Rickets and soil strontium

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Abstract

The subjects of this study were children aged 6-60 months living in villages in the Ulaş Health Region, Sivas. The villages were divided into two groups according to the amount of strontium in the soil: region 1, >350 ppm, 650 children; region 2, <350 ppm, 1596 children. Overall, the prevalence of one or more clinical signs of rickets was 22.9%. The prevalence in region 1 was 31.5% and that in region 2, 19.5%. These values were significantly different ($p < 0.001$). When other variables which may be relevant to the occurrence of rickets were taken into account, the difference in prevalence persisted. The results suggest that in villages where nutrition is mainly based on grain cereals the presence of strontium in the soil will increase the prevalence of rickets significantly. As a preventive measure, a greater proportion of the foods given to children in these villages should be derived from animal origin, and cereals and drinking water supplies should be obtained from villages with a low soil strontium content, or calcium supplements should be given. (*Arch Dis Child* 1996;75:524-526)

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The terms 'rickets' and 'osteomalacia' describe disorders in which mineralisation of the organic matrix of the skeleton is defective.¹ Rickets is an ossification defect encountered during the period of growth, whereas osteomalacia is a defect encountered after the epiphyseal plates are closed—that is, after growth is completed.

Vitamin D deficiency is one of the main causes of rickets and osteomalacia. Vitamin D increases the absorption of necessary minerals such as calcium and phosphorus from the intestinal tract. Sunlight is required for transformation of vitamin D to its active metabolites.¹⁻³ Another factor influencing calcium absorption is its interaction with strontium. Strontium absorption is higher in herbivores than in carnivores.⁴⁻⁶ Studies of prehistoric human remains have shown a greater accumulation of strontium in the skeletons of adult women whose diets contained little meat.⁵⁻⁹ Furthermore, during pregnancy and the breast feeding period the intestinal mucosa is altered and absorption of alkali metals (including strontium) increases.¹⁰

There are also studies indicating that rickets can be produced in rats by giving them

strontium and manganese. In these studies, it was suggested that strontium inhibited the parathyroid glands, leading to a reduction in the production of active vitamin D metabolites by the kidney.¹¹

The prevalence of rickets shows variations according to climatic conditions, geographical situation, and socioeconomic condition of the population. Rickets is still an important child health problem in developing countries.¹²⁻¹⁴ In Turkey in 1974 it was estimated that 4.39% of the children aged between 0 and 5 years showed signs of rickets.¹⁵ Within the Ulaş Health Centre Region, this rate reached 32.0% among the children aged 0-60 months.¹⁶ Sivas has the climatic features of Eastern Anatolia. Therefore, the long and cold winters prevent children from making sufficient use of sunlight. It has also been established that strontium is found in soil, in grain cereals, and in foods of animal origin in some regions of Sivas province, a part of which is in the Ulaş Health Region.^{17, 18} Based on this information, an attempt has been made to investigate whether rickets is more common in the villages with high soil strontium in the Ulaş Health Region, because of the interaction between the absorption of strontium and calcium.

Methods

This research was carried out on 2140 children aged 6-60 months living in the 55 neighbouring villages within the Ulaş Health Region between 1 September 1992 and 30 July 1993. There are no climatic, geographical, or socioeconomic differences between the villages in the region. Almost all families in these villages are farmers. The distance of these villages to Sivas is between 20 and 55 km, and transportation is easy. However, the villagers, especially the children, are not in the habit of travelling to Sivas very often.

The villages were divided into two groups according to the amount of strontium in the soil, based on the mine maps of the Mining Technology and Research Institute and on geology maps.^{17, 19} From these sources, villages having average soil strontium of more than 350 ppm were identified as region 1, and villages with average soil strontium of less than 350 ppm as region 2.

All the children aged 6-60 months in the region were included in the study. Medical students in their last year, trained earlier in the paediatrics department of the University Hospital for this purpose and supervised by the researchers, visited the children at home and examined them for signs of craniotables, rachitic rosary, conspicuous bulging at the

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Table 1 Distribution of rickets signs by strontium region (region 1: soil strontium >350 ppm; region 2: soil strontium <350 ppm)

Strontium region	No of signs of rickets							
	0 (n=1650)		1 (n=357)		2 (n=110)		3 + (n=23)	
	No	%	No	%	No	%	No	%
1 (n=613)	420	68.5	127	20.7	54	8.8	12	2.0
2 (n=1527)	1230	80.5	230	15.1	56	3.7	11	0.7

χ^2 : 45330, df: 1; $p < 0.001$.

