NUTRITIONAL INTAKE OF CHILDREN

II. CALCIUM, PHOSPHORUS AND IRON [1]

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FOUR FIGURES

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INTRODUCTION

The pattern of the changing food intake of children during the years of growth presents many interesting facets which merit further investigation. During infancy and adolescence, when physical growth is most rapid, nutritional requirements are high and, in a child with good physical and psychological health, appetite increases and food intake becomes greater.

However, during the latter part of the first year and through the pre-school years, demands for growth are somewhat lessened. At the same time development and maturation are progressing rapidly. The child in this post-infancy period is exploring his world, adding many new accomplishments, becoming independent in eating and in general activity, learning bowel control, and exerting his will in making selections. There are intervals when appetite is decreased and the intake of some or all nutrients is lowered. The observation that the decrease in consumption is most marked in a few specific foods and therefore the intake levels of some nutrients are decreased while the levels of others remain stationary or increase is leading to further study of the factors involved.

The purpose of this series of papers is to present the findings on nutrient intake of a group of healthy children during

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the first 5 years of life. Other aspects of the growth and development of these children which are pertinent to the changes in food intake will be reported at a later late.

EXPERIMENTAL

The background and techniques of this study were reported in detail in a previous publication (Beal, '53) and will be only briefly summarized here. Nutrition studies were added in 1946 to the program of the Child Research Council, which for many years has been following the growth and development — physical, physiological and psychological — of a group of children from "upper middle class" families of the Denver area. Since the purpose of this organization is research rather than therapy, and since the children enrolled are under the care of pediatricians not on the Council staff, no effort is made by the staff to influence dietary intake.

Nutrition data are obtained by a series of interviews and 24-hour intakes, carefully recorded at monthly intervals during the first 6 months of life, and thereafter at intervals of three months. Nutrients are calculated from food value tables (Bowes and Church, '51; U. S. Department of Agriculture, '48, '50).

The data in this paper represent 795 histories on 53 children (26 boys and 32 girls) who now range in age from 4 months to 9 years. Only the first 5 years of life are included. Eliminated from these data are histories on breast-fed infants during the period of such feeding and two single histories on older children who had illnesses of sufficient severity and duration to decrease markedly their food intake during the three-month period. All others histories taken on these 58 children are included except as otherwise specified

The first report in this series presented intake levels of calories, carbohydrate, fat and protein. The present report is concerned only with the intake of calcium, phosphorus and iron in food and does not include mineral concentrates which have been given to some of the children for varying

periods of time. Subsequent reports will deal with vitamin intakes.

RESULTS AND DISCUSSION

As previously reported, the intakes of calories, carbohydrate and fat rise rapidly during the first 12 to 18 months, then show only slight increases until three to 4 years, when the increase is accelerated. Protein intake, however, remains stationary during the period from 15 months until after three years of age. The pattern of these 4 nutrients is in sharp contrast to the pattern of the three minerals, each of which shows a distinct decrease during the post-infancy period. This contrast is obvious both in the group data and in the intakes of individual children.

The intakes of calcium and phosphorus of the children in this study from birth to 5 years of age are presented in table 1. Because of the skewness of the data, percentiles are used in preference to means and standard deviations. For each nutrient the table gives the values determined from visual smoothing of the 25th, 50th and 75th percentiles, with the lowest and highest intakes observed to date.

Intake of calcium rises rapidly in the first 6 months, with the median reaching 1.0 gm by 5 months. There is a slight further increase between 6 and 9 months, then the intake falls steadily to its lowest level between two and three years, when the median is 0.75 gm. This is followed by an acceleration so that by 5 years the median is again at the 1.0 gm level. An analysis of the data by sex shows relatively little difference between boys and girls during the first 5 months, but the levels for boys are higher between 6 and 15 months. It is of interest that the girls' intake of calcium begins to decrease after 9 months, while the boys reach a higher level of intake than the girls and maintain this higher level until after one year, when their intake also decreases. This is consistent with the relatively greater growth of the boys during the latter part of the first year (Boyd, '52). No observable sex difference in calcium intake is seen between 15

