



Bone mineral density, milk intake and physical activity in boys who suffered forearm fractures

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Abstract

Objective: To compare boys with and without forearm fracture in terms of their bone mineral density, intake of milk and dairy products, and physical activity.

Methods: There were 23 boys in each group (aged between 7 and 13 years). They were submitted to bone densitometry with dual-energy x-ray absorptiometry (DEXA) of the forearm (opposite side of the fracture). Participants answered questionnaires about their intake of milk and dairy products, and about their physical activity.

Results: The mean±SD of the bone mineral density of the radial and ulnar distal diaphysis in the case group (0.430 ± 0.038 g·cm⁻²) was significantly lower ($p = 0.018$) than that of the control group (0.458 ± 0.039 g·cm⁻²). Likewise, the mean of the distal metaphysis of the forearm was 0.309 ± 0.033 g·cm⁻² in the case group and 0.349 ± 0.054 g·cm⁻² in the control group ($p = 0.004$). Milk intake (1.5 ± 1.2 cups a day) was significantly lower in the case group ($p = 0.001$) than in the control group (2.7 ± 1.2 cups a day). The number of boys who practiced after-school physical activity was significantly lower ($p = 0.017$) in the case group (six boys = 26%) than in the control group (15 boys = 53%).

Conclusion: Boys who suffered forearm fracture showed lower bone mineral density compared with the control group. In the case group, milk intake and physical activity were lower than in the control group.

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Introduction

Bone fractures are a concern as they cause morbidity and sequelae that can affect mainly the joints. Fractures can occur at any stage of life, and are more common among children. The intensity and the mechanisms of injury, as well as bone resistance to fracture, are factors that determine the probability of a fracture. The intensity of the trauma is an important determining factor for fracture, but bone mineral density (BMD), upon which resistance to fracture depends,¹ also plays a role.

Few studies on bone resistance and BMD and on the possibility of low BMD in the event of a fracture have included pediatric patients. Marhaug² suggested that the bones of children who suffered a fracture have a low bone mineral content (BMC) compared to a control group (with no fractures).

Peak calcium (Ca⁺⁺) requirements occur during childhood and adolescence, a crucial period for maximization of bone density.³ According to Fuchs & Snow,⁴ the low intake of Ca⁺⁺ in childhood is related to an increased risk of fractures at this developmental stage; however, the interplay between Ca⁺⁺ intake and exercise during childhood is underreported in the literature.

Distal forearm fractures account for 21% of all fractures that occur in individuals younger than 17 years.⁵ Several *in vitro* and *in vivo* studies have been conducted since the 1980s in an attempt to establish an association between BMD and bone resistance to fracture.^{1,5-7}

The incidence of forearm fractures reaches its peak at the age of 13, affecting 807 and 140 per 100,000 boys and

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girls, respectively.⁸ This period precedes the critical years for bone mass accumulation, which is evident at the age of 14-15 years.⁹ The radius is the most commonly fractured long bone among children, representing 45% of the fractures.¹⁰ Hagino *et al.*⁸ studied Japanese individuals aged less than 20 years and suggested that low bone density of the distal diaphysis of the forearm may be the cause for a higher incidence of fractures at this site.

Families often wonder whether their children have weak bones, especially when the trauma that caused the fracture was not so strong. The answer to this question is not straight, once thorough examination is necessary after ruling out the possibility of inherited or acquired diseases.

The most referenced studies seeking to establish an association between bone mass and fracture in children^{8,11} have shown that lower bone mass may increase the risk of fractures in children. Goulding *et al.*¹² noted that a low BMC and lack of physical activity are associated with the enhanced risk of distal forearm fractures in boys.

The aim of the present study was to compare boys with and without forearm fractures in terms of their BMD, daily intake of dairy products, and physical activity.

Methods

Case-control study in which forearm fracture was measured as an outcome and BMD was the analyzed factor.

