CXXIII. THE CALCIUM METABOLISM OF ATROPHIC INFANTS AND ITS RELATIONSHIP TO THEIR FAT METABOLISM.

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FOR the purpose of this investigation, an infant is considered to be suffering from simple atrophy or marasmus if the body-weight is less than 80 % of the expected body-weight for its age, and if there is no other evidence of disease.

Many theories have been put forward from time to time as to the cause of atrophy, scientific basis for which has not been fully established. Czerny, as is well known, assumes that atrophic children have a low assimilative power for fat, and, as a result of fermentation and digestion, fatty acids are formed in excess in the intestinal tract. To neutralise these fatty acids, alkalies are taken from the tissues and excreted into the intestine and lost in the stool. In constipation, with soap stools, calcium, and in diarrhoea potassium and sodium are thus excreted. Thus, in his view, demineralisation of the body is the essential cause of atrophy.

Holt [Holt, Courtney and Fales, 1920] believes that there is no evidence of demineralisation of the body owing to low assimilative power for fat, and that excessive ingestion of calcium does not result in excessive excretion of calcium accompanied by a harmful loss of fat. He believes that an ample intake of both fat and calcium produces only beneficial results.

Marriot [1920, 1921] believes that atrophy is essentially the result of partial starvation for long periods of time, and that there is a negative mineral salt balance.

It has been shown recently that fat absorption in infantile atrophy (in the absence of diarrhoea) is normal [Parsons, 1924, 1]. The relationship between the fat and calcium metabolism in normal children has been the subject of considerable investigation, but until recently there have not been any extensive observations on the calcium metabolism of definitely atrophic children with the exception of a series of seventeen cases reported by Utheim [1922].

The present series of observations on the calcium metabolism of atrophic infants was made at the request of Dr Leonard G. Parsons, Physician to the Children's Hospital, Birmingham. The fat metabolism was investigated at the same time, so that the relationship between the fat and calcium could be

established. Certain observations made during this investigation have led to the belief that a large number of cases must be observed before any definite conclusions can be drawn. The total number of children investigated was forty-eight, but some observations on thirty-nine of these have already been published [Parsons, 1924, 2].

Preliminary observations showed that there is considerable variation in the composition of stools from day to day, and even from hour to hour; it was therefore deemed advisable to make the period of observation five days if possible. Since the length of time taken by food to traverse the alimentary tract of atrophic children may be as long as three days, to ensure that the stools examined in this series should be those resulting from a known intake of fat and calcium, the following routine was observed [Parsons, 1924, 1].

Collection of specimens.

The infant was given the specified diet for three whole days before the stools were collected, as well as during the period of collection. Since milk varies in composition from day to day, and since the proportion of fat and calcium depends on whether the milk has been properly mixed before use, and also to eliminate any errors due to inaccurate dilution of the milk or milk powder when making up the feeds, half an ounce extra was prepared for each meal and these samples were put together and analysed for fat and calcium every 24 hours for five days. The actual food intake was also observed and any food vomited was noted and subtracted from the intake. There was little vomiting in the cases observed. At the end of the third 24 hours, the infant was placed on a metabolism bed, and stools and urine were collected separately until the end of the eighth day. Every effort was made to collect complete specimens. The 24-hours collections of stools were then dried and analysed for fat and calcium. The mean of the five 24-hours samples of milk was taken as the average daily intake and the mean of the five 24-hours collection of stools was taken as the average daily output.

None of the infants was suffering from diarrhoea during the period of observation.

Methods of Analysis.

The stools were transferred as quickly as possible from the receiver to small glass dishes of known weight, and were then carefully dried for 24 hours (or longer if the stools were large) over an electric heater, thus ensuring a moderate temperature of about 60° to 80°. They were weighed before being pulverised. If the stools were very solid they were mixed with a little water and spread over the dish before being dried. If very fatty, instead of being pulverised, they were treated with ether and stirred thoroughly while the ether evaporated to ensure complete homogeneity, care being taken that there should be no loss during these operations.