TABLE 1

Calcium and phosphorus intake of children from birth to 5 years of age

AGE	NO. OF CASES	CALCIUM, GM					PHOSPHORUS, GM				
		Percentile					Percentile				
		Lowest	25	50	75	Highest	Lowest	25	50	75	Highest
years months											
0–0 to 0–1	27	0.19	0.49	0.58	0.65	0.92	0.15	0.38	0.46	0.53	0.77
0–1 to 0–2	34	0.27	0.70	0.81	0.94	1.17	0.21	0.56	0.66	0.76	0.90
0–2 to 0–3	35	0.31	0.82	0.91	1.04	1.29	0.27	0.66	0.75	0.86	1.00
0–3 to 0–4	38	0.31	0.86	0.96	1.09	1.37	0.28	0.73	0.81	0.92	1.10
0–4 to 0–5	37	0.33	0.89	1.00	1.14	1.38	0.32	0.78	0.86	0.99	1.20
0–5 to 0–6	38	0.36	0.91	1.04	1.16	1.55	0.39	0.83	0.91	1.03	1.32
0–6 to 0–9	40	0.66	0.92	1.05	1.17	1.57	0.70	0.88	0.95	1.09	1.32
0–9 to 1–0	41	0.65	0.88	1.02	1.16	1.44	0.71	0.90	0.99	1.14	1.40
1–0 to 1–3	42	0.58	0.79	0.97	1.13	1.35	0.56	0.87	0.99	1.16	1.37
1–3 to 1–6	40	0.48	0.72	0.90	1.07	1.53	0.64	0.83	0.94	1.12	1.56
1–6 to 1–9	37	0.44	0.66	0.82	1.00	1.52	0.47	0.79	0.90	1.07	1.54
1–9 to 2–0	36	0.38	0.62	0.77	0.95	1.37	0.45	0.76	0.87	1.02	1.42
2–0 to 2–3	36	0.36	0.61	0.76	0.92	1.33	0.42	0.74	0.85	0.99	1.36
2–3 to 2–6	37	0.48	0.60	0.75	0.91	1.34	0.52	0.73	0.84	0.97	1.37
2–6 to 2–9	34	0.23	0.60	0.75	0.91	1.36	0.37	0.73	0.84	0.97	1.33
2–9 to 3–0	33	0.32	0.61	0.75	0.92	1.41	0.44	0.73	0.84	0.98	1.28
3–0 to 3–3	31	0.35	0.62	0.76	0.93	1.56	0.46	0.74	0.85	1.00	1.45
3–3 to 3–6	29	0.42	0.65	0.78	0.96	1.37	0.39	0.76	0.88	1.03	1.38
3–6 to 3–9	27	0.46	0.68	0.82	1.00	1.36	0.46	0.78	0.91	1.07	1.28
3–9 to 4–0	25	0.48	0.71	0.87	1.05	1.40	0.59	0.80	0.96	1.10	1.31
4–0 to 4–3	26	0.50	0.74	0.92	1.09	1.53	0.57	0.82	1.00	1.13	1.41
4–3 to 4–6	24	0.43	0.76	0.96	1.13	1.79	0.49	0.85	1.03	1.16	1.61
4–6 to 4–9	24	0.49	0.78	0.99	1.16	1.47	0.56	0.87	1.06	1.19	1.45
4–9 to 5–0	24	0.38	0.79	1.01	1.18	1.44	0.55	0.89	1.09	1.22	1.41

months and three years; thereafter the number of cases is as yet too small to permit adequate differentiation.

Since milk is the major source of calcium in the diets of these children and since the pattern of milk intake of individual children is being subjected to further study, figure 1 is presented to show the contrast of the median intake of total calcium to the median intake of milk calcium; for ease of conversion, grams of calcium and equivalent values in ounces of milk are both indicated on the graph. The values for milk

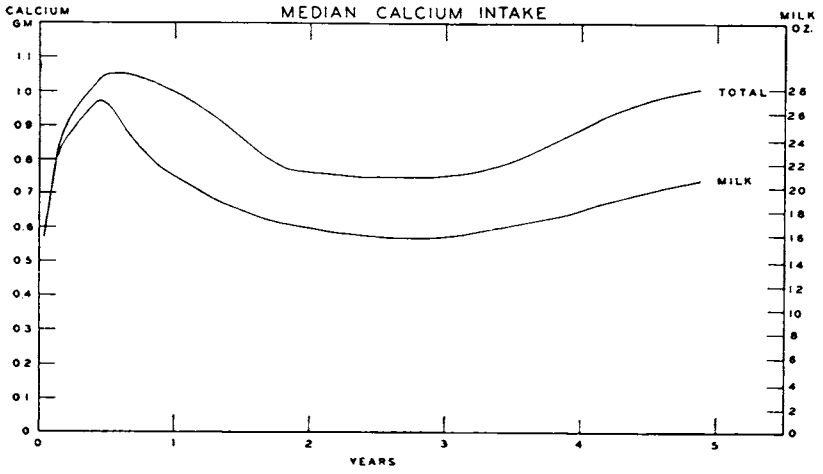

Fig. 1 Median intake of total calcium as contrasted with median intake of milk calcium of children in the first 5 years of life.

calcium include only the milk consumed as a beverage and on cereal; other sources of milk in the diet, such as pudding, soup and creamed dishes, have been excluded. Also excluded from the milk calcium median were 4 instances in which formulas simulating breast milk were used, since the low level of calcium in these formulas necessitates a different basis of conversion to ounces of milk.

