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Influence of calcium intake on bone mineral density and incidence of fractures in treatment-naive women from Lodz urban area – a part of EPOLOS study

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Abstract

Introduction. Inadequate calcium intake is a recognized osteoporosis risk factor. The aim of the study was to estimate calcium intake in women in the Łódź population, the influence of calcium intake on bone mineral density (BMD) and fracture incidence, as well as the relationship between calcium intake and age.

Material and methods. This cross-sectional investigation is a part of the EPOLOS study (a multicentre, population-based study on osteoporosis risk factors in Poland). In this study, 277 women from the Lodz urban area were involved [aged 20–80 years, not treated for osteoporosis before]. BMD was measured by dual-energy X-ray absorptiometry (DXA) in the lumbar spine and femoral neck. Fractures were self-reported and calcium intake was calculated according to data gathered in a questionnaire.

Results. An average daily calcium intake was 797±432 mg. 65.7% of the examined women took less calcium than 1,000 mg/daily. Daily calcium intake decreased with age – from 903 mg between 20–30 years of age, to 624 mg between the ages of 70–80. In women aged 50 and older, the prevalence of low BMD at the lumbar spine (T-score <–1.0) was 31.9%. Patients reported 75 low-trauma fractures. There was a weak negative correlation between age and calcium intake, and no correlation between BMD and calcium intake. Women with fractures were significantly older than women without fractures, had significantly lower BMD, and similar levels of calcium intake.

Conclusions. 1) Calcium intake below the recommended dietary intake was found in the majority of examined women. 2) No correlation between calcium intake and BMD, and between calcium intake and fracture incidence may suggest the involvement of factors other than calcium intake in pathogenesis of osteoporosis development. 3) Calcium intake gradually diminished with the age of the women.

Key words

Calcium intake, osteoporosis, fractures

INTRODUCTION

Calcium is an important mineral component of human diet. The prevalent part of calcium is located in the skeleton, while only 1–2% of calcium is present in soft tissues. Serum calcium concentrations are closely regulated within a narrow physiological range [1]. It is believed that low calcium intake may result in secondary hyperparathyroidism and lead to numerous clinical implications, both in children and adults, including rickets and low peak bone mass [2]. Low calcium intake is a recognized risk factor for postmenopausal and senile osteoporosis; therefore, an increased daily calcium intake is recommended for the prophylaxis of fractures [3]. The recommended calcium intake varies according to age, i.e., for young adults – 1,000 mg/daily, while for postmenopausal women and men over 65 years of age, it should be approximately 1,300 mg [4].

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Since epidemiological data affecting dietary calcium intake are scant, this cross-sectional epidemiological study has been conducted to estimate: 1) calcium intake in women in the population of an urban area; 2) the influence of calcium intake on bone mineral density (BMD) and fracture incidence; 3) the relationship between calcium intake and age.

MATERIALS AND METHOD

The EPOLOS was a Polish multicentre, population-based cross-sectional study on osteoporosis. Invitations to participate in the study were sent to people aged between 20–80 years of age, randomly selected on the basis of their personal identity number (PESEL). Exclusion criteria were as follows: personal history of osteoporosis, pregnancy, cancer, fracture during the previous year, and being overweight (>100 kg). The study was approved by the Ethics Committee of The Children's Memorial Health Institute. Participants signed informed consent to participate in the study. The study involved 277 women from region, aged 20–80 years. The subjects were divided into 6 groups: 20–30 years old (n=28),

31–40 years old (n=43), 41–50 years old (n=60), 51–60 years old (n= 65), 61–70 years old (n=52) and 71–80 years old (n=29). 128 of the investigated women were prior to menopause and 149 were postmenopausal. Physical examination was carefully performed. Body height (cm) and weight (kg) were checked, an epidemiological questionnaire completed, and bone mineral density of the lumbar spine and femoral neck measured using a DXA (dual-energy X-ray absorptiometry, Expert, GE) by 2 technicians. DXA results were presented according to the International Society of Clinical Densitometry (ISCD) positions [5]. In postmenopausal women over 50 years old, osteoporosis was diagnosed when the T-score was less than –2.5 SD, when the T-score was between –1 and –2.5 osteopenia, or low bone density was diagnosed, and normal bone density was diagnosed when the T-score was higher than –1.0. For premenopausal women, a Z-score was applied in which a Z-score of –2.0 or lower was defined as 'below the expected range for age'.