In many records published on the calcium metabolism of children, the

observations have been made on a few cases only. Holt, Courtney and Fales [1920] have, however, published a very complete record of the metabolism of thirty healthy children fed on cow's milk, some of whom were having cod-liver oil. In order to compare the results of this investigation with those of Holt and of Utheim, the same method of estimation has been used, namely, that of McCrudden [1920], but bromocresol-purple was used as the indicator in most of these cases; the results are all stated in terms of calcium oxide.

The calcium excreted in the urine of all the cases observed was not estimated, so that the figures do not show the actual retention of calcium. The retention is, however, not very different from the absorption. Holt states that the daily calcium excretion in the urine of healthy children fed on cow's milk is between 0.01 and 0.05 g. daily. A number of specimens of the urine in this series were examined and a similar range was found, viz. 0.017 to 0.034 g. The calcium excreted in the urine was from 1.8 to 6.0 % of the total calcium excreted, a figure slightly greater than that given by Findlay, Paton and Sharpe [1921], who state that it is less than 4 %; but the high figure of 6 % obtained here was in a case fed on a humanised dried milk.

Many previous investigators have used very different methods for the determination of faecal fat, and there have been differences in the methods of reporting the findings, so that the results are not strictly comparable. Holt, Courtney and Fales [1920] estimated the fat by a modified Rose-Gottlieb method. A method somewhat similar has been used in this investigation. The total weight of the dried faeces for the 24 hours having been found, about 0.5 g. of the pulverised material was weighed into each of two fat extraction tubes. To one was added 10 cc. of 30 % HCl and to the other 10 cc. of distilled water. Both were heated in a boiling water-bath for half an hour, cooled and extracted with 40 cc. of ether by shaking. After settling, 20 cc. of the clear ether solution was transferred with a pipette to a weighed flask of about 50 cc. capacity and evaporated. Repeated experiments under the same conditions, but without the material to be extracted, showed that on the average 3.4 cc. of the ether dissolved in the water or dilute acid, so that the weight of the residue from 20 cc. of the extract must be multiplied by 1.83 to give the total weight of the fat extracted from the known weight of the dried faeces. This eliminated the filtering process which is essential when all the ether extract is evaporated as in the modified Rose-Gottlieb method used by Holt and his co-workers.

This method was tested by estimating the fat in specimens of milk powder by this process, and by a Soxhlet extraction process. The following figures were obtained:

	Soxhlet	Author
(1)	22.87 %	23.19 % 22.52
(2)	28.63	28.64 28.47
(3)	30.38	30.84 29.52