As figure 1 indicates, milk is the essential source of calcium in these diets during the first three months, after which cereal and other solids contribute to the calcium content of the diet. The curves of the two medians thus become increasingly

separated throughout the first year, then from one through 5 years they are more nearly parallel. The consumption of milk as a beverage reaches a maximum at 6 months, when the median is about 27 ounces, then decreases to its lowest level of 16 ounces at two and one-half to three years before it starts to increase again. The range of intake is very wide.

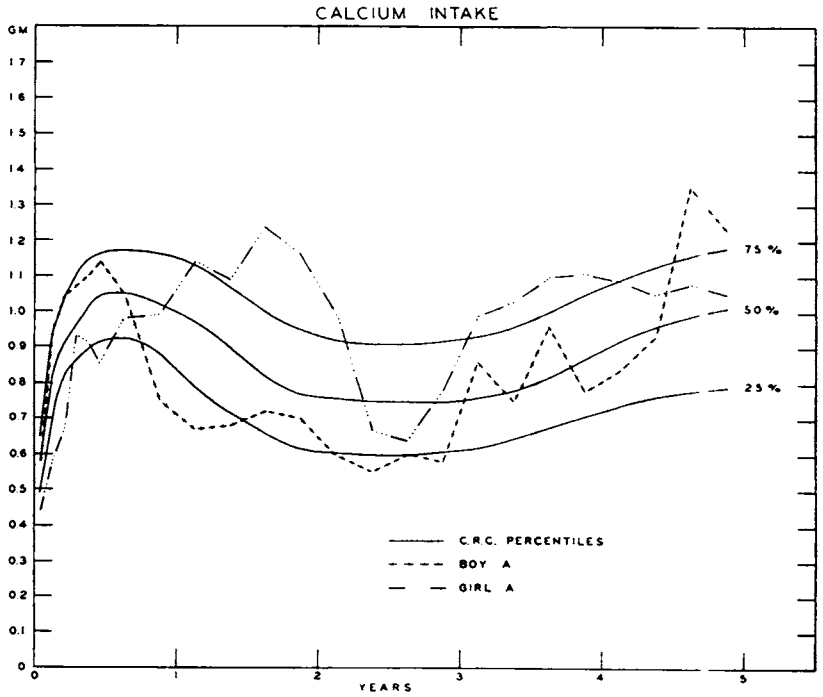

Fig. 2 Examples of individual variation in calcium intake from birth to 5 years of age.

For example, at two years and 9 months the lowest intake was 0.10 gm and the highest 1.15 gm, a range from approximately three to 32 ounces of milk. It should be noted that the children in whom this wide range is found are healthy children whose patterns of growth, with one exception, are satisfactory and who are not restricted in food intake by economic limitations.

Individual variations in calcium intake are shown in figures 2 and 3, in which 4 different patterns are indicated. Boy A had a relatively high intake during the first 6 to 9 months, after which his calcium intake decreased to below the 25th percentile by one year, remained low until nearly three years, and then rose to above the 75th percentile by