Subjects

Both age and gender of the analyzed group were based on the studies¹³⁻¹⁵ that found some evidence of regular and progressive bone mass accumulation in male individuals up to the age of 15 or 18 years, differently from female subjects, in whom there is sudden bone mass acquisition after the menarche. The boys who volunteered to participate in the study were all Caucasian and aged between 7 and 13 years. The case group was comprised of boys who fractured the diaphysis/metaphysis of the forearm (submitted to treatment) involving at least the radius. Participants were recruited from the Orthopedic Outpatient Clinic of *Hospital São Lucas da Pontifícia Universidade Católica do Rio Grande do Sul* (HSL-PUCRS), in Porto Alegre, southern Brazil. Surrogates signed a consent form, and the local Research Ethics Committee approved the study protocol.

The inclusion criteria in the case group were the following: medical treatment for less than 12 months, no orthopedic deformities, fractures involving the radius, with or without ulnar involvement, closed fracture (complete or incomplete), low-trauma fracture, i.e., by falling from a standing height or less while doing habitual activities (e.g.: during sports activities) and not related to traffic accidents. Initial x-ray was evaluated on admission to HSL-PUCRS.

The control group included boys who sought medical care at the Orthopedic Outpatient Clinic, with no past or current history of fracture, with no clinically relevant

osteoarticular disorders, and without any orthopedic deformities. Therefore, they were not submitted to any kind of rest over the last months. The most frequent reasons for having sought medical care were muscle contusion and clinical examination upon the request of parents to check the existence of *pes planus* and spinal deformities.

Procedures

Participants completed a questionnaire about their intake of milk and other dairy products and another questionnaire about physical activity in which school and after-school activities were described.¹⁶ On that occasion, weight and height were measured (Filizola), and information about the participants' state of health and occurrence of fractures was collected.

Bone densitometry (BD) was performed within two weeks after the initial evaluation at the Division of Densitometry of the Institute of Geriatrics (HSL-PUCRS) in Porto Alegre, using a Hologic QDR-4500 Acclaim fan-beam scanner (Boston-USA). The equipment was calibrated on a daily basis, following the routine of the Division of Densitometry.

Forearm scans were performed. Patients in the case group had their unfractured forearm evaluated, and in the control group, the scanned forearm was that which matched its counterpart in the case group.

Statistical analysis

Mean and standard deviation were calculated in the case of quantitative variables, whereas for categorical variables, absolute frequency and percentage were used. The case and control groups were compared by Student's t test for independent samples in the case of quantitative variables. The chi-square test with Yates' correction in 2x2 tables and Fisher's exact test (whenever necessary) were used for the categorical variables. The significance level was established at $\alpha \leq 0.05$.

We used the mean difference observed between groups as an estimator of the magnitude of the analyzed associations.¹⁶⁻¹⁸ The data were analyzed by Excel 97, SPSS v.9.0 and PEPI v.3.0 programs.

Results

Case and control groups were similar in terms of age, weight, height, and body mass index (BMI).

Intake of milk and other dairy products

Milk intake was lower in the case group than in the control group (Table 1). On average, individuals in the control group had the habit of drinking 1.2 more glasses of milk than those in the case group. This is a moderate and statistically significant difference ($p = 0.001$). With regard to the consumption of yogurt and cheese, no statistically significant difference was observed between the groups in this study.

Table 1 - Milk, yogurt and cheese consumption in each group

	Case (n = 23)	Control (n = 23)	Mean difference	p
Number of glasses of milk/day	1.5±1.2	2.7±1.2	1.2	0.001
Number of yogurt pots/day	0.7±0.6	0.8±0.7	0.1	0.596
Number of slices of cheese/week	1.0±1.2	1.1±0.8	0.1	0.208

Data are presented in mean±SD.

Physical activity

As shown in Table 2, the number of children who engaged in regular after-school activities corresponded to nearly 65% in the control group, and to only 26% in the case group. This 39% difference was statistically significant ($p = 0.017$). No significant difference was found between the groups with regard to leisure activities and to the active participation of students in activities during their breaktime at school.

Forearm BMD

Table 3 shows the BMD of case and control groups stratified by different regions of the forearm. The groups revealed a moderate difference in the BMD of the distal metaphysis (mean difference = 0.04; $p = 0.004$). We also found significant difference, with the same magnitude, in the BMD of the distal diaphysis (mean difference = 0.028; $p = 0.018$). As to the medial third of the forearm, BMD was similar in both groups.

As far as total BMD of the forearm is concerned, we observed significant difference between the groups, with moderate intensity, showing statistical significance (mean difference = 0.031; $p = 0.004$).