Table I. *Calcium Metabolism.*

No.	Food	% Fat in Food	% CaO in Food	Wt. of D.F. in 24 hrs. g.	% Total ash in D.F.	% CaO in D.F.	Per 24 hours				Per kilo. body weight			
							Fat intake g.	CaO intake g.	CaO output g.	CaO absorbed g.	Fat absorbed g.	CaO intake g.	CaO output g.	CaO absorbed g.
1	Humanised milk	4.9	0.128	17.1	14.4	3.7	41.5	1.10	0.66	0.44	0.027	8.9	0.29	0.17
2	"	4.2	0.113	13.5	15.0	5.0	29.6	0.81	0.66	0.14	17.8	0.027	6.3	0.23
3	"	4.2	0.122	11.4	16.8	5.8	29.1	0.84	0.66	0.17	21.0	0.029	6.5	0.24
4	"	4.2	0.112	4.2	17.6	8.6	30.9	0.83	0.37	0.46	55.6	0.027	7.3	0.21
5	"	3.2	0.094	4.9	22.8	6.9	14.4	0.43	0.34	0.08	19.5	0.030	4.9	0.16
6	"	3.5	0.100	3.8	20.7	9.0	26.2	0.74	0.35	0.39	53.6	0.029	8.3	0.25
	Average	—	0.111	9.1	17.9	6.5	28.6	0.79	0.51	0.28	34.6	0.028	7.0	0.23
7	Dried milk full-cream	3.1	0.176	21.5	21.5	7.5	38.3	2.16	1.60	0.56	25.9	0.056	5.0	0.41
8	"	2.1	0.160	5.9	22.1	10.8	19.4	1.50	0.63	0.87	58.1	0.077	3.3	0.32
	Average	—	0.168	13.7	21.8	9.2	28.9	1.83	1.12	0.72	42.0	0.067	4.1	0.37
9	Dried milk half-cream	1.4	0.162	4.0	—	15.6	11.5	1.38	0.63	0.75	54.2	0.120	2.5	0.39
10	"	1.3	0.143	2.0	26.3	13.1	7.5	0.73	0.24	0.49	67.3	0.098	3.7	0.40
11	"	1.2	0.120	1.9	30.8	14.6	10.6	1.04	0.26	0.78	75.4	0.099	3.9	0.39
	Average	—	0.142	2.6	28.6	14.4	9.9	1.05	0.38	0.67	65.6	0.106	3.4	0.39
12	Condensed	2.0	0.086	4.8	13.7	6.0	10.2	0.44	0.29	0.15	34.0	0.044	2.3	0.14
13	Milk and water and sucrose	3.3	0.147	7.3	27.7	13.6	30.9	1.38	0.99	0.37	27.9	0.044	6.3	0.31
14	"	3.2	0.176	7.5	30.1	14.3	29.0	1.63	1.06	0.57	34.8	0.056	5.6	0.35
15	"	3.0	0.150	6.3	16.2	7.3	25.0	1.26	0.48	0.78	61.4	0.050	5.0	0.29
16	"	2.6	0.118	7.7	27.0	11.3	26.1	1.28	0.79	0.40	30.9	0.049	4.4	0.24
17	"	2.4	0.145	7.5	19.7	11.6	19.9	1.23	0.86	0.37	30.3	0.062	3.7	0.27
18	"	2.4	0.119	3.2	26.6	15.4	16.3	0.81	0.48	0.33	40.6	0.049	3.6	0.19
19	"	1.7	0.131	8.9	22.6	5.6	14.7	1.14	0.48	0.66	57.6	0.078	2.9	0.35
20	"	1.6	0.113	1.4	28.8	6.5	10.5	0.75	0.09	0.65	87.6	0.071	2.7	0.20
21	"	*2.6	0.132	3.7	27.5	14.8	18.5	0.88	0.54	0.34	38.7	0.048	5.0	0.26
22	Milk and water and dextri-maltose	3.1	0.160	6.2	27.6	10.7	26.3	1.36	0.65	0.71	52.2	0.052	5.5	0.31
23	"	2.8	0.112	3.9	24.3	9.5	14.5	0.57	0.38	0.20	34.4	0.039	4.9	0.22

