Milk consumption and bone mineral density in middle aged and elderly women

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Abstract

Objectives—To study the effects of historical milk consumption on current bone mineral density at the hip and spine.

Design—Cross sectional study.

Subjects—284 community based women aged 44–74 years recruited from four general practice age-sex registers in Cambridge. Subjects categorised their average milk consumption up to age 25, from age 25–44, and from age 44 to the present time as ≥ 1 glass/day, < 1 glass/day but > 1 glass/week, or < 1 glass/week.

Main outcome measures—Bone mineral density at the hip and spine measured by dual energy x ray absorptiometry.

Results—Data on milk consumption up to age 25 years were available for 252 women. There was a consistent upward trend in bone mineral density at all sites with increasing historical milk consumption (total hip, femoral neck, trochanter, intertrochanter, $P < 0.05$; Ward's triangle, $P = 0.005$). Adjustment for age and body size did not alter these trends. Milk consumption up to age 25 was a significant independent predictor of bone mineral density at all sites in multiple linear regression analyses controlling for age, body mass index, menopausal status, smoking, ever use of hormone replacement therapy or oral contraceptives, physical activity, and alcohol intake. The effects of milk consumption from age 25–44 and from age 44 to the present were similar in direction though not statistically significant.

Conclusion—Frequent milk consumption before age 25 favourably influences hip bone mass in middle aged and older women.

Introduction

Osteoporosis is an important public health problem¹ and is the single most important cause of fractures in middle aged and elderly people.² Currently, it is estimated that there are about 190 000 fractures a year in the United Kingdom, costing the national health service about £600 million.³ In the United Kingdom, the population aged 65 years and over is projected to increase by 30% over the next 35 years.⁴ As fractures are more common with advancing age, the consequences of osteoporosis will become increasingly important.

Prospective studies have shown that low bone density is an important predictor of future fracture risk.^{5,6} Bone mass in middle age is determined by peak bone mass at maturity and the subsequent rate of age related bone loss. Identification of the determinants of peak bone mass may therefore facilitate the formulation of strategies for the prevention of osteoporotic fractures.

Calcium intake seems to be an important determinant of peak bone mass.^{7,9} It has not been estab-

lished, however, whether calcium intake early in life influences bone mass in later years. An assessment of milk consumption may be used as a reasonable proxy for calcium intake early in life as about 40–60% of children's calcium intake comes from milk.^{10,11} Indeed, a positive association between milk intake in childhood and adolescence and bone mineral density at the radius has been reported in postmenopausal women.¹² There is little information on the relation between milk consumption during youth and bone mineral density at the hip and spine in later years. The aim of this study was to relate historical milk consumption and bone mineral density in the axial skeleton in a sample of community based middle aged and elderly women.

Methods

SUBJECTS

We studied 284 women in the community aged 44–74 years who were recruited by letter from four general practices in Cambridge. These subjects were recruited as part of a larger community based bone density survey which started in October 1990. All subjects on the age-sex register in the eligible age range (40–75 years) were sent letters; they were unselected as regards their health status. About half of those approached agreed to participate. The subjects in this report are a random sample of subjects recruited to date. Each subject completed a questionnaire describing health and lifestyle characteristics including menopausal status, smoking history, current alcohol intake, parity, and previous use of oral contraceptives and hormone replacement therapy. Current physical activity (in kcal/week) was determined by questionnaire with a modification of the method of Paffenbarger *et al.*¹³ Current dietary calcium intake was estimated by 24 hour diet recall. Subjects were asked to categorise their average milk consumption up to age 25, from age 25–44 years, and from age 44 to the present as follows: ≥ 1 glass/day, < 1 glass/day, or < 1 glass/week.

BONE DENSITY MEASUREMENTS

Bone mineral density of spine (L2–L4) and hip (total hip, femoral neck, trochanter, intertrochanteric, and Ward's triangle) was measured by dual energy x ray absorptiometry with the Hologic QDR-1000 (Hologic Inc, Waltham, Massachusetts). Bone density results were expressed as areal density in g/cm². Precision for in vivo measurements (24 paired measures in normal volunteers aged 15–70 years) was 1.0% for the spine and 1.5–3.0% for the hip.¹⁴

STATISTICAL ANALYSES

Statistical analyses were performed with the statistical package for the social sciences (SPSS Inc, Chicago) on the mainframe computer at the University of Cambridge. Two sided tests were used and the level of statistical significance set at 0.05. Group means were

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compared using the MEANS procedure and means adjusted for age and body mass index were compared by analysis of variance (ANOVA). Multiple stepwise linear regression analysis was used to determine the independent effects of predictor variables.

Results

Data on milk consumption were available for 252, 263, and 284 women respectively for the periods up to age 25, 25-44 years, and from age 44 to the present. Descriptive statistics for the 252 women with data on milk consumption up to age 25 are shown in table I. There were few differences, although those women who drank the least milk were slightly older, more likely to be postmenopausal, and a higher proportion had used hormone replacement therapy.

