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Improved femoral neck BMD in older Finnish women between 2002 and 2010

Kirsti Uusi-Rasi[a,*], Saija Karinkanta[a], Ari Heinonen[b], Harri Sievänen[a]

[a] The UKK Institute for Health Promotion Research, P.O. Box 30, FI-33501 Tampere, Finland
[b] Department of Health Sciences, University of Jyväskylä, P.O. Box 35 (L), Jyvaskyla FI-40014, Finland

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ABSTRACT

Purpose: The number of hip fractures among Finns over 50-years of age rose constantly between 1970 and 1997, but since then, there has been a nationwide decline in incidence of hip fractures. One possible explanation, although not the only one, for the declining fracture rates, could be improved bone mineral density (BMD). The aim of this study was to evaluate differences in femoral neck BMD between older Finnish women born about a decade apart.

Methods: We compared the baseline data of two population-based samples of home-dwelling 70–80-year-old women who were initially recruited in exercise intervention studies ($N = 216$ in Cohort1, and $N = 389$ in Cohort 2). Femoral neck BMD was measured with DXA. Between-cohort differences were evaluated with analysis of covariance using age, height, weight, and use of hormone therapy as covariates.

Results: The later-born Cohort 2 was somewhat older and taller than Cohort 1. Adjusted mean difference (95% CI) in femoral neck BMD between the cohorts was 0.043 g/cm^2 (0.023–0.064) corresponding the mean difference of 0.36 (0.19–0.53) in *T*-score in favor of Cohort 2.

Conclusions: Despite several factors that basically could have indicated lower mean BMD in Cohort 2, the finding was the opposite. This suggests that the mean femoral neck BMD has increased substantially among older Finnish women within a decade, but primary reason for this improvement remains unclear, but improved social and economic resources may have at least partly accounted for this favorable phenomenon.

1. Introduction

Hip fractures in elderly people are a worldwide concern. While the number of hip fractures has increased in many countries in conjunction with aging of the population, declined incidence in hip fractures has recently been observed in national and community-based studies [1–4] including Finland. The number of hip fractures among Finns over 50-years of age rose constantly between 1970 and 1997, but since then, there has been a nationwide decline in incidence of hip fractures [5,6].

One possible explanation for the generally declining fracture rates could be improved bone mineral density (BMD), since the risk of fragility fractures increases with decreasing BMD. However, there is so far little evidence about secular improvements in BMD. Recently Looker et al. reported positive changes in BMD measured with dual energy X-ray absorptiometry (DXA) in older white women in NHANES cohorts from 1988–1994 to 2005–2008 [7], which is in line with declined prevalence of femoral neck osteoporosis [8]. In contrast, the prevalence of distal radius osteoporosis has not reduced in three cohorts of Swedish postmenopausal women measured with single photon absorptiometry in 1970–1974, 1987–1993, and 1998–1999 [9].

While low BMD should not be underestimated as a risk factor for fragility fractures, there are several other factors which are related to bone health. In fact, most non-vertebral fractures occur in individuals who are not diagnosed as osteoporotic by BMD criteria [10,11]. Although individual peak bone mass is under genetic control, it can be influenced by environmental factors, such as physical activity, nutrition, or diseases in different phases of life [12], or geographical factors [13]. The human skeleton needs mechanical loading throughout the life to remain viable. The capacity of the bones to adapt to loading or physical activity is substantially different between childhood and adulthood, and the effect of physical activity on bone size is generally less effective once axial growth has ceased [14]. Bone accrual and maintenance requires also sufficient amounts of many essential nutrients, of which sufficient calcium intake is an essential component of any preventive regimen, besides vitamin D. In fact, the first year of life may be crucial in terms of peak bone mass and proximal femur fragility later in life [15,16]. This being the apparent case, the conditions prevalent during postnatal and pubertal growth spurt may contribute to adult bone phenotype.

* Corresponding author. Tel.: +358 3 282 9111; fax: +358 3 282 9200.
E-mail addresses: kirsti.uusi-rasi@uta.fi (K. Uusi-Rasi), saija.karinkanta@uta.fi (S. Karinkanta), ari.o.heinonen@jyu.fi (A. Heinonen), harri.sievanen@uta.fi (H. Sievänen).

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The aim of this study was to compare femoral neck BMD of 70–80-year-old Finnish women between two cohorts measured eight years apart, collected in 2002 and 2010.

2. Methods

2.1. Subjects

We compared the baseline data of two population-based cohorts of home-dwelling women, who were initially recruited in exercise intervention studies [17,18]. The study protocol of both trials has been approved by the Ethics Committee of the Tampere University Hospital, Tampere, Finland. Each participant gave her written informed consent prior to baseline measurements.

The first study cohort (Cohort 1) was a random population-based sample of 70–80-year-old women (born from 1922 to 1932) living in the city of Tampere in 2002, Finland, and 216 of 4032 women had a screening examination with DXA. Sixty seven of them were excluded from the exercise trial [17] due to low femoral neck BMD (T-score < −2.5 indicating osteoporosis) or other reasons related to deteriorated health, but they were included in this analysis.

The second study cohort (Cohort 2) was a random population-based sample of all 70–80-year-old women (born from 1930 to 1940) living in the city of Tampere in 2010, and 409 of 9370 women were included in the trial [18]. Nine women were excluded due to bilateral hip prosthesis, and 11 women due to overlapping of the cohorts (already included in Cohort 1), leaving 390 women with DXA-measured femoral neck BMD for the present analyses.