24	"	2.8	0.103	3.6	24.4	12.5	14.9	0.55	0.45	0.10	18.2	0.037	4.6	0.19	0.16	0.03
25	"	†2.7	0.181	10.8	23.8	12.3	35.3	2.36	1.33	1.03	43.6	0.067	6.2	0.36	0.20	0.16
26	"	*2.7	0.143	2.6	31.6	11.2	16.0	0.87	0.29	0.57	65.7	0.054	5.2	0.30	0.10	0.20
27	"	2.6	0.122	6.6	18.6	9.7	15.7	0.73	0.66	0.06	8.7	0.047	4.2	0.25	0.23	0.02
28	"	*2.4	0.155	8.5	18.2	8.1	24.1	1.42	0.68	0.73	51.7	0.059	5.2	0.42	0.20	0.22
29	"	†2.3	0.174	7.3	25.1	13.1	16.4	1.22	0.95	0.27	22.2	0.074	5.0	0.44	0.34	0.10
30	"	2.3	0.126	2.4	21.9	11.1	15.7	0.84	0.26	0.58	68.8	0.054	3.6	0.20	0.06	0.14
31	"	2.3	0.144	2.2	25.5	12.6	11.9	0.74	0.26	0.48	65.0	0.040	4.3	0.29	0.10	0.19
32	"	2.3	0.130	7.5	26.6	9.2	21.1	1.22	0.70	0.52	42.8	0.058	4.3	0.28	0.16	0.12
33	"	2.0	0.093	6.7	24.7	11.8	27.5	1.27	0.77	0.50	39.5	0.046	4.2	0.21	0.13	0.08
34	"	2.0	0.111	6.8	17.9	8.7	17.3	0.98	0.59	0.39	39.6	0.057	4.5	0.31	0.17	0.14
35	"	2.0	0.127	6.3	16.9	5.8	12.9	0.81	0.35	0.45	56.0	0.063	3.7	0.29	0.13	0.16
36	"	1.9	0.126	3.1	28.5	12.3	11.9	0.81	0.56	0.25	31.0	0.074	3.7	0.28	0.20	0.08
37	"	1.8	0.117	10.7	18.4	5.6	15.0	1.00	0.57	0.43	42.8	0.066	2.1	0.25	0.14	0.11
38	"	1.8	0.128	3.7	20.8	10.6	11.4	0.83	0.39	0.44	52.7	0.073	3.0	0.24	0.12	0.12
39	"	1.8	0.130	2.0	23.4	5.9	8.1	0.59	0.12	0.47	80.0	0.073	2.8	0.22	0.04	0.18
40	"	1.7	0.108	7.4	23.6	7.2	19.5	1.22	0.52	0.69	57.0	0.063	4.4	0.31	0.13	0.18
41	"	1.7	0.104	4.5	38.1	8.2	9.2	0.56	0.36	0.20	35.2	0.061	2.7	0.19	0.12	0.07
42	"	1.6	0.139	7.7	35.7	12.2	18.0	1.56	0.94	0.63	40.2	0.087	4.1	0.43	0.26	0.17
43	"	1.4	0.101	4.4	21.5	5.0	6.6	0.49	0.22	0.27	55.6	0.074	2.3	0.21	0.10	0.11
	Average	—	0.131	5.8	24.6	10.1	18.1	1.04	0.57	0.47	45.6	0.059	4.2	0.28	0.15	0.13
44	Skim milk and D. M.	1.6	0.146	4.1	38.8	18.6	9.3	0.87	0.77	0.10	12.0	0.093	2.8	0.29	0.26	0.03
45	Skim milk and	§1.1	0.162	1.8	33.3	17.2	13.9	2.03	0.33	1.70	83.7	0.146	2.6	0.40	0.07	0.33
46	sucrose	0.9	0.153	6.4	29.6	13.2	8.6	1.52	0.83	0.69	45.2	0.176	1.6	0.33	0.18	0.15
47	Skim milk and D. M.	0.8	0.127	7.8	29.8	13.1	6.3	0.97	1.03	(-0.07)	0	0.153	1.5	0.28	0.29	(-0.02)
48	"	0.6	0.150	4.4	37.5	19.2	5.1	1.28	0.84	0.43	26.9	0.250	1.0	0.29	0.19	0.10
	Average	—	0.144	5.7	33.9	16.0	7.3	1.16	0.87	0.31	21.0	0.168	1.7	0.30	0.23	0.07
	Grand Average (48 cases)	—	0.131	6.3	23.8	10.3	18.3	1.04	0.60	0.44	43.0	0.067	5.3	0.28	0.16	0.12

* HCl added to make p_H 5.2 to 6.0 (approx.).

† Caseo added.

‡ Citric acid added to make p_H 5.2 to 6.0 (approx.).

§ Not included in averages.

The milk fat in all the specimen feeds was estimated by a similar method. After heating 10 cc. of the milk with 10 cc. of concentrated hydrochloric acid for half an hour in a water-bath, it was extracted with 30 cc. of ether and a similar correction was made. The residue from the ether extract of the dried faeces after treating with hydrochloric acid is reported as "total fat," but in reality is a mixture of fatty acid from the saponified fat, the free fatty acid and the neutral fat. The ether extract after treating with water only is reported as "unsaponified fat." It is a mixture of free fatty acid and neutral fat. "Total fat" — "Unsaponified fat" gives the saponified fat in terms of fatty acid and is reported as "saponified fat," as in Holt's paper.