In order to ascertain dietary calcium intake, a self-reported questionnaire was used. This validated questionnaire allows estimation of the dietary calcium intake on the basis of calcium contents in 20 different types of food, and the frequency of eating [6].

All calculations were made using STATISTICA PL 5.5 software. Results were presented as means±standard deviation (SD). Normality of data distribution was tested using Kołmogorow-Smirnow`s and Lillieforse`s tests. Pearson's correlation and multiple regression analysis were used to evaluate relationships and dependencies between calcium intake, BMD and age. Student`s t-test was used for comparison between groups with and without fractures. The results were considered significant for $p<0.05$.

RESULTS

Characteristics of examined population are presented in Table 1. DXA analysis was performed according ISCD positions [5]. 31.9% postmenopausal women at the age of 50 years and older had low BMD of the lumbar spine (18.8% – osteopenia and 13.1% – osteoporosis). 25.7% women aged 50 and older had low BMD in the femoral neck (21.9% – osteopenia and 3.1% – osteoporosis). The majority of women aged less than 50 had normal BMD (their Z-score was higher than –2SD) (Fig. 1; Tab.2). Patients reported 75 low-trauma fractures, located in the spine (6 fractures), hip and pelvis (3), forearm (30), arm and clavicle (11), ribs (2) and lower extremities (23) – 52 women sustained fractures. Calcium consumption varied from 128 – 1970 mg daily, with an average calcium intake of 798±432 mg (Tab. 3). 65.7% of the examined women took less than 1,000 mg/daily. In the group of women aged 20–30, the daily calcium intake was 903 mg; in 31–40 age group – 895 mg; in the 41–50 age group – 800 mg, in the 51–60 age group – 828 mg, in the 61–70 age group – 717 mg, in the 71–80 age group – 624 mg (Fig. 2). Only 17% of the investigated women were taking calcium supplements, most commonly in older groups (Tab. 3). There was a negative correlation between age and calcium intake ($r=-0.18$; $p<0.01$) (Fig. 3) and between age and femoral neck BMD ($r=-0.36$; $p<0.05$). Correlations between calcium intake and BMD of the femoral neck and between calcium intake and BMD of the lumbar spine (Fig. 4) were weak and statistically insignificant ($r=0.85$ and $r=0.109$, respectively; $p=0.9$).

Table 1. Characteristics of examined groups.

Age	No. of women	BMI [kg/m²]	Fractures
20–30	28	21.43±3.12	1
31–40	43	24.08±4.34	3
41–50	60	25.17±3.68	14
51–60	65	27.10±4.6	19
61–70	52	27.39±4.14	20
71–80	29	27.46±4.57	18
Total	277	25.73±4.07	75

BMI – body mass index. Results shown as mean±SD.

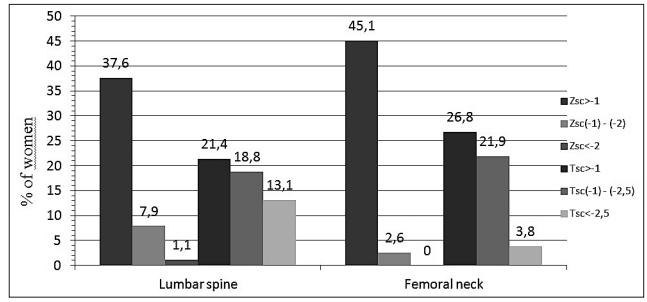

Figure 1. Bone mineral density (BMD) in lumbar spine and femoral neck. BMD was shown as Tsc in women aged 50 yrs and older, while in women below 50 yrs old – as Zsc