Table II shows mean regional bone mineral density by milk consumption up to age 25 years at the spine (n=245) and hip (n=248). There was a consistent upward trend in bone mineral density at all sites with increasing milk consumption. Bone mineral density was about 5% greater among those women reporting the most frequent compared with the least frequent milk consumption. Adjustment for age or body mass index, or both, did not alter these trends, which remained statistically significant for bone mineral density in the total hip, femoral neck, and Ward's triangle and approached statistical significance for trochanteric (P=0.076) and intertrochanteric (P=0.06) bone mineral density. Separate analyses adjusting for weight and height together and weight and height separately gave similar results. Similar results were also obtained when the analyses were repeated using only postmenopausal women and also after women who had ever taken hormone replacement therapy were excluded.

Milk consumption remained a significant predictor of bone mineral density at all hip sites in stepwise multiple linear regression analyses controlling for age,

TABLE III—Historical milk intake between age 25-44 years and from age 44 years to present. Mean (SD) bone mineral density (g/cm²) by milk consumption group; unadjusted and adjusted for age and body mass index by analysis of variance

	Milk intake		
	< 1 Glass/week	< 1 Glass/day	≥ 1 Glass/day
Spine (L2-L4):			
Age 25-44 years			
Crude	0.94 (0.16)	0.99 (0.18)	0.97 (0.15)
Adjusted	0.95	0.98	0.97
Age 44 years to present			
Crude	0.97 (0.17)	0.98 (0.17)	0.96 (0.16)
Adjusted	0.97	0.98	0.97
Total hip:			
Age 25-44 years			
Crude	0.84 (0.13)	0.88 (0.15)	0.87 (0.13)
Adjusted	0.85	0.87	0.88
Age 44 to present			
Crude	0.86 (0.15)	0.87 (0.14)	0.87 (0.12)
Adjusted	0.86	0.87	0.89
Femoral neck:			
Age 25-44 years			
Crude	0.70 (0.12)	0.73 (0.13)	0.74 (0.12)
Adjusted	0.71	0.73	0.75
Age 44 to present			
Crude	0.72 (0.13)	0.73 (0.12)	0.73 (0.12)
Adjusted	0.72	0.74	0.74
Trochanter:			
Age 25-44 years			
Crude	0.64 (0.10)	0.66 (0.12)	0.66 (0.11)
Adjusted	0.64	0.65	0.66
Age 44 to present			
Crude	0.65 (0.11)	0.66 (0.11)	0.66 (0.10)
Adjusted	0.66	0.66	0.67
Ward's triangle:			
Age 25-44 years			
Crude	0.52 (0.15)	0.57 (0.16)	0.59 (0.14)*
Adjusted	0.53	0.56	0.59*
Age 44 to present			
Crude	0.55 (0.16)	0.57 (0.15)	0.58 (0.15)
Adjusted	0.55	0.58	0.59

*P<0.05.

body mass index, menopausal status (premenopausal or perimenopausal *v* postmenopausal), smoking (never *v* ever), hormone replacement therapy use (never *v* ever), parity (nulliparous *v* parous), oral contraceptive use (never *v* ever), physical activity (kcal/week), alcohol intake (units/week), and years since menopause. The effect of milk consumption before age 25 was small, however, accounting for 1.5-2.0% of the variance in current spine and hip bone mineral density.

Similar analyses were performed using milk consumption from age 25-44 years (table III). A weaker trend of increasing bone mineral density at all sites was seen and was statistically significant only for Ward's triangle. Milk consumption from age 44 to present was weakly related to bone mineral density, although this was not statistically significant at any site (table III).

Discussion

Some of the potential shortcomings of this study should be acknowledged. Our recruitment rate of 50% is modest, though similar to that of Garton *et al* in Aberdeen (54%), who used open invitations.¹⁵ The findings of our study may have resulted from selection bias, although this is unlikely as there is no reason to believe that the observed relation would be seen only in respondents. The participants resembled other British populations with respect to body mass index, systolic and diastolic blood pressure, and alcohol intake, though fewer were current cigarette smokers.¹⁶ Therefore with the above note of caution we believe that our findings can be generalised to healthy middle aged and older women in the community. The retrospective assessment of milk consumption was also crude, although the resultant measurement error would be expected to obscure associations rather than produce spurious ones. The consistent dose-response trends further support the likelihood that the observed relations are real.

TABLE I—Descriptive statistics by milk consumption group in 252 women aged 44-74 years. Values are mean (SD) unless indicated otherwise

Variable	< 1 Glass/week (n=54)	< 1 Glass/day (n=90)	≥ 1 Glass/day (n=108)	P value
Age (years)	61.6 (7.3)	60.4 (8.0)	58.8 (8.3)	0.08
Body mass index (kg/m ²)	25.9 (4.1)	25.7 (3.8)	25.8 (4.4)	0.95
Years after menopause*	14.0 (9.0)	14.0 (7.5)	12.1 (7.2)	0.24
Exercise (kcal/week)	1711 (1861)	1678 (1481)	1885 (1606)	0.64
No (%) ever smokers	23/54 (43)	42/89 (47)	50/107 (47)	0.85
Alcohol (units/week)	2.7 (3.3)	4.4 (6.0)	3.5 (4.8)	0.13
Calcium intake (mg/day)†	758 (380)	908 (416)	852 (249)	0.26
Parity	2.4 (1.6)	2.4 (1.6)	2.3 (1.5)	0.84
No (%) postmenopausal	48/51 (94)	66/86 (77)	87/102 (85)	0.04
No (%) ever used hormone replacement therapy	20/54 (37)	18/90 (20)	16/108 (15)	0.006

*n=48, 66, 87.