The results obtained have been tabulated according to the kind of food, since all the specimens examined were either formed or semi-formed.

DISCUSSION OF RESULTS.

Fig. 1. To show relationship between the weight of dried faeces ——— and the weight of calcium oxide (daily) - - - - -

Relationship between the Weight of Faecal Matter and the Calcium Output. A consideration of Fig. 1 shows that the daily output of calcium oxide varies fairly regularly with the weight of the dried faecal matter for individual cases. Fig. 2 shows that while on the whole there is diminished output of calcium oxide with diminished weight of faecal matter for all the cases on any one diet, there is a very decided tendency for the lines representing faecal output and calcium oxide to converge as the faecal output diminishes. In other words, the proportion of calcium oxide in the faecal matter tends to become greater as the faecal output diminishes.

Absorption of Calcium. Fig. 3 shows the relationship between intake and output of calcium for the different diets. It is clear that the curves of intake and output of calcium are more or less parallel for any particular diet, though the two lines approach very closely at several points. Where the diet has a low fat content, as in skim milk, the output may be greater than the intake, indicating the output of endogenous calcium. This is in accordance with much

of the modern work on the absorption of calcium. Hopkins [1920] proved that oxidation destroys fat-soluble vitamin A. Making use of this observation, McCollum, Simmonds, Becker and Shipley [1922] found that associated with the growth-promoting vitamin A in milk fat is another vitamin which is concerned with calcium deposition. Since milk is believed to contain only a

Fig. 2. To show relationship between weight of dried faeces and output of calcium oxide on different foods. CaO ——— Faeces.

Fig. 3. To show relationship between the Intake and Output of calcium oxide for various diets. Intake ——— Output

moderate amount of the calcium-depositing vitamin, and if it is distributed in common with the growth-promoting vitamin, either equally in the cream and the residue of the milk, or possibly in greater proportion in the cream than in the residue, the skim milk would contain only a very small amount—too small an amount in all probability to cause the deposition of calcium. If, however, this factor is stored like vitamin A in the body, the amount of calcium absorbed from the food on a reduced fat diet depends on the amount of the vitamin stored and the length of time during which the low fat diet has been taken. The case in this investigation showing a negative calcium balance had been on a low fat diet for seventeen days, long enough in all probability for the store of anti-rachitic (Mellanby) or calcium-depositing (McCollum, etc.) vitamin to have been entirely removed.

That the absorption of calcium depends on the fat intake as well as, or even more than, the calcium intake, is shown graphically in Fig. 4. For all the cases on ordinary milk and water mixtures, there is, generally speaking, a diminished calcium absorption with a diminished fat intake. This is also true for the dried milk mixture when the fat content is not too high. In the cases on humanised dried milk mixtures, although there is a high fat content,

Fig. 4. To show the relationship between the weight of calcium oxide] absorbed and the fat intake ———.

Fig. 5. To show the calcium absorption according to the proportion between fat and calcium intake. •-|- calcium intake for 1 g. fat. ——— calcium intake in g. calcium output in g.

there is also a very low calcium intake, as shown in Fig. 3, compared with the other feeds, and consequently a low calcium absorption. This would indicate that an ample supply of calcium, together with an ample supply of fat results in a good absorption of calcium, and is in agreement with Holt's opinion previously stated. When the fat intake is less than 12 to 14 g. daily, the calcium absorption may be perilously low.

Fig. 5 indicates that there is also a certain relationship to be observed between the fat and the calcium intake to obtain the best absorption of calcium. The best absorption was obtained when there was from 0.04 to 0.078 g. of calcium oxide to 1 g. of fat in cow's milk and water mixtures, and the absorption was very good also when the intake of calcium oxide was as great as 0.12 g. to 1 g. of fat in the dried milk mixtures.