Table 2. Bone mineral density of hip and spine in age groups

Age	Hip BMD [g/cm²]	Hip T-score	Hip Z-score	Spine BMD [g/cm²]	Spine T-score	Spine Z-score
20–30	1.04±0.11	0.71±1.1	0.61±1.11	1.18±0.15	-0.18±1.28	-0.18±1.29
31–40	1.05±0.14	0.47±1.08	0.56±1.09	1.25±0.14	0.43±1.17	0.43±1.17
41–50	1.03±0.12	0.22±0.98	0.54±0.99	1.19±0.13	-0.1±1.05	0.05±1.04
51–60	0.98±0.13	-0.43±1.05	0.39±1,05	1.07±0.18	-1.1±1.54	-0.21±1.56
61–70	0.91±0.14	-1.17±1.0	0.20±0.99	1.00±0.18	-1.68±1.48	0.04±1.47
71–80	0.88±0.15	-1.42±1.02	0.29±0.98	1.03±0.19	-1.44±1.6	0.54±1.6
Total	0.98±0.13	-0.27±1,26	0.43±1.03	1.12±0.19	-0.18±1.55	0.07±1.38

BMD – bone mineral density. Results shown as mean±SD.

Table 3. Calcium intake in particular age groups

Age Group	Mean daily calcium intake [mg]	No. of women taking calcium suplements	% of women with low calcium intake
20-30	903.0±477.43	8/28 (28.6%)	60.7% <1,000 mg Ca/24 h
30-40	894.5±364.1	1/43 (2.3%)	69.7% <1,000 mg Ca/24 h
40-50	800.0±377.68	8/60 (13.3%)	75% <1,000 mg Ca/24 h
50-60	828.4±468.25	13/65 (20%)	69.2%
60-70	716.7±345.53	9/52 (17.3%)	77% <1,000 mg Ca/24 h 0% >1,300 mg Ca/24 h
70-80	624.3±338.64	8/29 (27.6%)	83.3% <1,000 mg Ca/24 h 3.49% >1,300 mg Ca/24 h
Total	797.7±394.83	47/277 (17%)	65.7% <1,000 mg Ca/24 h

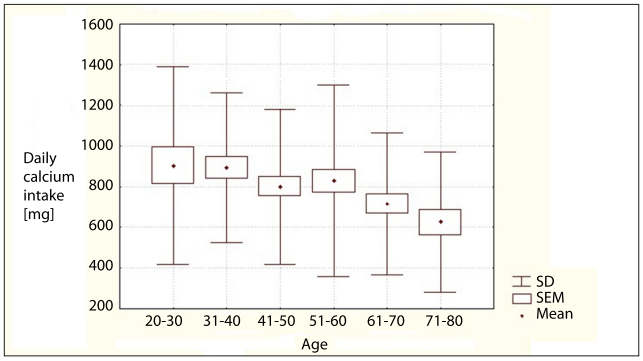

Figure 2. Calcium intake according to age; differences not statistically significant

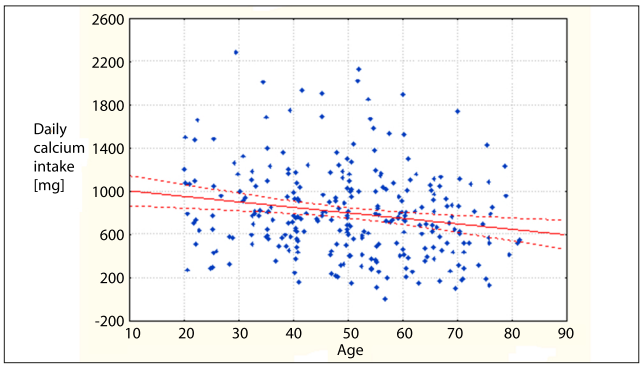

Figure 3. Negative correlation between age and calcium intake (r=-0.18, p<0.05)