Table 2 Rickets by strontium region and some other variables (region 1: soil strontium >350 ppm; region 2: soil strontium <350 ppm)

	Region 1		Region 2		Odds ratio
	No	(%)	No	(%)	
Age (months)					
6-12	33/82	(40.2)	41/176	(23.3)	2.22*
13-18	29/62	(46.8)	43/165	(26.0)	2.49†
19-24	21/64	(32.8)	41/160	(25.6)	1.42
25-36	41/125	(33.6)	56/348	(16.1)	2.55†
37-48	33/134	(24.6)	56/340	(16.4)	1.66*
49-60	36/146	(24.7)	60/338	(17.8)	1.52
Breast feeding duration (months)					
0	1/2	(50.0)	7/29	(24.1)	3.14†
1-3	43/113	(37.4)	82/323	(25.3)	1.79*
4-6	30/86	(34.9)	37/211	(17.5)	2.51†
7-12	41/164	(25.0)	68/456	(14.9)	1.90†
13-24	67/193	(34.7)	85/402	(21.1)	1.98†
24 +	11/55	(20.0)	18/106	(17.0)	1.22
Weight above 3rd centile					
Yes	134/477	(28.1)	247/1365	(18.1)	1.77†
No	59/136	(43.4)	50/162	(30.9)	1.72*
Height above 3rd centile					
Yes	113/406	(27.8)	201/1140	(17.6)	1.80†
No	80/207	(38.6)	96/387	(24.8)	2.04†

* $p < 0.05$; † $p < 0.01$.

wrist, bony deformities of the legs (genu valgus or genu varus), and delayed closure of the fontanelles, and measured their heights and weights. Weight and height measurements were evaluated by comparing them with National Center of Health Statistics (NCHS) standards.²⁰ Data were transferred to information forms and analysed statistically using Epi-Info (version 5); χ^2 tests and odds ratios were used to determine the differences between groups.

Results

In the two regions combined 22.9% of the children aged 6-60 months had one or more signs of rickets. The proportion of children with any signs of rickets was higher in region 1, with the higher soil strontium content, than in region 2 (table 1) ($p < 0.001$).

The data were analysed further by taking into account other independent variables which may also affect the occurrence of rickets. The proportion of children with any signs of rickets was shown to be significantly higher in region 1 than in region 2 for the following groups: aged 6-12 months, 13-18 months, 25-36 months, and 37-48 months; those breast fed for less than four months, 4-6 months, 7-12 months, and 13-24 months; those evaluated as above the 3rd centile or below the 3rd centile in height; and those evaluated as above the 3rd centile and below the 3rd centile in weight (table 2) ($p < 0.01-0.05$).

Discussion

This study, which relied on the clinical signs of rickets, showed that the prevalence of the disorder among 2140 children aged 6-60 months in the Ulaş Health Region was 22.9%. It is not appropriate to compare this prevalence with hospital based data obtained by serum and radiological analyses. However, in another study carried out in the Ulaş Health Center Region in 1990-1,¹⁶ a rachitic rosary sign was even present in more than 23% of children. Both of these studies show that the rickets problem in the region is a considerable one.

Nutrition based on grain cereals is abundant in the region, and the presence of strontium in cereal grown in the region has been demonstrated.¹⁷ We have shown that the prevalence of rickets among the children living in villages having a soil strontium content of more than 350 ppm (region 1) was significantly higher than that of the children living in other villages with lower soil strontium. This applied even when other variables were taken into account, suggesting that the difference in the prevalence of rickets may be related to the different content of strontium in the soil. In places where strontium is abundant in the soil and vegetable nutrition is prevalent, strontium uptake is increased and as a result the strontium/calcium ratio is raised. This may lead to inhibition of parathyroid gland activity, a reduction in active vitamin D metabolite production by the kidneys, and rickets.^{4-9 11}

There is no way to eliminate the strontium in the soil so we suggest that a greater proportion of the foods given to children in these villages should be derived from animal origin, and cereals and drinking water supplies should be obtained from villages with a low soil strontium content, or calcium supplements should be given.

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