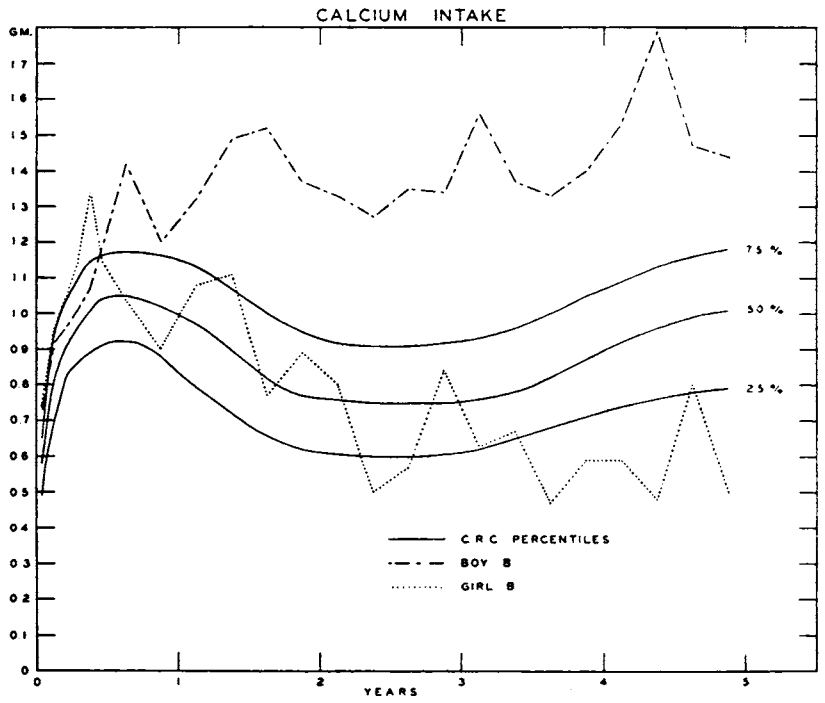

Fig. 3 Examples of individual variation in calcium intake from birth to 5 years of age.

4¾ years. However, his calorie intake has been consistently in the highest quartile and his protein intake above the median, indicating that a higher consumption of other foods was compensating for the decrease in milk. In contrast, the calcium decrease in Girl A, which was restricted to the period between two and three years of age, was reflected in calorie and protein levels as well.

Boy B and Girl B (fig. 3) present patterns of intake which are somewhat more unusual in this group. Boy B is one of the two children to date who have not had marked decrease in milk intake during this age range. While his calorie intake showed a decrease between two and 4 years of age, when his appetite was poor and consumption of many foods dropped, his protein and calcium intakes in this age period were consistently above the 75th percentile. Girl B, on the other hand, has shown an erratic pattern of calcium intake which decreased markedly between 6 months and two and one-half years and maintained a low level with no real increase between two and one-half and 5 years. Her intake of calories and protein reflected the milk decrease during the last half of the first year, then rose to the median or higher until 3½ years, when a general drop in food consumption lowered calorie and protein intake to levels comparable to that of calcium. The failure of this child to take an increasing amount of milk after three to 4 years of age, thus diverging from the pattern of the group, will make her an interesting subject of investigation of the physical and/or psychological factors involved.

While the patterns of intake vary from one child to another, there is a tendency in this group for the most common changes in intake to be similar to those of Boy A and Girl A. There is a period of marked decrease, occurring usually near the end of the first year and persisting for one to two years, with the lowest intake being shortly after two years of age, followed by an increase. These changes in level of intake parallel a theoretical calcium retention curve formulated by Stearns ('52) from calcium needs for growth during childhood. Since physical growth is relatively small in the period from two to 4 years of age, calcium needs are probably lower than at any other time until adulthood. However, the Recommended Allowance for calcium established by the Food and Nutrition Board of the National Research Council ('53) is maintained at a level of 1.0 gm from 10 months through 9 years of age.

Phosphorus intake shows a pattern similar to but less striking in change than that of calcium, since phosphorus reflects to a lesser extent the change in milk intake. The phosphorus

TABLE 2

Iron intake of children from birth to 5 years of age

AGE	NO. OF CASES	IRON, MG				
		Percentile				
		Lowest	25	50	75	Highest
years months						
0–0 to 0–1	23	0.2	0.3	0.4	0.9	1.4
0–1 to 0–2	31	0.4	0.6	1.0	2.1	6.4
0–2 to 0–3	34	0.5	1.0	2.2	4.2	5.9
0–3 to 0–4	37	0.6	1.8	4.0	5.8	10.4
0–4 to 0–5	36	0.9	3.5	5.6	7.6	15.1
0–5 to 0–6	37	3.4	5.0	6.9	9.5	20.6
0–6 to 0–9	40	3.5	7.0	9.8	12.3	17.8
0–9 to 1–0	41	2.8	8.4	10.8	14.7	24.0
1–0 to 1–3	42	3.4	7.0	9.6	13.0	19.0
1–3 to 1–6	40	2.4	5.9	8.2	11.5	19.7
1–6 to 1–9	37	2.3	5.1	7.3	10.3	20.5
1–9 to 2–0	36	3.4	4.7	6.7	9.3	15.9
2–0 to 2–3	36	3.4	4.5	6.2	8.4	16.1
2–3 to 2–6	37	3.3	4.5	5.9	7.8	12.0
2–6 to 2–9	34	2.1	4.6	5.8	7.3	11.9
2–9 to 3–0	33	3.0	4.6	5.7	6.9	9.5
3–0 to 3–3	31	3.6	4.7	5.7	6.8	13.1
3–3 to 3–6	29	3.3	4.9	5.7	6.7	11.2
3–6 to 3–9	27	3.3	5.0	5.8	6.8	8.9
3–9 to 4–0	25	3.6	5.1	5.9	6.9	8.2
4–0 to 4–3	26	3.5	5.2	6.1	7.1	10.8
4–3 to 4–6	24	2.8	5.3	6.2	7.3	9.6
4–6 to 4–9	24	3.6	5.4	6.4	7.4	11.1
4–9 to 5–0	24	4.0	5.5	6.6	7.6	9.2

percentiles rise in the first year. During the period when protein levels maintain a plateau and calcium levels decrease markedly, phosphorus follows an intermediate course, then increases as do the other two nutrients after three to 4 years of age.