It is interesting to notice that the absorption of the calcium from the half-cream dried milk was slightly better than from cow's milk and water mixtures giving the same fat intake. (Compare *A*, *B* with *C*, *D* in Fig. 4.)

Observations on the absorption of fat from the half-cream dried milk mixtures show that it is very good also, the average for these same three cases being 91 %. Both these findings confirm the opinion previously formed from clinical observation that the half-cream dried milks often produce better results in infant feeding than the full-cream dried milks.

The difference in the amounts of calcium absorbed by the same infant on (*a*) a milk of fairly high fat content, and (*b*) a milk of low fat content after seventeen days on this diet, is shown as follows:

% fat in food	Calcium intake per day g.	% absorption
2.0	0.44	34.0
0.8	0.97	0

Since the absorption of calcium is very largely affected by the kind of milk (liquid, dried by the roller process, or humanised and dried by the spray process), the average percentage absorption of 43.0 % for 48 cases has little value. The greater number of cases, however, show an absorption between 30 and 60 %, those below being practically all cases on skim milk or a dried milk mixture with a high fat content. The latter may be explained perhaps on the ground of the large weight of faecal matter generally produced on these diets when the fat content of the milk mixtures is very high, and consequently the output of saponified fat comparatively large. The average weight of the dried faeces for the group of six cases on humanised dried milk with a fat content varying from 3.2 to 4.9 % was 9.1 g. in 24 hours, while the average weight of dried faeces for the group of 31 cases on cow's milk and water mixtures with a fat content varying between 1.4 and 3.3 was 5.8 g. in 24 hours. The average output of saponified fat for six of these cases on the humanised dried milk mixtures was 2.6 g. in 24 hours, and for 31 cases on milk and water it was 1.6 g. in the same period (see Table II).

Table II. *Saponified Fat.*

No. of cases	Food	Output of sap. fat g.	Possible CaO as soap g.	Total CaO output g.	Possible CaO as phosphate g.
6	Humanised milk	2.6	0.26	0.51	0.25
2	Dried milk full-cream	3.8	0.38	1.11	0.74
3	" half-cream	0.6	0.06	0.38	0.32
1	Condensed	1.7	0.17	0.29	0.12
31	Milk and water	1.6	0.16	0.57	0.41
4	Skim milk	0.6	0.06	0.87	0.80

Absorption per Kilogram of Body-weight. While the actual weight of calcium oxide absorbed by these infants during observation varied between 0 and 1.70 g. in 24 hours, with an average of 0.44 g., the amount absorbed per kilogram of body-weight varied from 0 to 0.33 g., with an average of 0.12 g. Holt, Courtney and Fales state that the average absorption of calcium oxide by healthy infants on a diet of cow's milk is 0.09 g. per kilo.

Fig. 6 shows the relationship between the weight of calcium oxide and the fat absorbed per kilogram of body-weight. From this graph it can be seen that to ensure an absorption of 0.1 g. of calcium oxide, the fat must be between 2 and 6 g. per kilo. Holt states that the fat intake should be not less than 4 g. per kilogram to ensure an absorption of 0.09 g. of calcium oxide in healthy children on cow's milk. This graph shows quite clearly that with the high fat intake found with the humanised dried milk mixtures, the absorption of calcium is poor.

Fig. 6. To show the relationship between weight of fat absorbed and weight of calcium oxide absorbed per kilo. of body-weight. —•— fat. calcium.

Fig. 7. To show relationship between the output of saponified fat —•— and calcium oxide daily.

Since the average absorption of calcium oxide for the group of half-cream dried milk is 0.26 g. per kilo. of body-weight, it is evident that in some instances an amount of calcium much greater than what is thought to be the normal amount can be absorbed by atrophic children. Observations show also that the fat absorption of atrophic children is sometimes greater than the normal for healthy children [Parsons, 1924, 1]. Fourteen out of 31 cases on milk and water showed an absorption per kilo. of body-weight above the average of 0.12 g. With one exception these correspond to an intake of between 0.040 and 0.078 g. of calcium oxide for 1 g. of fat intake and the percentage of fat in the food was between 1.6 and 3.1.