Discussion

The forearm considered for BMD in the control group was case-matched, following the order of inclusion in the

study, and matched by dominance (right or left). This was done because, according to Karjalainen & Alhava,¹⁹ BMC may be 6 to 9% higher in the radius, on the dominant side. In general, the values obtained by similar studies showed that BMD is accountable for bone resistance in approximately 70 to 80%.^{20,21} Whether the boys from the case group were not capable of using the unaffected upper limb was not evaluated in a systematic fashion in this study. Therefore, we do not know whether this factor interfered with the results.

Due to racial differences in BMD,²²⁻²⁴ only Caucasian boys participated in the study. Exposure to sunlight, which is essential for vitamin D synthesis, was not evaluated in this study. We believe it was similar in both groups, since cases and controls were assessed at the same time of the year.

We added the intensity of the trauma that caused the fracture to the selection criteria of the case group. Fractures resulted from falls (low-trauma fractures). According to Landin & Nilsson,⁵ this is an important aspect to be considered, since forearm fractures in children as a result of low trauma may indicate a lower BMC in this region.

The present study revealed a significantly lower BMD in forearm regions that were more prone to fractures. These data are clinically relevant, since studies on fractures have demonstrated that the risk of fracture doubles with every standard deviation below the mean.¹²

With regard to nutritional aspects, the 24-hour diet recall was not used; instead, we used a questionnaire about the intake of milk and other dairy products (main sources of calcium). Nevertheless, this method did not allow estimating whether children had achieved the age-appropriate calcium intake (1,300 mg/day).²⁵ This study showed that children who suffered fractures have a lower milk intake. These data concur with those of Chan *et al.*,¹¹ whose study of children younger than 12 years who had suffered a forearm fracture revealed that four out of 17 children met less than 60% of the recommended calcium intake (minimum of 240 ml of milk a day, in addition to other dietary sources), and that in the control group, all children met at least the minimum recommended intake. Therefore, as shown by several studies,^{3,4,26-30} there is a positive association between calcium intake and bone mass accumulation in children.

Table 2 - Number of boys engaged in physical activity in each group

	Case (n = 23)		Control (n = 23)		p
	f	%	f	%	
Leisure activities	22	95.7	23	100.0	0.999
During breaktime at school	19	82.6	20	87.0	0.999
After-school activities	6	26.1	15	65.2	0.017

Table 3 - Bone mineral density according to forearm region in g·cm⁻²

	Case (n = 23)	Control (n = 23)	Mean difference	p
Density of the medial third	0.515±0.045	0.534±0.060	0.019	0.220
Density of the distal diaphysis	0.430±0.038	0.458±0.039	0.028	0.018
Density of the distal metaphysis	0.309±0.033	0.349±0.054	0.04	0.004
Total density	0.420±0.032	0.451±0.038	0.031	0.004

Data presented in mean±SD. The mean difference between groups is provided, followed by P obtained through the Student's t test for independent samples.

Gallo³¹ asserts that the best way to achieve an adequate calcium intake is by the ingestion of calcium-rich foods. In this case, milk is the best source, since it contains a high proportion of calcium, is natural, and is easily consumed by children and adolescents.

According to Chan *et al.*,¹¹ children with fractures and below-average BMD should have their diet carefully assessed and be counseled about adequate calcium intake if their diet is potentially deficient.

Johnston *et al.*²⁷ state that children who ingest more calcium improve their bone mass acquisition, and that nutrition and activity contribute 20% or more to BMD.

Despite genetic contributions to BMD, environmental factors, including physical exercise, are especially important before puberty.^{30,32} In the present study, the number of boys who engaged in after-school physical activities was significantly smaller in the case group (26%) than in the control group (53%). In this study, after-school activities were those such as soccer, basketball and swimming practice done twice or three times a week. These findings suggest that physical exercise may have a positive effect on bone mass acquisition, being larger in those individuals who are regularly involved in some kind of physical activity.

In conclusion, boys with forearm fractures had a lower BMD at the fracture site compared to those boys who have never had a bone fracture. In the group with fractures, milk intake was lower and boys participated less in after-school physical activities than boys who have never suffered a fracture.

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