XXXIV. THE HYDROGEN ION CONCENTRATION AND THE CALCIUM AND PHOSPHORUS CONTENT OF THE FAECES OF RACHITIC CHILDREN.

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IN a previous paper [Redman, 1928] an attempt was made to correlate the p_H of the faeces of rachitic children with their clinical condition, the children being kept in hospital on a special diet, but different groups undergoing different methods of treatment, and their clinical condition being controlled by X-ray photographs. In the present paper another aspect of the same work is described.

The investigation consisted in the determination of the p_H of fresh samples of faeces and the estimation of the calcium and phosphorus in the same samples when dried. The p_H values were determined by means of the quinhydrone electrode.

Calcium was estimated in the following manner. A suitable quantity of dried faeces was burnt to a grey ash in a vitreosil crucible. The ash was extracted with hot dilute HCl and well washed with hot water. The filtrate was made just alkaline to methyl red with ammonia and then just acid with acetic acid; it was then boiled, precipitated with boiling ammonium oxalate solution and left overnight. The precipitate was filtered off, washed, dissolved in hot, dilute H_2SO_4 and titrated with standard permanganate solution.

For the estimation of phosphorus a portion of dried faeces was digested in a round-bottomed flask with a mixture of conc. H_2SO_4 and conc. HNO_3 till all the nitric oxide fumes were boiled off and oxidation was complete.

The liquid was cooled, diluted with water and made slightly alkaline with ammonia, then just acid with nitric acid and a volume of 50 % ammonium nitrate added. After heating to 70° the solution was precipitated with ammonium molybdate mixture, well shaken, cooled and filtered by suction. The precipitate was washed with 10 % HNO_3 , then with 2 % NH_4NO_3 and lastly with distilled water. It was then washed back into the flask, dissolved in a known volume of $N/2$ NaOH, boiled for 20 minutes, cooled and titrated with $N/2$ H_2SO_4 , using phenolphthalein as indicator. 1–2 cc. of acid were added in excess and the solution boiled again for 15 minutes. It was then cooled again and accurately titrated with $N/2$ NaOH.

Curves were then plotted to show the relationship between the p_H and the percentages of calcium and phosphorus in the faeces at different periods of time under the same conditions of diet, but under different treatments, until healing of the rickets was established.

The children were kept on the following diet:

Milk	Mince
Cream	Minced chicken
Cocoa, made with milk	Bacon gravy
Raw egg beaten in milk	Bread
Blancmange	Rusks
Custard	Butter
Beef tea or chicken broth	Oranges

Two younger children (Nos. 48 and 49) did not receive mince, chicken or cocoa.

The different treatments were as follows:

1. Cod-liver oil and malt together with
 - (a) artificial sunlight (tungsten-cored carbon arc),
 - (b) mercury vapour lamp.
2. "Ostelin."
3. Irradiated ergosterol.
4. "Radio-malt."
5. Irradiated cholesterol.

The routine method of dealing with the faeces was described in the previous paper.

Curves have been plotted from one or two representative cases from each group of children and from one control child on the same diet, but not suffering from rickets. Figs. 1 to 7 show the curves for rachitic children and Fig. 8 shows the curve for the normal child; the ordinates on the left refer to "percentages," those on the right refer to p_H , while the abscissae refer to the periods of time in days.

Figs. 1 and 2 (cod-liver oil) show a pronounced fall in the output of calcium in both cases 34 and 36 as treatment proceeds and healing occurs, but a rise in No. 34 towards the time of complete cure.

A tremendous drop occurred simultaneously in the amount of phosphorus in case 34 but was not so marked in case 36. The phosphorus curve crossed the calcium curve about the 25th day in case 34, but unfortunately data were not obtained for case 36, in which the two curves were approaching each other towards the 15th day.

The calcium curve swings in a corresponding manner to the p_H curve in the later part of case 34, and practically all the time in case 36.

In Fig. 3 (case 38, "ostelin"), calcium output fell to a minimum about the 23rd day. The phosphorus curve did not reach its minimum till later, on the 29th day.

No correlation between p_H and either calcium or phosphorus was apparent.

Fig. 4 (case 40, irradiated ergosterol) is remarkable in that the calcium values are almost all lower than those obtained for phosphorus; also for the fact that, on this treatment, cases took a much longer time to heal.

In Fig. 5 (case 44, "radio-malt") great variations occur in the calcium but

not nearly so marked in the phosphorus output. Again, the phosphorus curve crosses the calcium curve as healing occurs and then diverges from it. The

Fig. 1. Case 34. Treatment. Cod-liver oil and A.S. X-ray. Cured 51 days.

Fig. 2. Case 36. Treatment. Cod-liver oil and Hg vapour lamp. X-ray. Cured 38 days.

Fig. 3. Case 38. Treatment. "Ostelin." X-ray. Cured 62 days.

Fig. 4. Case 40. Treatment. Irradiated ergosterol. X-ray. Nearly cured 63 days.

●—● Calcium ×—× Phosphorus ○—○ pH

p_H and calcium curves swing together for the greater part of the time. Clinically, the case improved rapidly in general condition and intelligence.

Figs. 6 and 7 (cases 48 and 49, irradiated cholesterol) show tremendous variations in calcium over the first 15 days but greater output of phosphorus

Fig. 5. Case 44. Treatment. "Radio-malt." X-ray. Nearly cured 38 days.

Fig. 6. Case 48. Treatment. Irradiated cholesterol. X-ray. Cured 35 days.

Fig. 7. Case 49. Treatment. Irradiated cholesterol. X-ray. Nearly cured 36 days.

Fig. 8. Case 47. Normal child.

—●— Calcium × — × Phosphorus ○ — ○ pH

in No. 48 than No. 49. The improvement in the clinical condition of both these children was almost dramatic after a few days' treatment. It is notice-

able that in case 48 the phosphorus curve crossed the calcium curve before the 10th day and rose to a great height before settling down. At this period very loose stools occurred and the quantity of irradiated cholesterol administered had to be reduced. This is interesting in view of recent work pointing to the ill-effects produced by over-dosage with vitamins in concentrated form. Towards the 18th day the phosphorus curve crossed the calcium curve again, then fell and remained consistently low as complete cure was established.

In case 49 the phosphorus values were low throughout and the child made excellent progress till cured. The p_H values were all below 7 in case 48 and nearly all below 7 in case 49, and can be fairly well correlated with calcium values but not with those for phosphorus.

Fig. 8 (case 47, normal child) shows variations in both calcium and phosphorus but no crossing of the calcium curve by the phosphorus curve, both curves rising and falling fairly well together and with a certain amount of correlation with the p_H curve.

SUMMARY.

The results suggest a certain degree of correlation between p_H and the percentage of calcium in the faeces of rachitic children.

The best clinical results were obtained by the use of irradiated cholesterol and it is noteworthy that p_H values were practically all below 7, which may indicate some confirmation of the work of Zucker and Matzner [1924], and of Bacharach and Jephcott [1926], on rachitic rats in which it was shown that when healing occurred the reaction of the faeces became acid and remained so. On the other hand, the cases in question (Nos. 48 and 49) were on a diet from which the mince and chicken, given to the rest of the children, were excluded and the p_H of the faeces may have been influenced thereby.

Of other cases, healing appeared to be more rapid when the percentage of phosphorus was consistently low, *e.g.* No. 36 on cod-liver oil and mercury vapour lamp treatment, and No. 44 on "radio-malt." In the former case the p_H was less than 7 on all occasions but one.

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