Clinica Chimica Acta, 55 (1974) 255—257

SHORT COMMUNICATION

CCA 6572

THE DISTRIBUTION OF CALCIUM IN FINGERNAILS FROM HEALTHY AND MALNOURISHED CHILDREN

JOHN R.K. ROBSON and GEORGE J. BROOKS

Human Nutrition Program, School of Public Health, University of Michigan, Ann Arbor, Mich. and Department of Materials and Metallurgy, School of Engineering, University of Michigan, Ann Arbor, Mich. (U.S.A.)

(Received March 18, 1974)

Introduction

It has previously been observed that nail hardness increases in malnutrition [1,2]. In protein-calorie malnutrition this hardness could be due either to an absolute increase in mineral or to a relative increase caused by disturbances in collagen metabolism, leading to a reduction in the onychogen [3].

Direct chemical analysis of fingernails has demonstrated an increase in the sodium and calcium concentrations in kwashiorkor [4]. Histochemical analysis of nails from healthy humans has revealed that calcium is concentrated in the dorsal and ventral cells of the nail plate [5]. In order to determine whether increases in hardness might be due to changes in calcium distribution in nails, clippings from healthy well-nourished, and malnourished subjects, were examined using the electron microprobe X-ray microanalyzer.

Materials and Methods

The sample. Nineteen fingernails were collected from African children suffering from clinically overt protein-calorie malnutrition of the kwashiorkor type. Nail clippings were also collected from 14 other children of African and Caucasian origins of approximately the same age who were apparently healthy and adequately nourished. They had no signs of disease or nutritional deficiency, nor had they a history of illness, injury, or infection in the six week period prior to providing the sample. All of the children were between the 50th and 75th percentile for height and weight based on the Iowa growth standards [6]. Nails were obtained from the middle finger of the left hand and were removed either by stainless steel clippers or scissors. Each clipping was cut with a sharp scalpel in the sagittal plane providing a section with a flat surface, and exposure to the dorsal, intermediate, and ventral zones.

Because of difficulties in mounting the section of nail on a flat surface, the specimens were held in a specially designed copper clip fastened to a block of the same metal. Held firm in this fashion the exposed edge of the nail clipping was filed flush with the surface of the copper block. In order to provide electrical conductivity, an inert graphite-based paste was applied around the nail and a layer of carbon was evaporated onto the entire upper surface. The microprobe was adjusted to measure the most intense calcium peak ($Ca_{\alpha}K$ at 3.3360 Å) using a lithium chloride analyzing crystal. A calcium fluoride standard was used to set the spectrophotometer accurately on the calcium peak. Most satisfactory results were obtained by using a stationary spot beam of 20 μm diameter. The accelerating voltage was 15 kV and the beam current 0.10 μA. The sensitivity of the microprobe is high for calcium [7] and has been found to be greater than the metallic impregnation techniques used in histology [8]. Thus, the calcium X-ray signal in 10^{-13} g of bone has been found to have an intensity of several hundred X-ray quanta per second [9]. The number of counts per second for the calcium fluoride standard was 7850 and the background emission attributable to extraneous calcium resources was 3.9 counts per second. Areas of the sagittal section were selected at random. Counts for calcium at each location were taken for 10 s. The number of areas examined on each section varied between 4 and 17 depending on the size of the sample.

Results and Discussion

The mean concentration of calcium was higher in nails from children in the malnourished group (see Table I). Although the lowest counts per second in both groups were similar, there was a four-fold difference in the highest counts recorded. The microanalyzer measures the concentrations of calcium only, so that it is not possible to say whether the total amount of calcium in the nails from the two groups differed.

Calcium counts were obtained over all of the zones in the nails from the children with kwashiorkor.

The ventral, central and dorsal zones of the nail cannot be differentiated in the cross sections viewed by the microprobe, but when the normal nails were scanned, the distribution of calcium was concentrated in areas corresponding to the dorsal and ventral zones of the nails. This conforms to the observations made by Jarrett and Spearman [5].

These preliminary data suggest that in kwashiorkor, the distribution of calcium in the nail matrix is less orderly. If so, this would offer an explanation for the differences observed in nail hardness in well-nourished and malnourished individuals. Thus, in preparing the nail for the Knoop Hardness Test, the dorsal surface of the nail is removed by polishing, and the test is applied to the central zones of the matrix of the nail. In nails from healthy individuals, the central zone would be virtually free of calcium and, therefore, relatively soft. But, in the nails of children who have suffered protein depletion, calcium deposited in the central zones of the matrix would give a higher Knoop Hardness Number [1,2].

TABLE I

CONCENTRATION OF CALCIUM IN NAILS FROM WELL-NOURISHED AND MALNOURISHED CHILDREN (COUNTS PER SECOND)

Well-nourished			Malnourished		
Nail No.	Range	Mean	Nail No.	Range	Mean
1	9—13	10	1	12—161	67
2	0—12	10	2	14—31	22
3	7—13	9	3	8—13	10
4	6—9	8	4	17—73	39
5	6—14	10	5	14—29	21
6	13—22	17	6	21—30	24
7	10—17	14	7	14—25	18
8	9—16	12	8	14—26	20
9	11—15	13	9	19—24	21
10	12—28	16	10	10—20	14
11	11—18	15	11	14—38	26
12	13—19	17	12	12—19	15
13	6—9	8	13	12—17	15
14	9—46	17	14	13—35	18
			15	64—83	74
Mean for all nails: 12.57			16	11—16	13
Range: 9—17			17	16—45	27
			18	29—52	39
			19	14—18	16
			Mean for all nails: 26.26		
			Range: 10—74		

Acknowledgements

We are grateful to Professor Wilbur C. Bigelow for permission to use the facilities of the Department of Materials and Metallurgy, School of Engineering, University of Michigan.

This research was partially financed by General Research Support Grant No. NIH 5-SOI RR 05447-09.

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