While the intakes of the nutrients thus far presented are largely a reflection of voluntary consumption by the children, the iron levels during the first two and one-half years are affected by the large amount of iron added to the specially prepared baby foods which are commonly fed to the infants in this series. This high iron content, particularly of the cereals, results in an intake which rises sharply from the

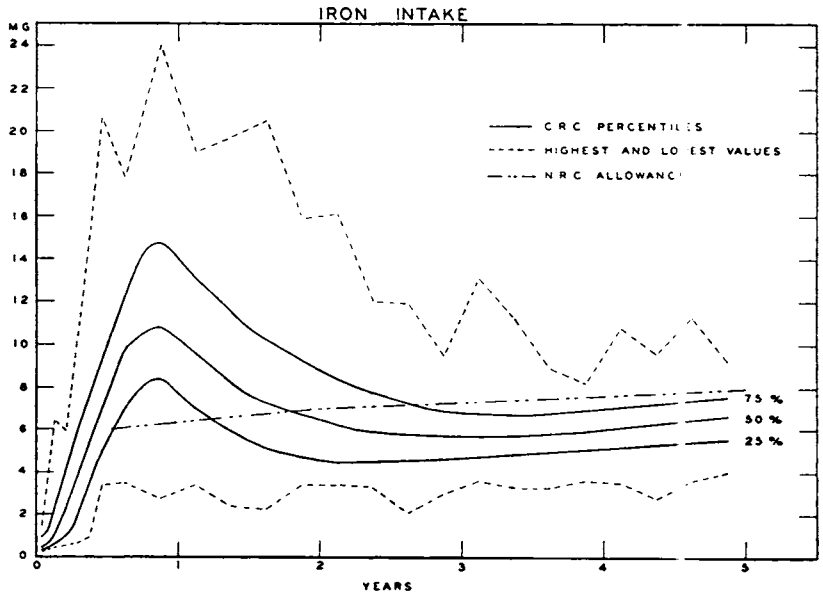

Fig. 4 Iron intake of children in the first 5 years of life, showing smoothed 25th, 50th and 75th percentiles and observed minimum and maximum values as contrasted with the Recommended Dietary Allowance.

time of introduction of solids into the diet to a peak at about one year of age, after which there is a decline as these foods are replaced by foods prepared at home. Thus, as may be seen in table 2, the median iron intake, which reaches a peak of more than 10 mg daily by one year, drops in the next 18 months to a level under 6 mg daily. These percentile values were determined with the exclusion of 4 instances in which high-iron formulas were given.

After two and one-half years of age, more than 75% of the children in this group consume an amount of iron which is less than the Recommended Allowance of the National Research Council (fig. 4). There is evidence from recent balance studies, some using radioactive iron, that absorption of iron from food is relatively small (Macy, '42; Moore and Dubach, '52) and that the dietary requirements of iron for children need review (Johnston, '53; Darby et al., '47). The fact that the children in this series have, on the whole, satisfactory levels of hemoglobin and erythrocytes (Meyers, unpublished data) leads one to believe that these levels of iron intake are adequate to meet their needs.

SUMMARY

Data have been presented from 795 nutrition histories on 58 children in the first 5 years of life. Calcium, phosphorus and iron intakes have been computed in terms of quartiles and maximum and minimum levels observed. In addition, some of the individual patterns of calcium intake have been shown.

Intake of calcium rises rapidly in the first 6 months, less rapidly between 6 and 9 months, then decreases to a lower level between two and three years, when the median calcium level is 0.75 gm and the median milk intake is 16 ounces. This is followed by an increase in milk and in total calcium. There is a sex difference in calcium intake between 6 and 15 months, with the boys reaching a higher level than the girls and maintaining that level for a longer period of time.

Phosphorus intake increases during the first year, then shows a pattern intermediate between the stationary intake of protein and the markedly decreased intake of calcium in the early pre-school years, increasing again between three and 4 years.

The sharp rise of iron intake during the first year, due primarily to the high iron content of commercially prepared infant cereals, is followed by a decrease as these foods are replaced in the diet. After three years, levels of iron intake

increase, but from two and one-half years to 5 years more than 75% of the intakes remain below the Recommended Allowance of the National Research Council.

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