The results obtained by Holt, Courtney and Fales for 30 cases of bottle-fed healthy children, from 2 to 16 months, some having cod-liver oil, and by Utheim for 17 cases of atrophic infants from 3 weeks to 15 months are given for comparison.

	Av. % absorption of calcium oxide		Av. absorption of calcium oxide		Av. daily excretion of calcium oxide	
	%	Range %	g.	Range	g.	Range
Holt <i>et al.</i>	37.2	0 to 66.7	0.081	-0.064 to 0.133	0.75	0.34 to 1.58
Utheim	24.9	0 to 68.5	0.067	-0.48 to 0.309	0.71	0.125 to 2.136
Hickmans	43.0	0 to 83.7	0.12	-0.02 to 0.33	0.60	0.09 to 1.60

(These figures include the 39 cases quoted by Parsons [1924, 2].)

The observations on the calcium metabolism of infants recorded before Holt's paper of 1920 show much lower absorption figures, due probably to the different methods used for the estimations, and are consequently not shown here for comparison.

The Relation between the Excretion of Calcium and Saponified Fat. Fig. 7 shows that with a general decrease in the output of saponified fat, there is also a similar though not parallel decrease in the calcium oxide output. It is important to notice that in the cases on a skim milk diet, the weight of the calcium oxide excreted is greater than the weight of the saponified fat (expressed as fatty acid). This would be equally true if the weight of all the saponified fat were expressed in terms of calcium soap. The excess therefore must be excreted as calcium phosphate or calcium carbonate. There was sometimes a slight effervescence when dilute acid was added to the dried faeces. No estimation of the phosphorus has yet been done on these specimens, but theoretical considerations indicate that the weight of calcium oxide possibly held as phosphate is greatest in the group on skim milk (see Table II).

Telfer [1922] states that 20 to 30 % of the total calcium oxide excreted normally exists in the form of calcium soap. For this group of 31 cases on milk and water the average figure for the amount of calcium oxide which could possibly be held as soap is within this range, but the proportion is considerably greater in the cases on humanised milk powder mixture with a high fat content (54 %), and less for the cases on skim milk (13 %).

SUMMARY.

(1) Many atrophic infants can absorb calcium as well as normal infants, and in many cases can absorb larger amounts per kilo. of body-weight than is usually absorbed by normal children.

(2) In atrophy an ample intake of fat and calcium is beneficial.

(3) When the fat content is low, while the calcium content is high, this diet being continued for any length of time, the absorption of calcium may reach a perilously low level and there may be a negative balance.

(4) The calcium output depends somewhat on the calcium intake but more so on the fat intake. The fat intake should be not less than 12 to 14 g. daily.

(5) The best absorption takes place when there is a definite relationship between the fat and calcium intake, namely, when there is from 0.04 to 0.078 g. of calcium oxide for 1 g. of fat in milk and water mixtures; the absorption is also very good when the calcium oxide is as high as 0.12 g. in a certain dried milk mixture.

(6) The average percentage absorption of calcium oxide for 48 cases was found to be 43.0, but there is a great difference in the percentages shown with different diets.

(7) The actual weight of calcium oxide absorbed varied from 0 to 1.70, with an average of 0.43 g. in the 24 hours.

(8) The amount of calcium oxide absorbed per kilo. of body-weight varies from 0 to 0.33 g. with an average of 0.12 g.

(9) To ensure an absorption of 0.1 g. per kilo. of body-weight, the fat must be between 2 and 6 g. per kilo.

(10) Different foods have different calcium values. A variety of dried milk, made by the roller process shows a high amount of calcium absorbed. A dried humanised milk powder made by the spray process shows a very low value, while ordinary milk and water mixtures give an intermediate value.

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