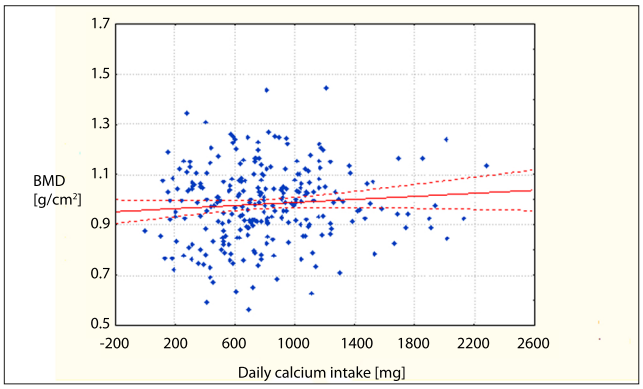

Figure 4. Correlation between calcium intake and BMD of femoral neck was weak and not statistically significant (r=0.85, NS)

In multiple regression analysis, the influence of age and calcium intake on hip BMD was analyzed. It was found that age was the only factor significantly influencing hip BMD; there was no influence of calcium intake on hip BMD (model R: 0.57; p<0.0001; for age β=–0.57; p<0.001 and for calcium intake β=–0.002; p=0.97). When analysis was carried out separately for pre- and postmenopausal women, age significantly influenced hip BMD in postmenopausal women (model R: 0.42; p<0.0001, for age β=–0.42; p<0.0001; for calcium intake β=–0.02; p=n.s.) but not in premenopausal women (model R: 0.18; N.S., for age β=–0.18; p<0.05, for calcium intake β=–0.0; p=n.s).

Calcium intake in the group with fractures (767 mg±497 mg) was lower than in the group without fractures (805 mg±388 mg), although the difference was insignificant (p =0.54). Women with fractures were significantly older and had lower BMD, both in the femoral neck and the lumbar spine (Tab. 4).

Table 4. Comparison of women with and without fractures

	With fractures	Without fractures	p
No. of women	52	225	-
Ca intake [mg/daily]	804.8±388.2	766.7±496.8	0.54
Femoral neck BMD [g/cm²]	0.88±0.12	0.96±0.15	p<0.001
L2-L4 BMD [g/cm²]	1.05±0.17	1.13±0.19	p<0.01
Age [years]	58.4±12.9	48.5±14.7	p<0.001

DISCUSSION

The results of the presented study confirm the low calcium intake in the Polish population. Earlier, chronic dietary calcium deficiency was found in 51% of children, and chronic deficiency in vitamin D supply in 99% of children [7]. Investigations carried out between 1975–1987 showed low calcium intake in 6.2% – 50% of women and in 14 – 37.4% of men [8, 9]. In the HAPIEE study (Health, Alcohol and Psychosocial factors In Eastern Europe), only 59% of men and 64% of Polish women aged 45-69 years, declared a calcium intake of more than 700 mg/d [10]. In a recently published RAC-OST-POL study, calcium deficiency in diet was also shown [11]. These results confirm dietary calcium deficiency in the population of Polish adults, the phenomenon which has also been demonstrated in the presented study. This shows that the mean calcium intake was 798 mg/d, and more than 65% had a calcium intake lower than 1,000 mg/d. Also, taking calcium supplements was not able to equalize calcium requirements; only 17% of investigated women were taking calcium supplements, compared to 37.2% in other European countries [12]. The phenomenon of dietary calcium deficiency is widespread and has been observed in the USA [13, 14] and Europe [10, 12, 15]. The highest level of daily calcium intake was found in Denmark (1,145.6 mg/d) and the lowest in Hungary (586.7 mg/d) [12]. In the quoted research [12], the mean calcium intake in Polish women was only 694 mg/d, but – in contrast to the presented data – dietary calcium was investigated in other group of subjects, namely in older women with osteoporosis prior to their inclusion into the trial investigating the anti-fracture efficacy of a new anti-osteoporotic drug [12].