†n=23, 40, 49.

TABLE II—Historical milk intake up to age 25 years. Mean (SD) bone mineral density (g/cm²) by milk consumption group; unadjusted and adjusted for age and body mass index by analysis of variance

	Milk intake			P value
	< 1 Glass/week	< 1 Glass/day	≥ 1 Glass/day	
Spine (L2-L4):				
Crude	0.94 (0.15)	0.96 (0.16)	1.00 (0.17)	0.087
Adjusted	0.96	0.97	1.00	0.216
Total hip:				
Crude	0.84 (0.13)	0.86 (0.13)	0.90 (0.14)	0.023
Adjusted	0.84	0.86	0.89	0.039
Femoral neck:				
Crude	0.70 (0.11)	0.72 (0.12)	0.75 (0.13)	0.018
Adjusted	0.70	0.72	0.75	0.048
Trochanter:				
Crude	0.63 (0.10)	0.64 (0.11)	0.68 (0.11)	0.031
Adjusted	0.64	0.65	0.68	0.076
Intertrochanter:				
Crude	0.99 (0.17)	1.01 (0.17)	1.06 (0.17)	0.036
Adjusted	0.99	1.01	1.04	0.060
Ward's triangle:				
Crude	0.52 (0.13)	0.56 (0.16)	0.60 (0.16)	0.005
Adjusted	0.53	0.57	0.59	0.019

n=51, 89, and 105 for spine analyses; 53, 89, and 106 for hip analyses.

The most important finding in this study is the significant positive association between milk consumption early in life and subsequent hip and spine bone mineral density in middle age. Our findings complement earlier work by Sandler *et al*, who found that bone mineral density of the distal radius was 2-3% higher in postmenopausal women who consumed milk with every meal than in rare consumers.¹² Bauer *et al* recently reported similar findings for radius and calcaneus bone mass among 9704 non-black women aged over 65 years.¹⁷

We believe that the most likely explanation for this finding is through a positive effect of milk consumption on peak bone mass. This hypothesis is supported by work by Matkovic *et al* showing higher peak bone mass in an area of former Yugoslavia with high calcium intake than in a neighbouring area with low calcium intake coupled with roughly equal rates of age related bone loss.⁹ It is possible, though less likely, that individuals consuming more milk when young as a group possess other attributes which are associated with milk consumption and which are responsible for their greater bone mass in later years. Once into middle age they may also possess fewer risk factors for low bone mass. In contrast to the report by Sandler *et al*,¹² we had information about several potential confounding factors (exercise, smoking, alcohol intake, parity, use of oral contraceptives and hormone replacement therapy, menopausal status) and were able to control for these factors in the analyses.

Our results are biologically plausible given that milk is an important source of dietary calcium in children^{10,11} and dietary calcium is an important determinant of peak bone mass.⁷⁻⁹ A three year longitudinal study found that calcium supplements significantly increased radial, hip, and spine bone mineral density in children aged 6-14 years who already had an adequate dietary intake of calcium.¹⁸ Supplementation with dairy products has been shown to retard vertebral bone loss in premenopausal women aged 30-42¹⁹ and to improve calcium balance and reduce bone turnover in postmenopausal women.²⁰

CLINICAL IMPORTANCE

The observed differences in bone mass between the most and least frequent milk consumers are modest, and their clinical significance is unclear. There are few published data on the relation between previous milk intake and fractures. One case-control study found no relation between milk consumption in adolescence and hip fracture,²¹ while Kelsey *et al* found no association between historical milk intake between ages 18-50 and age 50 to the present and risk of proximal humeral fracture.²² Dietary calcium intake, on the other hand,

has been linked in some^{23,24} but not all²⁵ studies with risk of hip fracture. Future studies should look at the relation between milk consumption early in life and fracture risk in later years.

Milk consumption among children and young adults in the United Kingdom has been declining steadily since the mid-1970s.²⁶ This trend may have a number of explanations, including concern about saturated fat intake and competition from the soft drinks industry.²⁷ Our preliminary data suggest that these trends may result in lower peak bone mass and in theory a modest increase in fracture risk at the hip and spine in later life. Our findings are tentative and require a longitudinal study for confirmation. From a public health perspective, preventive strategies against osteoporosis and fractures in later life should encourage milk consumption among children and young adults to improve peak bone mass.

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Public health implications

- Osteoporosis and fractures are an increasing public health problem
- Bone mineral density is an important predictor of future fracture risk
- Identification of factors which influence peak bone mass may facilitate the development of preventive strategies
- In this study frequent milk consumption before age 25 years was associated with higher hip bone mineral density in middle aged and elderly women
- Milk consumption should be encouraged during childhood and adolescence and may help prevent osteoporotic fractures in later life