, height, and reproductive history, were investigated among 550 women ages 48 years or older. Nutrition was assessed using food frequency questionnaires adapted to include foods considered to be major contributors to calcium intake in this population.

Bone mineral density was inversely associated with age, decreasing 3% with every additional 5 years of age. Duration between menarche and menopause was positively related to BMD. A 5-year increase in duration of menstruating was associated with a 3.5% increase in BMD. Irregularity of menstruation cycle, and months of lactation were not associated with BMD. Weight was strongly related to BMD. An additional 5 kg in weight was associated with a 5% increase in BMD; however, this effect leveled off at heavier weights. Dietary calcium intake was marginally related to BMD, increasing 0.5% with each increase of 100 mg in daily calcium intake.

2. Vertebral Fractures

Vertebral fractures are the most common of osteoporotic fractures, but few epidemiological studies of vertebral fracture are available. Most vertebral fractures occur in the absence of specific trauma, and are often asymptomatic, or have mild symptoms, so that only about one-third of all patients with vertebral fractures visit a clinic or hospital. Therefore, radiological screening is necessary to determine the prevalence and incidence of vertebral fracture. In addition, lack of consensus about diagnostic criteria for vertebral fracture has made comparisons between epidemiological studies difficult.

(1) Incidence of Vertebral Fracture

The AHS participants have received a postero-anterior and lateral chest X-ray examination every 2 years since 1958. The diagnosis of vertebral fracture was based on the reading of X-ray images by radiologists.

The incidence of thoracic vertebral fractures was determined among the 14,607 eligible AHS subjects, after excluding subjects who had thoracic vertebral fracture at their initial examinations or who had been examined only once from 1958 to 1986.

Thoracic vertebral fracture incidence declined by a factor of 0.5 in men and 0.6 in women with each succeeding decade in the year of birth (Fig 2) 4). Among women, the incidence increased by a factor of 1.7 with each 10 year increase in age.

(2) International Comparison on Vertebral Fracture Prevalence

Geographic comparisons of disease frequency can provide major insights into disease etiology. Comparing migrants to native populations provides a unique opportunity to examine the effects of environmental factors. However, there are few comparative studies of vertebral fracture prevalence using standardized criteria.

We compared prevalence of vertebral fractures among Japanese women, women of Japanese descent living in Hawaii.
(Japanese-Americans), and North-American Caucasians using standardized objective criteria.

Spinal radiographs of women ages 50 years and older were obtained from the AHS women in Hiroshima, Japanese-Americans from the participants of the Hawaii Osteoporosis Study, and Caucasian participants of the Rochester Epidemiology Project in Minnesota. Fractures were defined as vertebral height more than three standard deviations (SD) below the vertebra-specific mean. Compared to Japanese-Americans, the prevalence of vertebral fracture is greatest among Japanese; odds ratios were 1.8 for Japanese women and 1.5 for American Caucasians (Fig 3).

(3) Risk Factors

To explore factors related to the prevalence of vertebral fracture in Japanese and Japanese-Americans, BMD and potential risk factors were compared. Age-specific BMD was higher among Japanese-Americans than Japanese. Height, weight, age at menarche and natural menopause, lactation period, and rates of cigarette smoking also differed between the two populations. The magnitudes of differences in risk factors between these two populations sometimes varied by birth cohort.

Among the factors evaluated, BMD and age at menopause (or years between menarche and menopause) were associated with age-adjusted prevalence of vertebral fracture in Japanese and Japanese-Americans. The observed difference in prevalence of vertebral fracture between the two populations was accounted for primarily by the differences in BMD and age at menopause (or years of menstruation). These findings suggest that age and menstrual history may play important roles in spine fracture independent of BMD. Age and menstrual history might affect not only bone mass but also bone quality.

3. Risk Factors of Hip Fracture in a Cohort Study

Hip fracture risk factors were examined in the 4573 eligible AHS subjects who had no previous hip fracture, who responded to a questionnaire survey, and who undertook the AHS examination in the 1978-1980 examination cycle. During the follow-up period from 1978 to 1992, 55 subjects had hip fracture not due to traffic accident, major injury, or pathological causes.