In the presented study, calcium intake in the investigated group was age-related. Accordingly, the oldest group of women was characterized by the lowest calcium intake (mean 624 mg/d, and less than 4% of women aged over 60 had sufficient calcium intake). This deficit could be regarded as severe, because in that age group the recommended dose of calcium should be the highest. The presented findings on the relationship between age and calcium intake have been supported by others [14, 15], and may result from greater awareness of osteoporosis risk among younger patients [16].

However, no correlation was found between calcium consumption and BMD, either in analysis of cortical bone (represented by the femoral neck), or in trabecular bone (represented by the lumbar spine). Moreover, a statistically insignificant lower calcium intake was shown in the group with fractures than that in group without fractures (767 vs. 805 mg/daily). These results are in contrast to the RAC-OST-POL study [11], in which low calcium consumption was also shown, but a relationship between calcium intake and low BMD and fractures was found. However, in the presented study, calcium intake was almost twice as high when assessed in comparison to the RAC-OST-POL study

(767 vs. 336 mg/daily in a group with previous fractures and 805 vs. 395 mg/daily in a group without fractures), which may depend on the application of a different questionnaire or the existence of real differences in calcium intake. The age of the investigated group (20–80 years in the EPOLOS study and over 55 years in the RAC-OST-POL study) may also affect the results obtained. In the presented study, low BMD – both in the femoral neck and the lumbar spine, as well as age – were much stronger factors influencing fractures than low calcium intake. However, another explanation is also possible; namely, that calcium intake is not influenced by fracture occurrence, since the patients studied here experienced fractures before enrollment into the study, and past history of fracture did not affect their nutritional habits.

Data on the influence of calcium consumption on BMD and on fracture occurrence in adults are inconsistent. It was shown that calcium intake diminished the rate of bone loss in postmenopausal women [17], and caused reduction of vertebral fractures [18] and hip fractures [19]. Other researchers, however, did not observe any beneficial effect of calcium intake on BMD [15, 18], or on non-vertebral fractures [13, 18]. In some studies, even increased risk of hip and vertebral fractures have been shown [20, 21]. The explanation for those discrepancies included racial and population-related differences. The population investigated by in the presented study comprised pre- and postmenopausal women, with normal or only slightly decreased BMD. It was also noted that numerous observations of the positive calcium effects on BMD were derived from analysis of known osteoporotic subjects [12] (i.e., of a different type of population than that investigated here). There were also methodological differences, e.g. details of dietary questionnaires, self-reported nature of data, various sources of calcium and the suggested non-linear dependency between fracture risk and dietary calcium [17, 21, 22]. Moreover, many dietary factors other than calcium (i.e., vitamin D, protein, phosphates, magnesium) and non-dietary factors (e.g. falls) are suggested to influence the BMD and fracture risk [22].

The limitations of the presented study include the self-reporting nature of fracture incidence, especially important in case of vertebral fractures, because only approximately 1/3 of vertebral fractures are clinically determined [23], moderate population size and lack of routine assessment of vitamin D concentration. The latter issue is a very valid point, since the Polish population is vitamin D-deficient [7]. The design of the study, however, reflects standard clinical practice in Poland during the period of data collection.

Despite the above-mentioned drawbacks, emphasis must be placed on the strength of the project: a quite wide range of subject population through the system of random recruitment. In that way, a population of individuals was obtained who considered themselves to be entirely healthy prior to the study. Therefore, the design of the presented study reflected what might be encountered if population-based preventive measures are undertaken, as it was directed towards a presumably healthy (and treatment-naive) population, rather than towards patients already attending osteoporosis clinics.

CONCLUSIONS

1. Calcium intake below the recommended dietary intake was found in the majority of examined women.
2. No correlation between calcium intake and BMD and between calcium intake and fracture incidence may suggest an involvement of additional factors, other than calcium intake, in pathogenesis of osteoporosis development.
3. Calcium intake gradually diminished with the age of the women.

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