A pre-screening *Health history questionnaire* (information of self-reported health, injuries, medication, diseases, and life style factors such as diet, physical activity, smoking and consumption of alcohol) was gathered in both cohorts.

In addition to age range from 70–80 years, the inclusion criteria in both studies were moderate to vigorous exercise no more than twice a week and no contraindication to supervised exercise. However, the exercise programme (except 'program' in computers) for the Cohort 1 included jumping exercise and was rather demanding, while in the Cohort 2 the exercise was balance and resistance training with less strict exclusion criteria. In addition, the women in the Cohort 2 had to be fallen at least once during the previous year, while the Cohort 1 did not have this criterion.

2.2. Bone densitometry

Femoral neck BMD was measured with DXA in both cohorts according to our standard procedures. For the Cohort 1, BMD was assessed with Norland device (Norland XR-26, Norland Inc., Fort Atkinson, WI, USA), and for the Cohort 2 with Lunar device (Lunar Prodigy Advance, GE Lunar, Madison, WI, USA). Precision of femoral neck BMD measurements was 0.5% and 1.4%, respectively. For cross-calibration, femoral necks of 50 volunteer postmenopausal women were measured with both devices and a linear regression analysis was used to convert Norland BMD values to Lunar BMD values as follows: $\text{fnBMD}_{\text{Lunar}} = 0.972 \times \text{fnBMD}_{\text{Norland}} + 0.098$ (r = 0.981, SEE 0.031). The femoral neck BMD values were also expressed in T-scores using the reference data of the Lunar device.

2.3. Statistical analysis

Means and standard deviations (SD) were used as descriptive statistics. Between-cohort differences were evaluated with analysis of covariance (ANCOVA). Since 17.2% of women in the Cohort 2 used hormone replacement therapy, this was used as a covariate in addition to age, height and weight.

Table 1
Clinical characteristics (mean, sd) of the study cohorts.

	Cohort 1, year 2002 N = 216	Cohort 2, year 2010 N = 390
Age, y	73.0 (2.5)	74.2 (3.0)
Height, cm	159.0 (5.5)	159.8 (5.7)
Weight, kg	70.2 (10.6)	72.1 (11.7)
BMI	27.8 (3.9)	28.3 (4.5)
Femoral neck BMD, g/cm^2	0.804 (0.125)	0.852 (0.123)
T-score	−1.46 (1.04)	−1.05 (1.02)
Number of delivery, if any	2.34 (1.15), n = 173	2.33 (1.04), n = 314
Nulliparous, n (%)	43 (19.9%)	46 (11.8%)
Diagnosed OP, n (%)	56 (25.9%)	2 (0.5%)
No diagnosed disease, n (%)	47 (21.8%)	49 (12.6%)
Age at menopause, y	49.7 (4.5)	49.4 (4.9)
Use of HRT, n (%)		
Never or canceled	216 (100%)	321 (82.3%)
Current	–	69 (17.7%)
Regular use of calcium, n (%) supplements	46 (21.3%)	40 (10.3%)
Regular use of vitamin D, n (%) supplements	27 (12.5%)	27 (6.9%)
Calcium intake, mg/d	931 (318)	1126 (428)
Education, n (%)		
Basic	92 (42.6%)	130 (33.4%)
Vocational	110 (51%)	215 (55%)
University degree	14 (6.5%)	45 (11.4%)
Smoking, n (%)		
Never	182 (84.3%)	314 (80.5%)
Canceled	26 (12.0%)	63 (16.7%)
Current	8 (3.7%)	13 (3.3%)

Since the inclusion criteria for the Cohort 1 were stricter, we did also a subgroup analysis and excluded from the Cohort 2 all women, altogether 200, who most likely had not been eligible to Cohort 1 due to declined functional ability, such as knee or hip prosthesis, severe arthritis in the lower limbs or vertebrae, or severe cardiovascular symptoms.

3. Results

Characteristics of the study cohorts are shown in Table 1. The later-born Cohort 2 was somewhat older and taller than Cohort 1. Also their mean body mass index was slightly greater.

Mean age at menopause was similar in both cohorts being 49.7 (4.6) years. In both cohorts, about one half of the women had vocational education, but the Cohort 1 included more women with only basic education and fewer women with university degree than Cohort 2 (Table 1). More women in the Cohort 1 were nulliparous, but there was no difference in the number of deliveries between parous women. The Cohort 1 appeared to be healthier, as approximately one fifth (22%) of them had no diagnosed disease in contrast to 13% in the Cohort 2. Use of vitamin D supplements was not common in either of the cohorts, 27 (12.5%) women in the Cohort 1 reported regular use of supplements, while in the Cohort 2 only 7% (26 women) used supplement. Use of calcium supplements was twice as common in Cohort 1 as in Cohort 2.

Smoking was rare in both cohorts. Only about 3% of women were current smokers in both cohorts. Also the use of alcohol was generally low, about 20% being teetotallers, 16% of those who used alcohol reported the use of wine or beer two to three times a week, and the rest of women few times a year.

Adjusted mean difference (95% CI) in femoral neck BMD between the cohorts was 0.041 (0.021–0.061) g/cm^2 corresponding the mean difference of 0.34 (0.18–0.51) in T-score in favor of the Cohort 2 (Fig. 1). One quarter (25.9%) of women in the Cohort 1