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Children Who Avoid Drinking Cow's Milk Are at Increased Risk for Prepubertal Bone Fractures

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ABSTRACT

The full fracture histories of 50 children (30 girls and 20 boys, age range 3 to 13 years) who had avoided drinking cow's milk for prolonged periods were compared with those in a birth cohort of more than 1,000 children from the same city. Children who avoided milk did not use calcium-rich food substitutes appropriately and had low dietary calcium intakes and low bone mineral density values. Many were overweight (22 of 50). Significantly more of the children who avoided milk reported fractures (16 observed vs 6 expected, χ^2=31.0, P<.001, df=5). They also experienced more total fractures than the birth cohort population (22 observed vs 8 expected, χ^2=33.6, P<.001, df=5). All of the fractures occurred before puberty, the majority (18 of 22) being associated with only slight trauma. Forearm fractures were especially common (12 fractures). We conclude that young children avoiding milk are prone to fracture.

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Bone fractures are a frequent problem for children (1,2). Low bone density and high body weight increase fracture risk during growth (3-5). Adequate absorption of dietary calcium is important for optimal bone growth (6,7).

In Western countries dairy products are the major dietary source of calcium. Sustained milk avoidance during growth may therefore jeopardize bone health unless appropriate substitute calcium-rich foods are consumed (6). Optimizing bone mass is recommended to reduce the risk of fracture in children (8). In addition, recent work has linked adult osteoporotic fractures to low milk consumption during childhood (9).

Low consumption of dairy foods may also affect body weight (10). Substitution of high-energy drinks of low nutritional value for milk (11) can promote weight gain while low calcium intakes may augment adipogenesis (12-15).

We recently observed that a group of 50 white children with a history of avoiding drinking cow's milk had low dietary calcium intakes, short stature, poor skeletons, and a high prevalence of adiposity (16). Many had already had bone fractures, which was worrisome considering the decreasing consumption of milk over the past 50 years (11,17). The current study was therefore done to obtain more information about their fractures and to compare their observed fracture frequencies with those expected in children of similar age and sex from the general community.

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METHODS

The Otago Ethics Committee approved the study. Informed consent was obtained from parents and children. At baseline 30 girls and 20 boys, age range 3 to 10 years, with a history of cow's milk avoidance were recruited from advertisements in shops, community centers, and schools (16). Children's heights (Harpenden stadiometer, Holtain Ltd, United Kingdom) and weights (electronic scale, Model 169N; Tanita Corporation, Tokyo, Japan) were measured without shoes in light clothing. Body mass index (BMI) values, defined as weight (kg)/height (m^2), were used to identify overweight (BMI >85th percentile for age) and obese (BMI > 95th percentile for age) subjects (18). Dual energy x-ray scans of the nondominant forearm, lumbar spine (L2-4), and total body were taken (Lunar DPX-L scanner; Lunar Corporation, Madison, WI) and volumetric bone mineral density values (g/cm^3) expressed as z scores for age as described previously (16). Current dietary calcium intake was estimated (19), and information concerning reasons for milk avoidance, duration of this, and use of high-calcium substitute foods was collected. Pubertal status was self-assessed (3,5).

Participants were re-interviewed 2 years later to record detailed information about any fractures occurring since birth and trauma severity (20). Simultaneous fractures of the radius/ulna or tibia/fibula on the same limb were classed as a single fracture event (20). Data obtained from the Dunedin Multidisciplinary Health and Development Study (a birth cohort of more than 1,000 children born in 1972/1973) was used to provide comparative information concerning fractures in the general community

Table 1. Baseline characteristics and prevalence of relevant risk factors in children with and without fractures who avoid milk[a]

History of fracture	Nil (n=34)	Positive (n=16)
Baseline characteristics	← mean (SD[b]) →	
Age (y)	5.8 (2.0)	6.7 (2.1)
Height (cm)	112.6 (14.3)	121.4 (16.2)
Weight (kg)	22.4 (8.7)	27.5 (10.2)
BMI[c] (kg/m^2)	17.0 (2.4)	18.1 (3.0)
Age commenced milk avoidance (y)	1.0 (1.9)	0.7 (1.2)
Duration of milk avoidance (% lifespan)	77 (33)	81 (30)
Calcium intake (mg/d)	449 (250)	438 (189)
Prevalence of risk factors	← n (%) →	
Symptoms to cow milk	16 (47%)	9 (56%)
Family members avoiding milk	26 (77%)	13 (81%)
Calcium intake below 300 mg/d	9 (27%)	5 (31%)
Overweight[d]	13 (38%)	9 (56%)
Low z score at 33% radius[e]	16 (47%)	6 (38%)
Low z score at lumbar spine[e]	11 (32%)	9 (56%)

[a]Groups with and without fractures did not differ statistically for any variable (P>.05).
[b]SD=standard deviation.
[c]BMI=body mass index.
[d]Overweight=BMI above 85th percentile for age.
[e]Low z score=volumetric bone density (g/cm^3) below −1 SD.

Table 2. Number of fractures observed in the study population compared with total fractures expected from community data[a]

Age (y)	Time exposed (y)	Observed fractures (n)	Expected fractures (n)	Fracture rate per 1,000 person years in community
0-2.9	150	9	1.97	13.1
3-4.9	96.1	5	2.08	21.7
5-6.9	83.4	4	1.99	23.8
7-8.9	44	4	1.15	26.0
9-10.9	16.2	0	0.80	49.3
11-13	6.3	0	0.45	72.4
0-13	396.0	22	8.44	

[a]Goodness of fit χ^2=33.57, P<.001, degrees of freedom=5.

by age and sex (21). Fracture frequencies (observed vs expected) were tested using a χ^2 test.