The risk of hip fracture significantly increased with decreases in body mass index (BMI). Women who drank alcohol regularly had a risk twice as high as non-drinkers. Drinking milk almost every day was protective against hip fracture. Women who had a history of vertebral fracture had a risk 2 times higher than those without vertebral fractures. The risk was higher among women whose age at menarche was 17 or higher or women who had five or more children. No relationship was observed between fracture risk and body height, intake of coffee, tea, Japanese tea, and smoking. The risk of fracture increased with the number of risk factors; women with four or more risk factors had 8 times higher risk than those with one or no risk factor.

We concluded that several factors, such as BMI, intake of milk, alcohol consumption, prevalence of vertebral fracture, age at menarche, and number of children were related to the risk of hip fracture, and women with multiple risk factors are at high risk. Lifestyle factors such as calcium intake and lower alcohol consumption may help prevent hip fractures in a Japanese population.

DISCUSSION

We determined the frequency and risk factors of osteoporosis and associated bone fractures among a Japanese cohort in Hiroshima and Nagasaki, known as the Adult Health Study
(AHS). We found lower bone mass and a higher prevalence of vertebral fracture among Japanese women, as compared to women of Japanese descent living in Hawaii (Japanese-Americans) and American Caucasians. However, the incidence of vertebral fracture has decreased progressively among successive Japanese birth cohorts, so that Japanese born in later years currently have a lower risk than previous Japanese generations had when they were of similar age. These findings suggested that environmental factors probably play an important role on occurrence of osteoporosis and vertebral fracture.

The decreasing incidence of vertebral fracture among the Japanese population may reflect dietary improvements, changes in physical stature, and hormonal conditions of the Japanese people. According to the National Nutrition Survey by the Ministry of Health and Welfare, daily calcium intake per person has increased from 270 mg in 1950 to 540 mg in 1993. The physical stature of Japanese has also increased. In the AHS women, height increased 2.5 cm and weight increased 1.6 kg with each succeeding decade in birth cohort. In addition, the hormonal profile of Japanese women has changed. More recent birth cohorts of the AHS experience menarche 0.5 years earlier and natural menopause 1.0 year later.

Japanese have gradually adopted a more westernized diet in the past 40 years. However, despite increasing intake of fat and protein in Japanese, dietary levels were still lower than those of Japanese-Americans. In addition, current and past differences between Japanese and Japanese-Americans have been reported for dietary calcium and vitamin D intake and supplement use. Other factors such as sunlight exposure, medication, and physical activity may also contribute to differences in bone mass and prevalence of vertebral fractures between Japanese and Japanese-Americans.

In spite of low bone mass and higher vertebral fracture prevalence among Japanese compared to Japanese-Americans and Caucasians, the incidence of hip fracture was similar among Japanese and Japanese-Americans, but only about one-half of that in Caucasians in America and Europe. In contrast to the decreasing incidence of vertebral fracture, the incidence of hip fracture in Japan has been reported to increase in recent years. These results suggest that different risk factors might contribute to the occurrence of vertebral fracture and hip fracture.

Although vertebral fractures are rarely associated with a specific episode of external trauma, hip fractures primarily result from the interaction between injury, usually a fall, and bone strength. Thus, risk factors for falls play an important role in the etiology of hip fracture. From the AHS cohort study, age, body mass index, milk intake, alcohol consumption, prevalence of vertebral fracture, age at menarche, and number of children were related to the risk of hip fracture. Among these factors, habitual alcohol consumption may increase the risk of hip fracture by increasing the risk of falls.

Additional comparisons of Japanese and migrant Japanese to each other, and to Caucasian populations, may help elucidate risk or preventive factors related to bone mass, bone quality, and falls. Such studies may lead to new strategies for preventing osteoporosis and associated bone fractures.

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