RESULTS

As reported previously (16), the study children had low dietary calcium intakes, reduced z scores for bone mineral content, and low volumetric bone density values. However, the baseline characteristics and risk factors for fracture of children with and without fractures did not differ (Table 1).

Forty-six subjects attended the follow-up interview. Baseline data concerning fractures were used for the other four children, who had left Dunedin. Table 2 shows that more study children than community subjects had a positive fracture history (16 observed vs six expected, χ^2 = 31.0, P <.001, df=5). Twenty-two fractures were confirmed (12 radius/ulna, three fingers, two tibia/fibula, one clavicle, one femur, one ankle, one nose, one metatarsal), 17 from radiological records and five from the clinical history (time in plaster). All of these fractures occurred before puberty, 18 of 22 being associated with only slight trauma (minor trips or falls incurred during normal play). Twelve children broke one bone; four children broke multiple bones (on different occasions). Fracture subjects came from 12 different families, and fracture-free children from 24 different families. No child had known skeletal abnormalities and no fractures were attributed to abuse. Interestingly, seven of the nine children breaking their forearms were overweight.

DISCUSSION

Others have shown that children who habitually avoid milk have low calcium intakes and poor skeletons (22-26), but this study is the first to demonstrate that young children who avoid milk sustain more fractures than community controls of similar age and sex. One in three study children had fractures, and 18 of their 22 fractures (82%) occurred before 7 years of age. This high fracture occurrence is a concern because milk consumption is generally decreasing today (17,27). Lower milk consumption may trigger an increase in fracture rates in the young, and health professionals need to advise parents and families about ways to prevent this. Although 2% to 7.5% of infants avoid cow's milk because of symptoms (allergy, mucous production, rhinitis, dermal, or gastrointestinal problems) (28), only half of the study children reported symptoms. Half avoided milk because they disliked the taste, for cost reasons, or because their families choose not to supply this food regularly (16). The present findings suggest that 4% to 15% of young children may consume very little cow's milk for long periods at a time of life when their bone needs for calcium are high. Without appropriate dietary substitutions, such youngsters may be more prone to fractures.

Both osteopenia (16) and overweight (data not shown) were more prevalent in the study population than in the community. The low bone densities and high body weights of children avoiding milk probably contributed to the large number of fractures they sustained because both increase new fracture risk during growth (4). Many study subjects had sufficiently poor calcium intakes to impair bone mineralization, and their volumetric bone density z scores were low (16). While severe calcium deprivation among the children avoiding milk probably contributed to their impaired bone mineralization, other nutrients in milk may also be important for optimal bone development. Dairy products are an important source of protein, vitamins, other minerals, and growth factors anabolic to bone, such as osteoprotegerin (29) and milk basic protein (30). Milk consumption also increases blood levels of insulin-like growth factor 1, a powerful stimulant of bone formation (31).

Parental behavior influences milk consumption (32) and this probably reinforced low milk consumption. Many participants had family members who avoid milk. Importantly, the children were not making appropriate dietary substitutions for their low milk consumption (16). Children who avoid milk but who consume appropriate substitute high-calcium and high-protein foods instead of milk or who use supplements may not have the same high risks of osteopenia and fracture as children who avoid milk but make no appropriate dietary adjustments. This possibility warrants further study.

Although the prevalence of osteopenia and overweight were similar in children with and without fractures, it seems likely that all children with these characteristics were at increased fracture risk. Fracture events are to some degree a matter of chance because bones rarely break spontaneously and some degree of trauma is required to precipitate fracture. Children who take frequent risks and fall often or heavily may be more likely to fracture a bone than are children who are nimble and less adventurous. However, in this study most fractures resulted from only slight trauma, suggesting that weakness of the skeleton or imbalance of body weight to skeletal strength, rather than excessive risk-taking behavior, explained most bone breakage.

Low physical activity levels may have contributed to the adiposity and the poor skeletal growth of the study children because overweight children are frequently inactive children. Because weight-bearing activity stimulates osteogenesis and helps burn excess calories (33-36), all children should be encouraged to participate in regular physical activity to optimize bone development and maintain a healthful body weight. Calcium intake and weight-bearing activity also influence the microarchitecture of bone (37,38). Finally, children should spend sufficient time outdoors to boost their vitamin D levels to ensure good alimentary absorption of calcium (39,40).

A limitation of the current study is its relatively small sample size. The birth cohort population used for normative fracture information was also born earlier than the study children. Although fracture rates could have increased over time in the whole community, not just in children avoiding milk, this seems unlikely. We acknowledge that we did not evaluate anthropometry, bone density, or nutrition close to the actual dates of fracture. Thus, past fracture events cannot be definitively attributed to low dietary calcium intakes, osteopenia, or excessively high body weight documented at measurement. However, milk avoidance was chronic and few subjects used substitute high-calcium drinks and foods to compensate for milk avoidance. Because low bone density (41,42) and high adiposity (43) track, study children who were osteopenic and heavy for their bone development at scanning were also probably osteopenic and overheavy at time of fracture.

CONCLUSIONS

Dietitians should be aware that young children who habitually avoid drinking cow's milk without using calcium substitutes are prone to fractures and overweight. Nondairy calcium-rich foods or drinks or mineral supplements, regular exercise, and outdoor activity should be recommended and healthful body weight maintained. Children need good nutrition, adequate vitamin D, and weight-bearing physical activity during development to build strong skeletons and achieve their genetic potential peak bone mass. This should reduce their risk of osteoporotic fractures later in life.

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